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AUTOMATIC CONTROLLING OF CARBON DIOXIDE IN INDOOR CONDITION FOR SPLIT TYPE AIR CONDITIONING SYSTEM

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***Abstract*— This work deals with implementation and analysis of Split HVAC System having automatic CO2 level adjustment through fresh air arrangement and Reverse Cycle (Heat Pump) features in the class rooms of school premises. Carbon-dioxide sensors have been used as part of a demand controlled ventilation (DCV) system for room requiring mechanical ventilation, and their performance can significantly impact energy use in these systems. The basic working principle of Air conditioning system, reverse cycle feature and NDIR CO2 sensors have been discussed. A survey has been conducted by various authors on the HAVC systems of classrooms of various colleges is also reviewed.**

***Index Terms*— Demand Controlled Ventilation, Non-Dispersive Infrared, HVAC.**

I. INTRODUCTION

The most common method to incorporate demand controlled ventilation (DCV) into the design of an HVAC system is to adjust the amount of outdoor ventilation based on the level of CO2 in the building air. The CO2 level can be monitored by a sensor located in the occupied zone or in the return airstream [1].

Split HVAC System with automatic CO2 level adjustment through fresh air arrangement and Reverse Cycle (Heat Pump) features has been discussed which increase comfort level and good for human health. Carbon-dioxide sensors are widely used as part of a demand controlled ventilation (DCV) system for the class room.

II. BASICS OF AIR CONDITIONING SYSTEM

Air conditioning is the control of temperature, moisture content, cleanliness, air quality, and air circulation, as required by occupants, a process, or a product in the space. Hence it is often referred as environmental control. Human beings have a long history of struggling to make their lives more comfortable through the control of the immediate environment.

There are seven main processes required to achieve full air conditioning and they are listed and explained below:-

A. Heating

The process of adding thermal energy (heat) to the conditioned space for the purposes of raising or maintaining the temperature of the space.

B. Cooling

The process of removing thermal energy (heat) from the conditioned space for the purposes of lowering or maintaining the temperature of the space.

C. Humidifying

The process of adding water vapor (moisture) to the air in the conditioned space for the purposes of raising or maintaining the moisture content of the air.

D. Dehumidifying

The process of removing water vapor (moisture) from the air in the conditioned space for the purposes of lowering or maintaining the moisture content of the air.

E. Cleaning

The process of removing particulates, (dust etc.,) and biological contaminants, (insects, pollen etc.,) from the air delivered to the conditioned space for the purposes of improving or maintaining the air quality.

F. Ventilating

The process of exchanging air between the outdoors and the conditioned space for the purposes of diluting the gaseous contaminants in the air and improving or maintaining air quality, composition and freshness. Ventilation can be achieved either through natural ventilation or mechanical ventilation. Natural ventilation is driven by natural draft, like when you open a window. Mechanical ventilation can be achieved by using fans to draw air in from outside or by fans that exhaust air from the space to outside.

G. Air Movement

The process of circulating and mixing air through conditioned spaces in the building for the purposes of achieving the proper ventilation and facilitating the thermal energy transfer

III. LAYOUT OF AIR CONDITIONER SYSTEM

An air conditioning system comprises five major components as shown in figure 1:-

1. Evaporator Coil
2. Compressor
3. Condenser Coil
4. Receiver/Drier
5. Expansion device

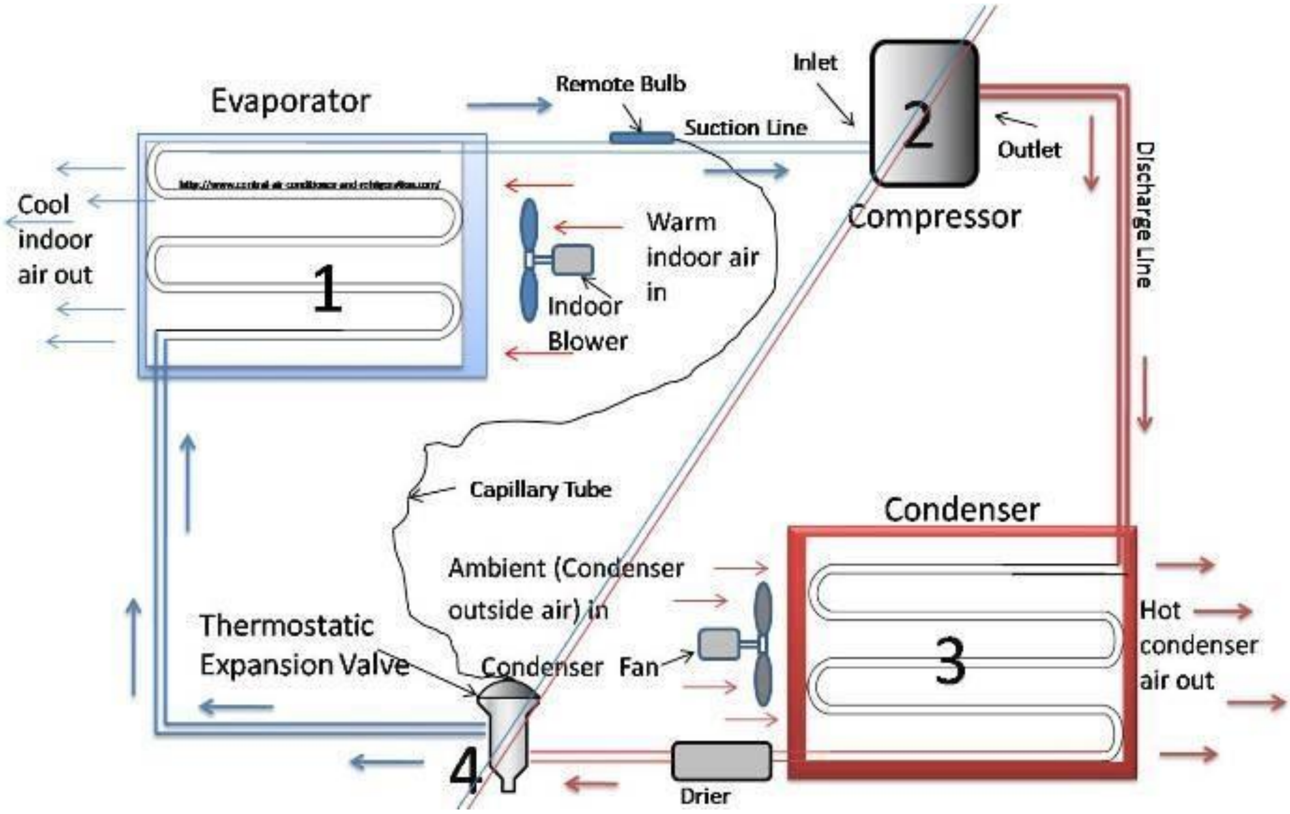

FIGURE 1: LAYOUT OF AIR CONDITIONER SYSTEM

IV. REVERSE CYCLE AIR CONDITIONER SYSTEM

A reverse cycle is an Air Conditioning system which can also provide very efficient heating. It takes less energy to relocate heat than it does to create it. Just as refrigeration system removes and relocates heat from a cooler or freezer, so too does a heat pump remove heat from cold outdoor air and relocate it to within a building. A four way reversing valve is used to swap the functions of the evaporator and condenser in order to change from cooling to heating mode. The diagram below shows a reverse cycle piping layout.

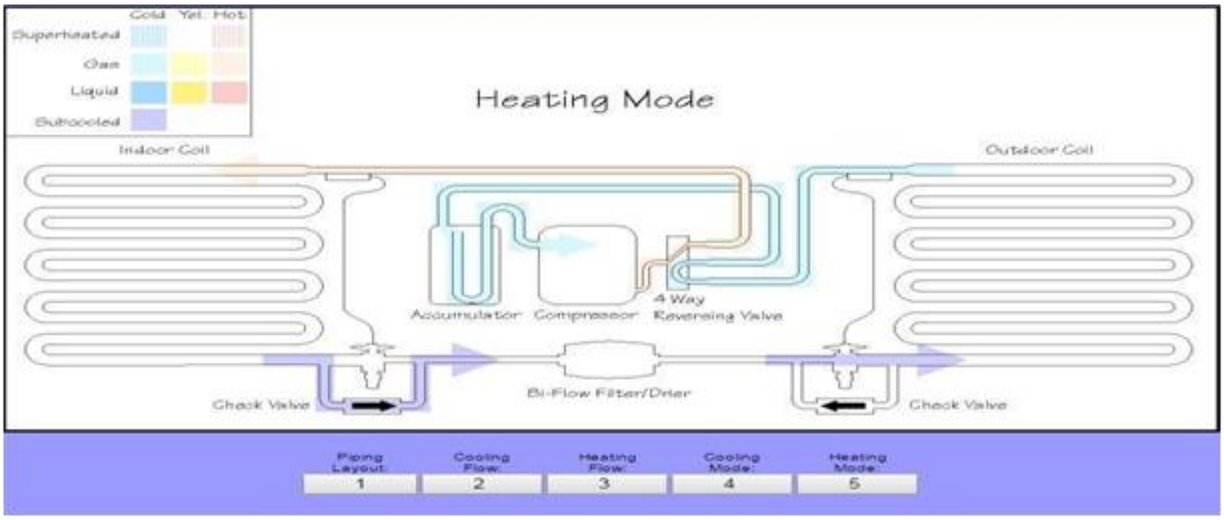

FIGURE 2 PIPING LAYOUT OF REVERSE CYCLE AIR CONDITIONER SYSTEM

A Indoor Air Quality Many factors affect indoor air pollution levels such as maintenance activities, the presence of contaminant sources (e.g. building materials, furnishings and equipment), the levels of contamination outdoors, the season, indoor humidity and temperature, and ventilation rates [14].Concentrations of specific contaminants in indoor air can often be considerably higher than concentration levels outdoors [21]. Indoor contaminants include formaldehyde, volatile organic compounds (VOCs), particles, pesticides, radon, fungi, bacteria, and nitrogen oxides. In addition to indoor air contaminants, occupants can experience similar discomfort and health symptoms similar to those attributed to indoor contaminants due to indoor environmental factors. Often, the presence of both indoor contaminants and other indoor environmental factors makes it difficult to identify direct causes of occupant discomfort and health symptoms. [22]. Generally, HVAC systems and water damage to the building envelope are the most common sources of building related IAQ problems [22]. Other causes of IAQ problems can be attributed to various phases of the building process including poor site selection, choice of materials, roof design, poor construction quality, improper installation or any number or combination of other factors [14]. Poor ventilation was another common issue that affected College occupants. Low ventilation rates generally increase the risk V2-418 2011 2nd International Conference on Environmental Science and Technology IPCBEE vol.6 (2011) © (2011) IACSIT Press, Singapore for health symptoms. There is also a consistent relationship between health symptoms and ventilation rates or CO2 concentrations. [25] found that some increases in ventilation rates up to 20 LS-1 per person decreased prevalence of SBS symptoms or improved perception of IAQ. [36] found that air -conditioned buildings may increase risk of SBS systems compared to those that are naturally ventilated.

V. WORKING OF CO2 SENSOR IN THE HVAC SYSTEM

Carbon dioxide gas (CO2) is a component of the earth‘s atmosphere. Although carbon dioxide is invisible and odorless, an increased CO2 content in the indoor air leads to fatigue and reduced concentration for humans. In rooms with high occupancy, such as conference rooms and theaters, the negative effects on humans becomes all the more evident. CO2 is a relevant parameter for optimizing indoor air quality and process control.Wireless CO2 sensor is connected with HVAC controller and send signal in form of voltage or current. After received signal, controller send a signal to servo motor in form of Voltage and current. Fresh Air damper is opened with help of servo motor, Servo motor is working while stop signal received means voltage & current is stop then servo motor is stopped means damper closed. Its all at work simultaneous. CO2 Concentration are set in the CO2 sensor, Its sense accordingly. 1,000ppm Recommended max. CO2 level in indoor air HVAC-GRADE CO2 SENSORS For HVAC applications, two CO2 sensor technologies are available: photoacoustic and NDIR. Of these the NDIR is the most commonly used technology for DCV application. As shown in Figure 1, the essential components of a NDIR CO2 sensor include an IR (infrared) radiation source, detector, optical bandpass filter, and an optical path between the source and the detector which is open to the air sample. The bandpass filter limits the IR intensity that is measured in a specific wavelength region. The detector measures this intensity which is proportional to the CO2 concentration. The main configurations used for HVAC grade CO2 sensors are: (1) single-beam, single-wavelength, (2) dual-beam, single-wavelength, and (3) single-beam, dual wavelength.

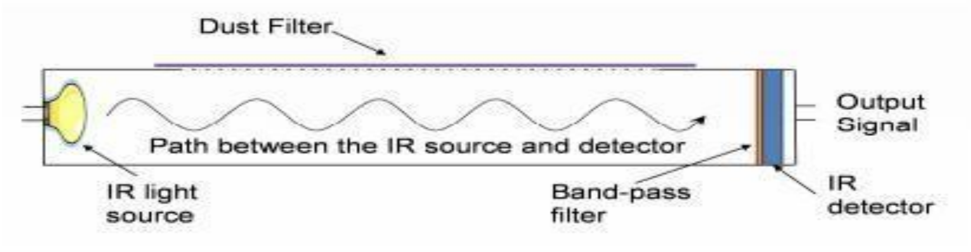

Figure 3. NDIR CO2 Sensor

IR light interacts with most molecules by exciting molecular vibrations and rotations. When the IR frequency matches a natural frequency of the molecule, some of the IR energy is absorbed. While carbon dioxide has several absorption bands, the 4.26m band is the strongest. At this wavelength, absorption by other common components of air is negligible. Hence, CO2 sensors use the 4.26 band. Quantitative analysis of a gas sample is based on the Beer-Lambert law (Equation 1), which relates the amount of light absorbed to the sample concentration and path length.A = [log10 (I0 / I)] = εcl (1) where, A = decadic absorbance I0 = light intensity reaching detector with no absorbing media in beam path I = light intensity reaching detector with absorbing media in beam path ε = molar absorption coefficient (absorption coefficient of pure components of interest at analytical wavelength) c = molar concentration of the sample component l = beam path length From Equation 1 it is evident that the attenuation of an IR beam at 4.26

µm is proportional to the number density of CO2 molecules in the optical path. For gases, the molecular density is directly proportional to the pressure and inversely proportional to the temperature. Thus temperature and pressure corrections must be applied when using IR absorption to determine CO2 concentrations. Operational and environmental conditions affect the performance of all CO2 sensors. An unavoidable operational effect is a result of the degradation of the IR light source over time. Since the principle of operation is based on measured attenuation of the IR beam, a decrease in lamp intensity affects the sensor output. Environmental conditions such as dust, aerosols and chemical vapors may also affect the sensor performance by altering the optical properties of the sensor components due to long-term exposure to these contaminants. To minimize the effects of air-born particulates, sensor manufacturers use a filter media across the opening of the sensor’s optical cavity where the air sample is analyzed. Various techniques are used by CO2 sensor manufacturers to compensate for the long-term effects of operational and environmental conditions. Some sensors automatically reset the baseline value (normally 400 ppm) according to a minimum CO2 concentration observed over a time period. However, the logic used to reset the baseline and frequency of correction varies with manufacturer, and often it is not well documented. This technique relies on the fact that many buildings experience an unoccupied period during which CO2 levels drop to outdoor levels. Other compensation techniques include dual-beam, single-wavelength and single-beam, dual wavelength designs.

A. Layout of Ducting with Heating Ventilation & Air Condition's System and CO2 sensor in the Class Room

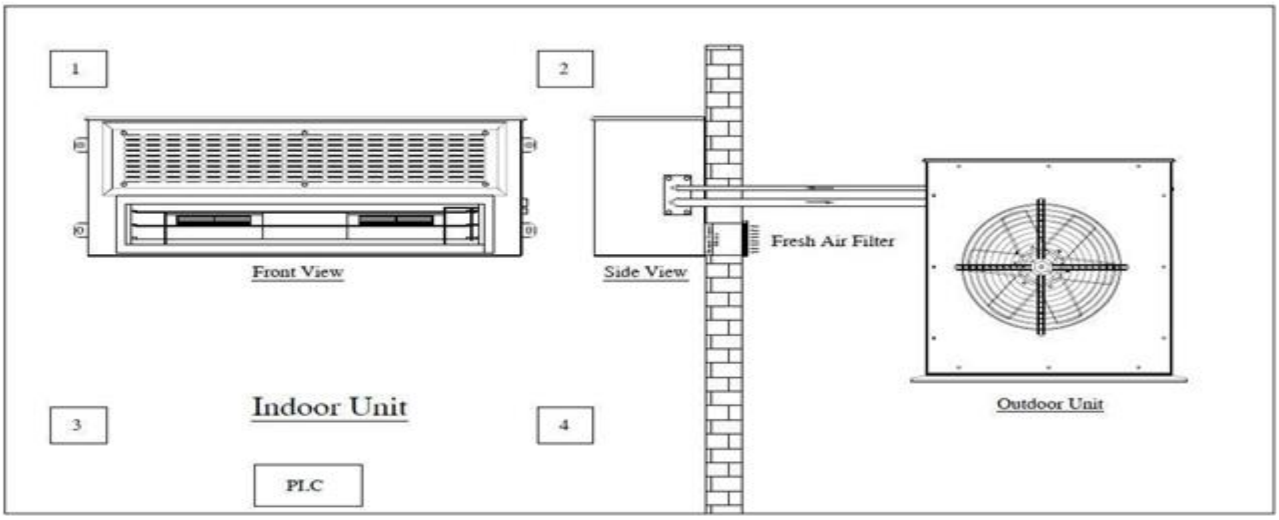

FIGURE 4. HVAC DUCTING WITH CO2 SENSOR

B. Micro Controller

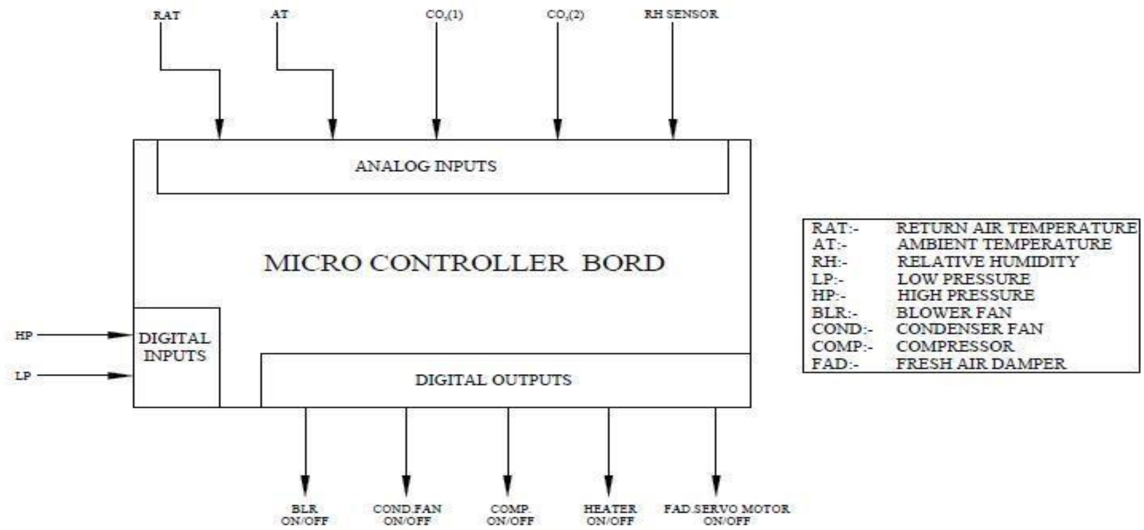

FIGURE 5. CONFIGURATION OF MICRO CONTROLLER

VI. MEASUREMENT AND ANALYSIS

A. Ventilation Rates

Ventilation surrogates the IAQ level, minimizing the concentration of harmful pollutant. The higher ventilation rates are associated with improved of health. It has rarely been measured in Colleges, although inadequate ventilation is often suspected to be an important condition leading to reported health symptoms. [2] recommends a minimum ventilation rate of 8 L/s-person (15 cfm/person) for classrooms. Given typical occupant density of 33 per 90m2 (1000 ft2) and a ceiling height of 3m (10 ft), the current ASHRAE standard would require an air exchange rate of about 3 air changes per hour (ACH) for a classroom. [34] reported ventilation measurements made in 6 noncomplaint Colleges in the U.S. Northwest - 2 in Portland, and 4 in Spokane, WA. Colleges ranged from 3-25 years in age, 1-3 stories; all had mechanical ventilation systems of some type. Ventilation rates, calculated on a whole building volume basis, ranged from 4.5 L/s-person to 31 L/s-person. The whole or average building rate, however, includes unoccupied areas such as hallways and gymnasiums, and, as the authors point out, this average rate overestimates the local ventilation rate of occupied classrooms. For example, in one of the elementary Colleges, the whole building ventilation rate was 4.5 L/s-person while the ventilation rate in an occupied classroom was only 1.6 L/s-person. [35] also reported ventilation rates measured in 2 Colleges in Sante Fe, which were being mitigated for high radon concentrations. Twelve pre- and post-radon mitigation ventilation rates were below 3 ACH with one exception. [9] in his research of eight primary Colleges in United Kingdom revealed that pupils work and performance increased 7% in addition due to the intervention the fresh air supply from 0.3-0.5 to 16L/s per person. This is supported by [18], where the poor ventilation rates for the adult population could be expected that not only the comfort and health, but also the learning performance of College children are affected by the poor environmental conditions in classrooms. By improving classroom conditions can substantially improve the performance of College works by children.

B. CO2 Concentrations

Carbon dioxide concentrations are often used as a surrogate of the rate of outside supply air per occupant. Indoor CO2 concentrations above about 1000 ppm are generally regarded as indicative of ventilation rates that are unacceptable with respect to body odors. Concentrations of CO2 below 1000 ppm do not always guarantee that the ventilation rate is adequate for removal of air pollutants from other indoor sources [25], [1].It is difficult to adequately characterize indoor CO2 concentrations since they are a function of occupancy and ventilation rate, both varying as a function of time. Grab samples or other short-term measurements may be inadequate to provide information on the long-term ventilation conditions in Colleges.

The most common building factors associated with indoor environmental complaints are related to the Heating Ventilation and Air Conditioning (HVAC) systems. The recommended ventilation rate for a classroom is 15 cfm/person with a specified maximum occupancy of 50 persons per 1000 ft2 for Colleges provides outdoor air requirements for classrooms of 15 cubic feet per minute (CFM) per person. According to [5], the ventilation rate for Colleges with desiccant cooling systems (humidity control) averaged 15 cfm/person, whereas conventional HVAC system Colleges 20 averaged only 5 cfm/person. This study cited inadequate HVAC maintenance and poor design as causes for poor indoor air quality from HVAC systems. Students occupying rooms with old air handling unit filters reported more symptoms from the eyes, nose and throat than students with newer filters [29]. HVAC systems can cause indoor air quality problems and/or distribute contaminants throughout a building. Table 3.2 and figure 3.1 present findings from literature relative to measurements of CO_2, ventilation and other measures of the indoor conditions in classrooms and Colleges. Specifically, the findings determined whether ASHRAE recommended concentration of 1,000 ppm CO_2 and ventilation rate of 15-cfm/person were met. Results from Table II, only two studies met the ventilation guidelines, and 14 of the 16 studies failed to meet the ventilation guidelines. The data indicates that, most often, mechanically ventilated and unoccupied rooms meet standards for CO_2, whereas naturally ventilated and occupied rooms did not. When new Colleges were compared to old Colleges, measurements were relatively equal.

High levels of CO_2 can result from inadequate ventilation systems, inadequate air exchanges from the opening and closing of windows and doors, and overcrowded classrooms. Occupied and air conditioned rooms measured higher levels of CO_2 than rooms cooled with ceiling fans. Rooms with desiccant active control systems met standards for ventilation, while rooms with conventional HVAC systems did not [5]. Other study findings indicate that low ventilation rates were associated with worsening health or perceived air quality outcomes. Also, the literature associates increases in CO_2 with decreased attendance [27]. [30,31] reported average and ranges of indoor CO_2 concentrations for 96 classrooms in 38 Swedish Colleges randomly selected from a population of 130 Colleges; 61% of them had mechanical supply and exhaust air systems while the remainder had natural ventilation.

Concentrations averaged 990 ppm CO_2 for the 38 Colleges, but were above 1000 ppm for 41% of the measurements (maximum = 2800 ppm). In general, CO_2 measurements in Colleges suggest a significant proportion of classrooms probably do not meet the ASHRAE Standard 62-2007 for minimum ventilation rate, at least part of the time. The particular concern is the potential for increased risks of contracting certain communicable respiratory illnesses, such as influenza and common colds in classrooms with low ventilation rates [17].

Table 1 Measurement CO_2 (PPM) And Ventilation (CFM/PERSON)

STUDY	SAMPLE	CO_2 ventilation guidelines met	CO_2 (ppm) or ventilation (cfm/person)
[17]	3 Colleges 9 Classrooms	Yes	• 638.27- 698.60ppm, 555.50- 647.60ppm,545.60-675.0ppm
[3]	39 Colleges	No	• 1080 ppm
[5]	10 Colleges	Yes - desiccant No - HVAC	• Desiccant (15cfm) • HVAC system <5 cfm/person
[6]	24Colleges	No	• 4000ppm
[8]	10 Colleges 2 districts	No	• 1461 ppm • 79% exceeded standard
[11]	7classrooms	No	• 1017-1735 ppm
[9]	3 Colleges 7 classrooms	No	• 1,387, 644, and 1,455 ppm
[12]	9 Colleges 64classrooms	No	• 533-1552 ppm
[13]	7 Colleges	No	• 1316 ppm

[16]	5Colleges 5 classrooms	No	• > 1000 ppm
[19]	12Colleges 12 classrooms	No	• 1,150 ppm • Range 760 –1620 : 84% did not meet standard
[20]	2Colleges 5 classrooms	Yes	• Old College :509 ppm • New College: 512ppm
[22]	67 Colleges 384 classrooms	No	• 1,070 ppm portable classrooms(1,064 ppm) • traditional classrooms (1074ppm
[27]	22 Colleges 436 classrooms	No	• 45% of classrooms >1,000 ppm
[28]	1 test chamber 1 classroom	No	• without ventilation (1790 - 2190 ppm) • with ventilation(1032 - 1536ppm)
[33]	104Childcare Center	Yes-Natural Ventilation No-Air- Condition	• Natural Ventilation(463-509 ppm) • With air-condition(Mean 1184ppm) (range 995-1337ppm)

VII. CONCLUSIONS

Anxiously, majority of Colleges is exposed to the inadequate IAQ due to insufficient ventilation and care activities, temperature, and breathing rates. These conditions will lead to the SBS symptom and affecting the child's performance as they are sore to any changes surrounding them. The peered researchers indicate that 14 of 16 studies failed to fill the CO2 ventilation guidelines. However, it is hard to endure the characteristic indoor CO2 as it often used as a surrogate of the rate of outdoor supply air per occupant and a purpose of occupancy and ventilation rate. This critique proves that the land of knowledge regarding IAQ in Colleges is limited. With the potential exception of the early investigations not reported in the peer reviewed literature, there has been no coherent approach to evaluations of IAQ and health outcomes in Colleges. Many of the existing studies lack the hardness and quality necessary to adequately address the problem. In summation, although there is some effort to identify the IAQ problems in Colleges, there are no plans currently in office to improve the indoor environmental quality in Colleges More studies are asked in which relations between symptoms and measured exposures to multiple specific contaminations to be looked into. Furthermore, quantitative data is needed for exposure-health response relationships for specific pollutants suspected to cause health symptoms, in parliamentary procedure to offer a sound foundation for determining standards for refurbished pre-College and for insuring cost effective mitigation measures. In conclusion, although there is evidence that many Colleges are not adequately ventilated, the extent of the problem is not recognized. Careful and thorough measurements of ventilation rates and/or CO2 levels in a representative sample of Colleges would provide much needed data on the fraction of Colleges with this.

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