CARBON DIOXIDE MONITORING IN OFFICE BUILDINGS: THE CASE-STUDY OF SUI NORTHERN GAS PIPELINES LIMITED IN LAHORE

SCIENTIFIC PAPER

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ABSTRACT

In Lahore, almost all the working occupants in office buildings face the problem of indoor CO_2 air pollution due to the less ventilated working environment and lack of quality ventilation systems. The main objective of this scientific paper is to collect CO_2 measurements on different points of indoor spaces in the research site, analyze the collected results and suggest solutions to the minimization of CO_2 molecules between 600 ppm and 800 ppm. The selected research site was the third-floor indoor spaces of the Head Office of Sui Northern Gas Pipelines Limited (SNGPL) in Lahore, Pakistan. For measuring CO_2 indoors, AZ 7752 CO_2 meter was used in all the office spaces and working spaces except in circulation spaces for conducting CO_2 assessment, which was the main research method. CO_2 assessment was done by noting down CO_2 readings on A3 blowups of the different portions of SNGPL third floor plan. The collected results have shown that in research site's regularly occupied office spaces, carbon dioxide levels were ranging from 1295 ppm to 3216 ppm. There is a need to conduct indoor CO_2 assessment on weekly basis with CO_2 meters for controlling IAQ and install quality HVAC system or displacement ventilation or equivalent system with high exhaust airflow rate and high ventilation efficiency according to the occupancy level of rooms in office buildings for ensuring minimum CO_2 levels between 600 ppm and 800 ppm.

Keywords: Indoor Air Quality, CO_2 Assessment, Ventilation, Environmental Sustainability, Indoor Environmental Quality

1. INTRODUCTION

EPA states that air pollution in interior spaces is usually 2 to 5 times more in quantity than that in exterior spaces and sometimes, indoor air pollution has the quality of exceeding itself hundred times more than that of outdoor air pollution. Indoor air pollution is more dangerous than outdoor air pollution (MANA, 2019). Many studies have been carried out related to the causes and sources of indoor air pollution. Studies have also been undertaken on the causes of having indoor CO_2 in indoor spaces. However, no detailed study or sufficient study has been taken up on increasing indoor fresh air supply and decreasing the amount of human-produced CO_2 in indoor spaces. It is also observed that CO_2 monitoring is not carried out on day-to-day basis after installing HVAC systems in office spaces. This scientific paper focuses on the method of taking CO_2 measurements undertaken in the third floor of Sui Northern Gas Pipelines Limited, Lahore in order to improve indoor air. This scientific paper deals with the data analysis of CO_2 measurement results accumulated in the third floor of Sui Northern Gas Pipelines Limited, Lahore.

2. MATERIALS AND METHODS

For knowing the amount of CO_2 in the third floor of Sui Gas Northern Pipelines, AZ 7752 was chosen for noting down CO_2 readings on randomly selected measurement points of indoor spaces in the third floor of Sui Northern Gas Pipelines Limited (SNGPL).

Figure 2.1: AZ 7752 CO_2 Meter
Source: (Amazon, 2019)

CO_2 meter is a digital instrument used for getting the amount of carbon dioxide concentration in one air sample expressed as parts per million (ppm) in order to enable occupants to maximize ventilation efficiency either mechanically or naturally in confined spaces with multiple occupancy (PCE, 2019). The unit ppm (parts per million) means if CO_2 meter is showing 850 ppm as the amount of CO_2 on its small LCD screen then this indicates that 850 molecules of carbon dioxide per million molecules of air are present in one measurement point of indoor space (WSU, 2013).

AZ 7752 CO_2 Meter is a selected material for internally measuring carbon dioxide in SGNPL because this was the only economical CO_2 measuring handheld machine available in Pakistan. AZ 7752 CO_2 Meter is a scientific machine made in Taiwan which is designed with NDIR (Non-Dispersive Infrared) wave guide technology sensor and displays CO_2 ranging from 0 to 9999 ppm with 1 ppm CO_2 resolution on its LCD with a size of 44mm (L) x 26 mm (W) after thirty seconds of warm-up time. The size of this CO_2 handheld instrument is 205 mm (L) x 70 mm (W) x 56 (H) mm. If the CO_2 reading on meter's LCD exceeds 1000 ppm, the CO_2 alarm in this instrument will ring (AZ-Taiwan, n.d.). This research method of measuring CO_2 through CO_2 meter(s) is called CO_2 Assessment.

In order to conduct CO_2 Assessment, the researcher acquired the vector AutoCAD Drawing of the third floor of Head Office Sui Northern Gas Pipelines Limited (SNGPL), which was selected as the research site, so that the researcher can A3 print-outs of blow-ups of every possible portion of mechanically CAD-drawn third floor plan of the Head Office SGNPL and note down all the CO_2 readings measured on the indoor spaces of the research site. Except circulation spaces (bathrooms, stair halls, lifts etc.), almost all the indoor spaces were selected for indoor CO_2 measurement on different randomly chosen measurement points of indoor spaces.

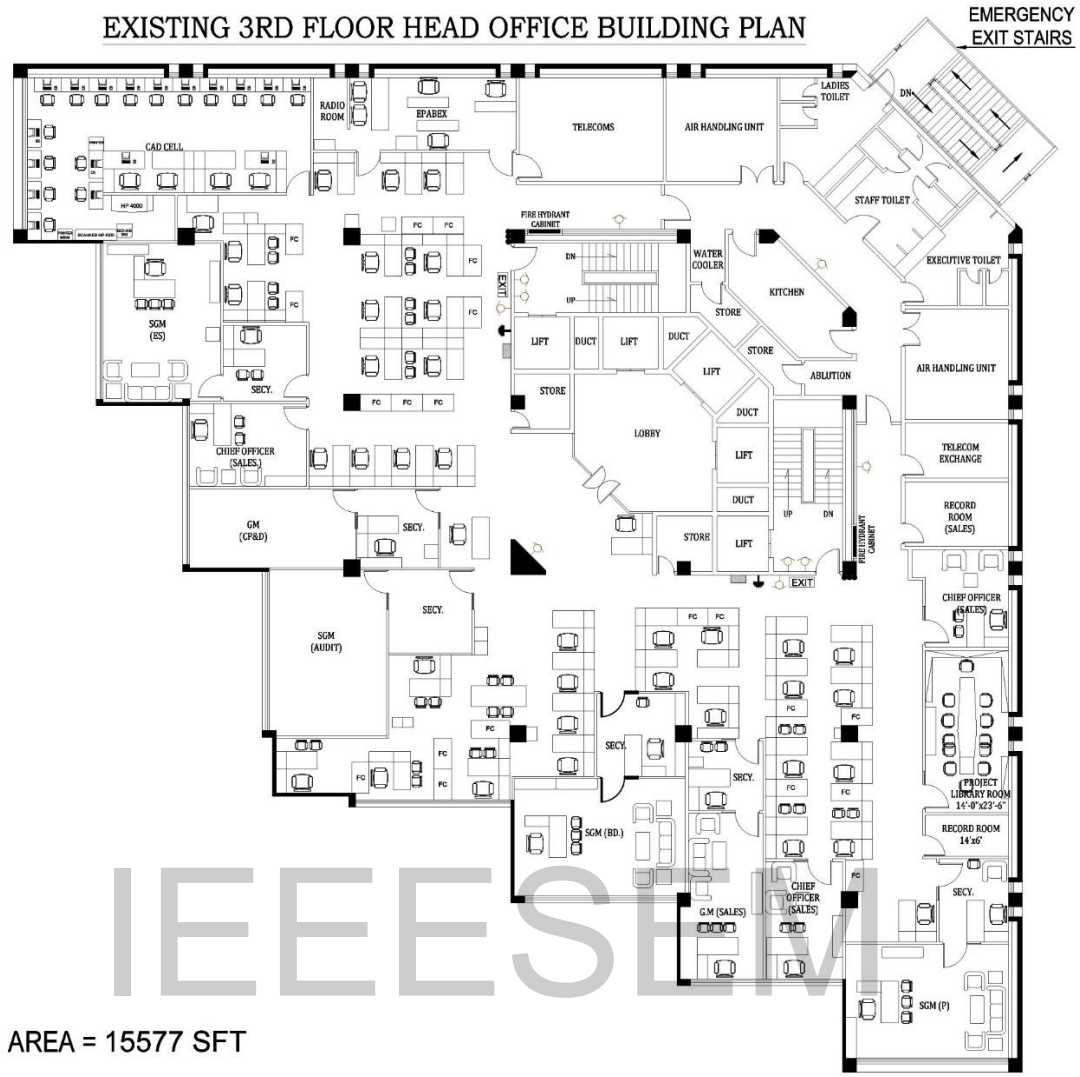

Figure 2.2: Third Floor Plan of the Head Office, SGNPL, Lahore
Source: Head Office SNGPL Lahore

The following indoor spaces in the Head Office Sui Northern Gas Pipelines Limited (SNGPL) were considered for conducting CO_2 assessment: CAD Cell, Radio Room, EPABEX, Telecoms, Air Handling Unit Rooms, Telecom Exchange Room, Record Rooms, Chief Officer Rooms, General Manager Rooms, Project Library Room, Secretary rooms of different general managers and open working spaces with workstations.

3. RESULTS AND DISCUSSION

All the indoor spaces of SNGPL's third floor will be analyzed according to the criteria given below:

Table 3.1: NIOSH Recommendations of CO_2 Levels

CO_2 Indoor Levels	Interpretations
600 ppm	The best maintained level of CO_2 in indoor spaces
600 ppm-1000 ppm	Only acceptable if CO_2 does not exceed 1000 ppm
1000 ppm or more	At this rate, indoor CO_2 comes in a position to cause health issues like, irritation, tiredness and headache
*Outdoor levels of CO_2 between 250 ppm and 350 ppm are acceptable	

Source: *(AZ Instrument, 2013)*

The results (which were collected on Wednesday, 27th November, 2019) are presented in the shape of blow-ups displaying different portions of the SNGPL Head Office Building's third floor plan shown in Figure 2.2. The results are the following:

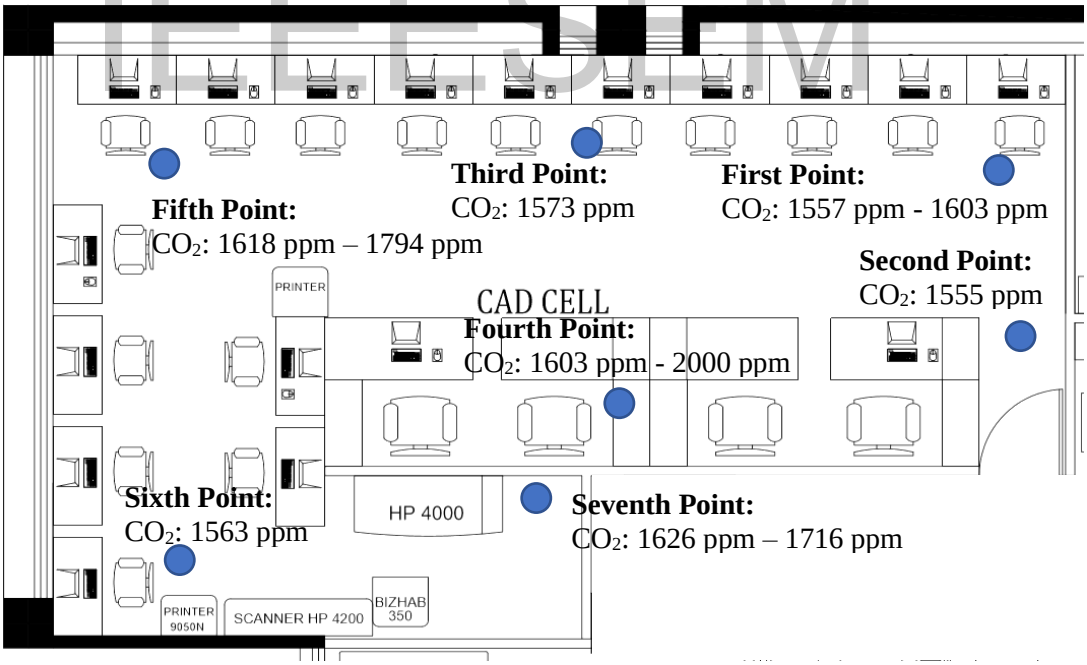

Figure 3.1: CAD Cell in the Third Floor Plan (SNGPL)
Source: Head Office SNGPL, Lahore

The CAD Cell, in Figure 3.1, is 41'-0" (W) x 23'-6" (L), which is mostly found to be unventilated since the expired air and human-produced carbon dioxide were not

removed. From randomly selected points of measurement, CO_2 was ranging from 1555 ppm to 2000 ppm.

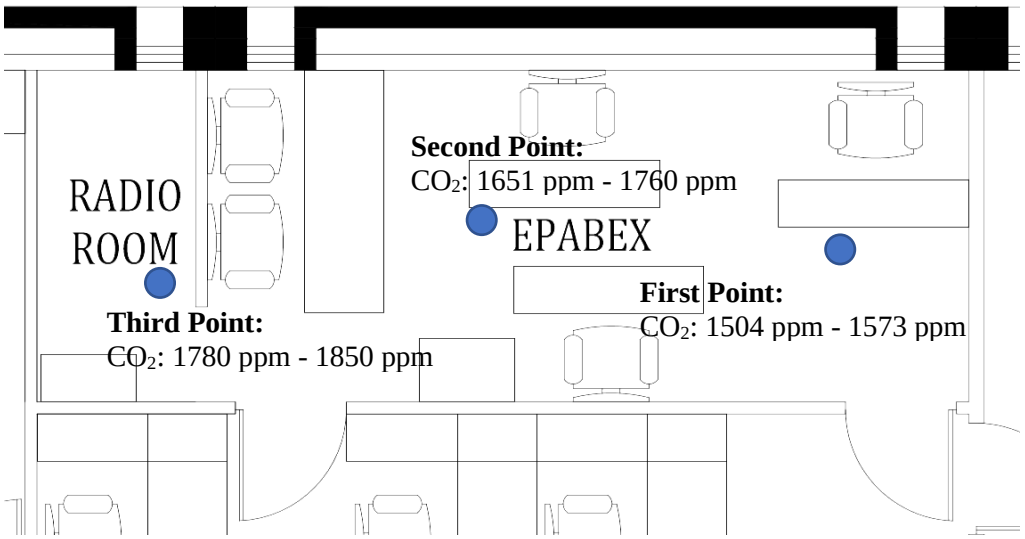

Figure 3.2: EPABEX in the Third Floor Plan (SNGPL)
Source: Head Office SNGPL, Lahore

The rooms shown in Figure 3.2 are also found to be filled with CO_2 pollution. Three CO_2 readings were noted down from three different points of measurement and the CO_2 values were ranging from 1504 ppm to 1850 ppm.

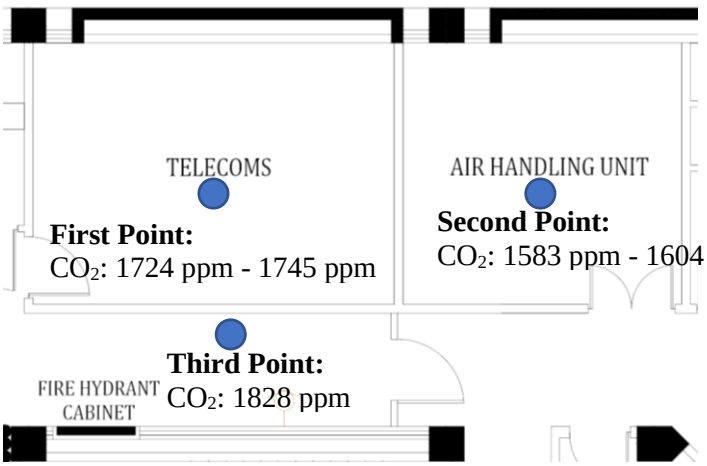

Figure 3.3: Telecoms+AHU in the Third Floor Plan (SNGPL)
Source: Head Office SNGPL, Lahore

The regularly occupied indoor spaces, displayed in the Figure 3.3, are also got carbon dioxide levels higher than 1000 ppm. There is no effective means of true ventilation in these rooms.

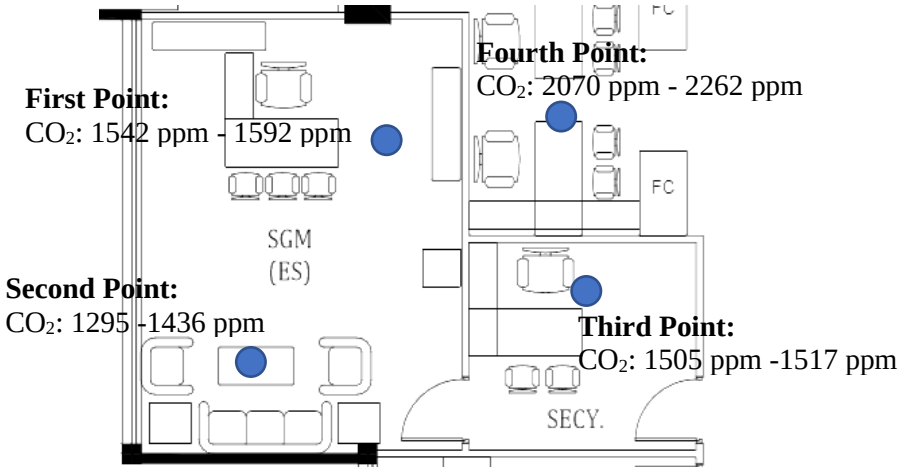

Figure 3.4: SGM (ES) in the Third Floor Plan (SNGPL)
Source: Head Office SNGPL, Lahore

This is the Senior General Manager Office with Secretary Room in Figure 3.4 which shows that CO_2 pollution was touching 1592 ppm due to the lack of mechanical ventilation with effective exhaust air flow rate. Secretary Room was also littered with 1517 CO_2 molecules per million molecules of air and the working area has got 2262 ppm of carbon dioxide on the fourth point since the carbon dioxide molecules were not excluded from all these confined spaces with little fresh air.

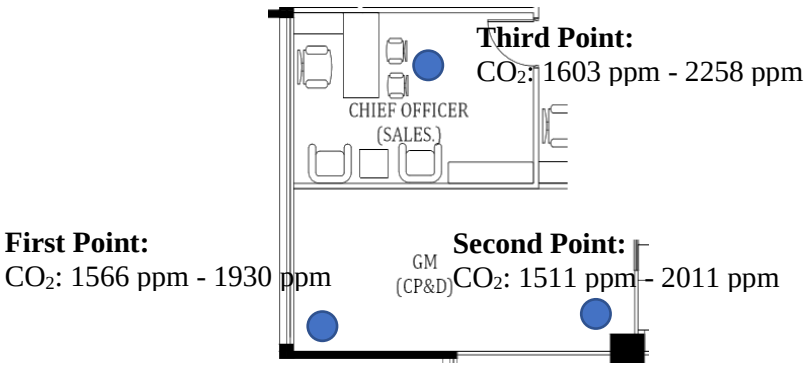

Figure 3.5: Chief Officer (Sales) in the Third Floor Plan (SNGPL)
Source: Head Office SNGPL, Lahore

In Figure 3.5, the rooms of Chief Officer (Sales) and General Manager (CP & D) are having excessive CO_2 levels from 1511 ppm to 2258 ppm. Effective mechanical ventilation system with higher ventilation efficiency is required according to the number of persons occupying these spaces regularly.

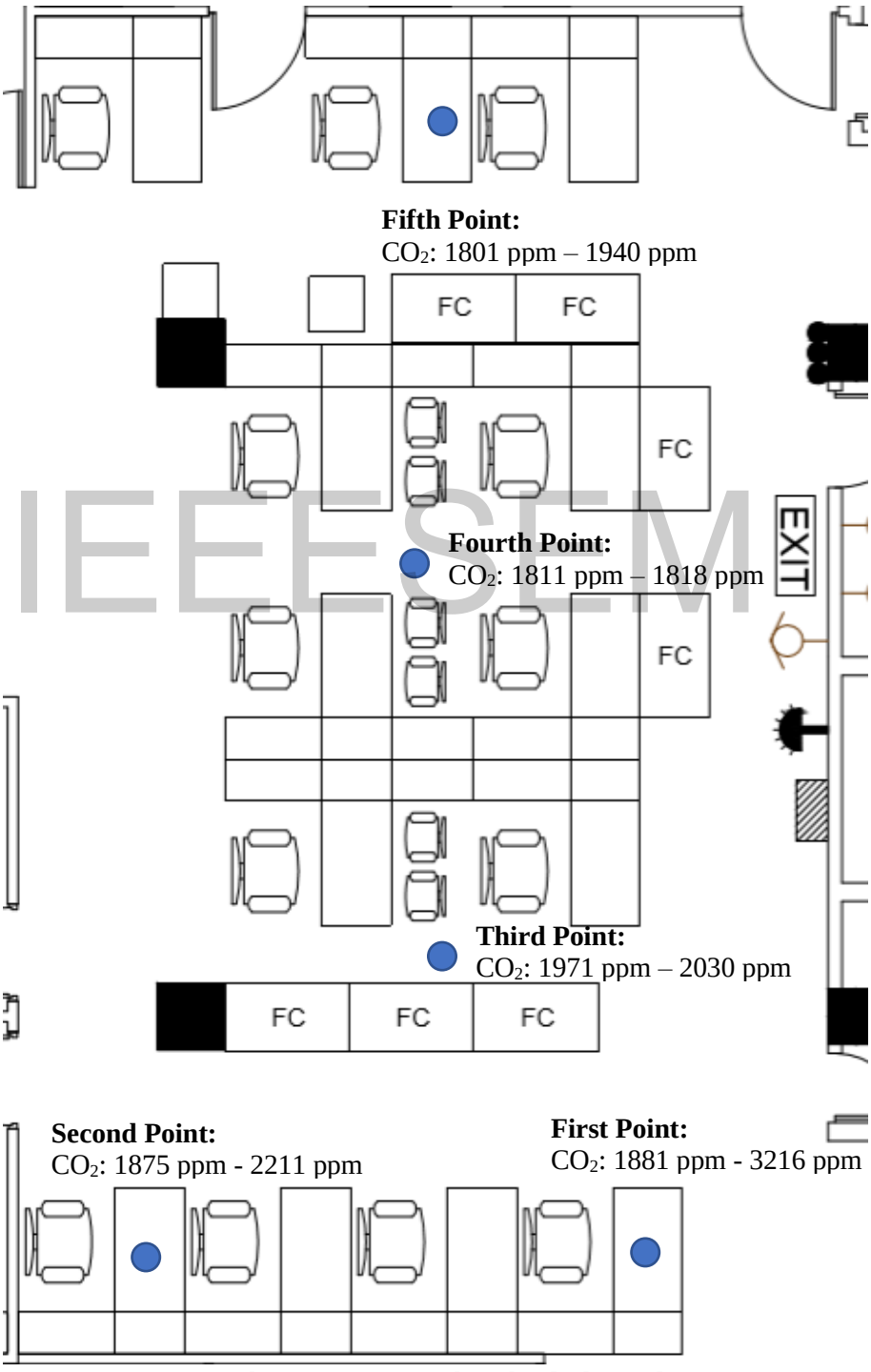

Figure 3.6: Working Space 1 in the Third Floor Plan (SNGPL)
Source: Head Office SNGPL, Lahore

In Figure 3.6, the open working space with workstations is shown which is surrounded by CAD Cell, Senior General Manager Room (ES) and Secretary room (ES), Chief Officer (Sales) Room, EPABEX Room, Telecom Room and the Lobby Area with stairs and lifts. The recorded CO_2 levels were starting from 1801 ppm and ending at 3216 ppm in this interior space. Exhaust vents with good exhaust air flow rate are required to be installed over breathing occupants for controlling indoor air quality and limiting carbon dioxide levels between 600 ppm and 800 ppm.

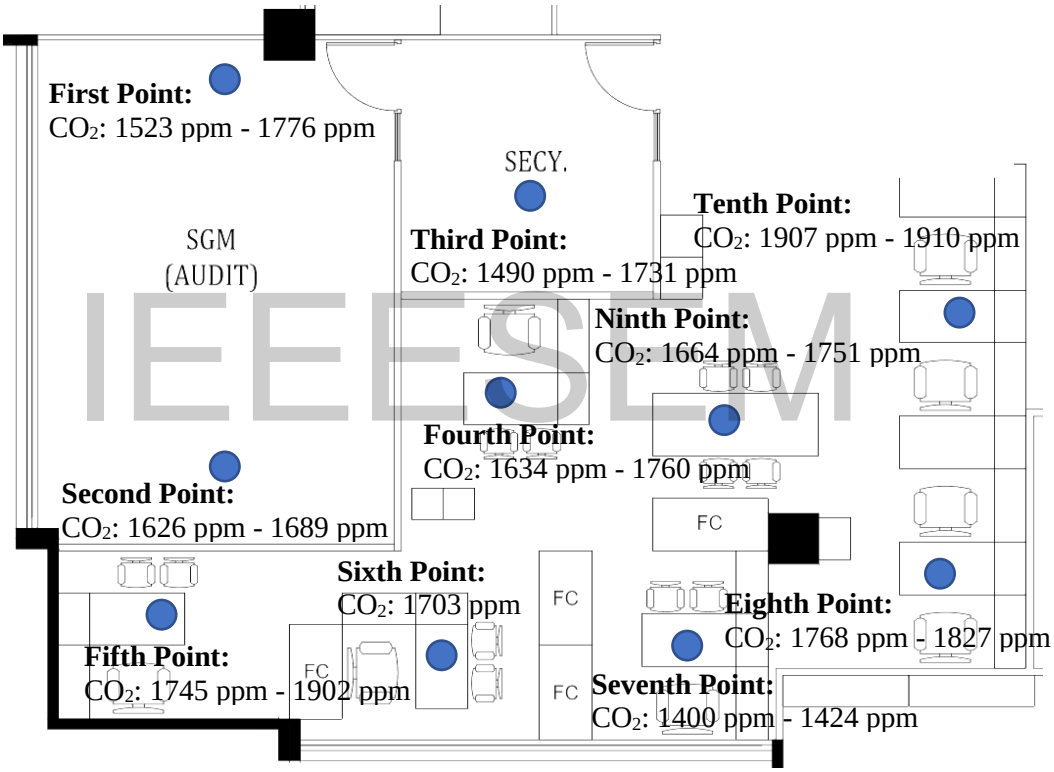

Figure 3.7: SGM (Audit)+Working in the Third Floor Plan (SNGPL)
Source: Head Office SNGPL, Lahore

In Figure 3.7, it is shown in the plan that the Senior General Manager (Audit) Room has got excessive CO_2 levels ranging from 1523 ppm to 1776 ppm and the secretary room attached with it has CO_2 concentration from 1490 ppm to 1731 ppm. The other seven points of measurement shown in working space from third to tenth are starting from 1400 ppm and going up to 1910 ppm. All these internal spaces need the

integration of mechanical ventilation system, air purifiers and CO_2 scrubbers which should be installed near the occupants and machines which are exhaling or outgassing carbon dioxide indoors.

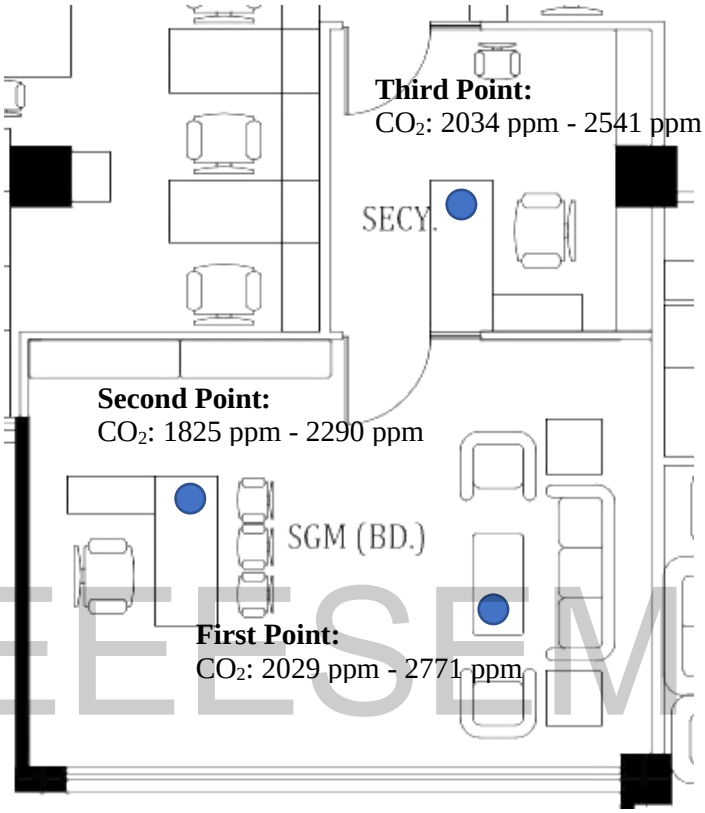

Figure 3.8: SGM (BD.) + Secretary in the Third Floor Plan (SNGPL)
Source: Head Office SNGPL, Lahore

In Figure 3.8, two points were selected for taking CO_2 readings from CO_2 meter in the Senior General Manager (BD.) room and the values were fluctuating between 1825 ppm and 2771 ppm. The Secretary's room adjacent to SGM (BD.) room has got CO_2 pollution above 2000 ppm. All these interior spaces should be equipped with mechanical ventilation system and CO_2 scrubbers near to the occupants.

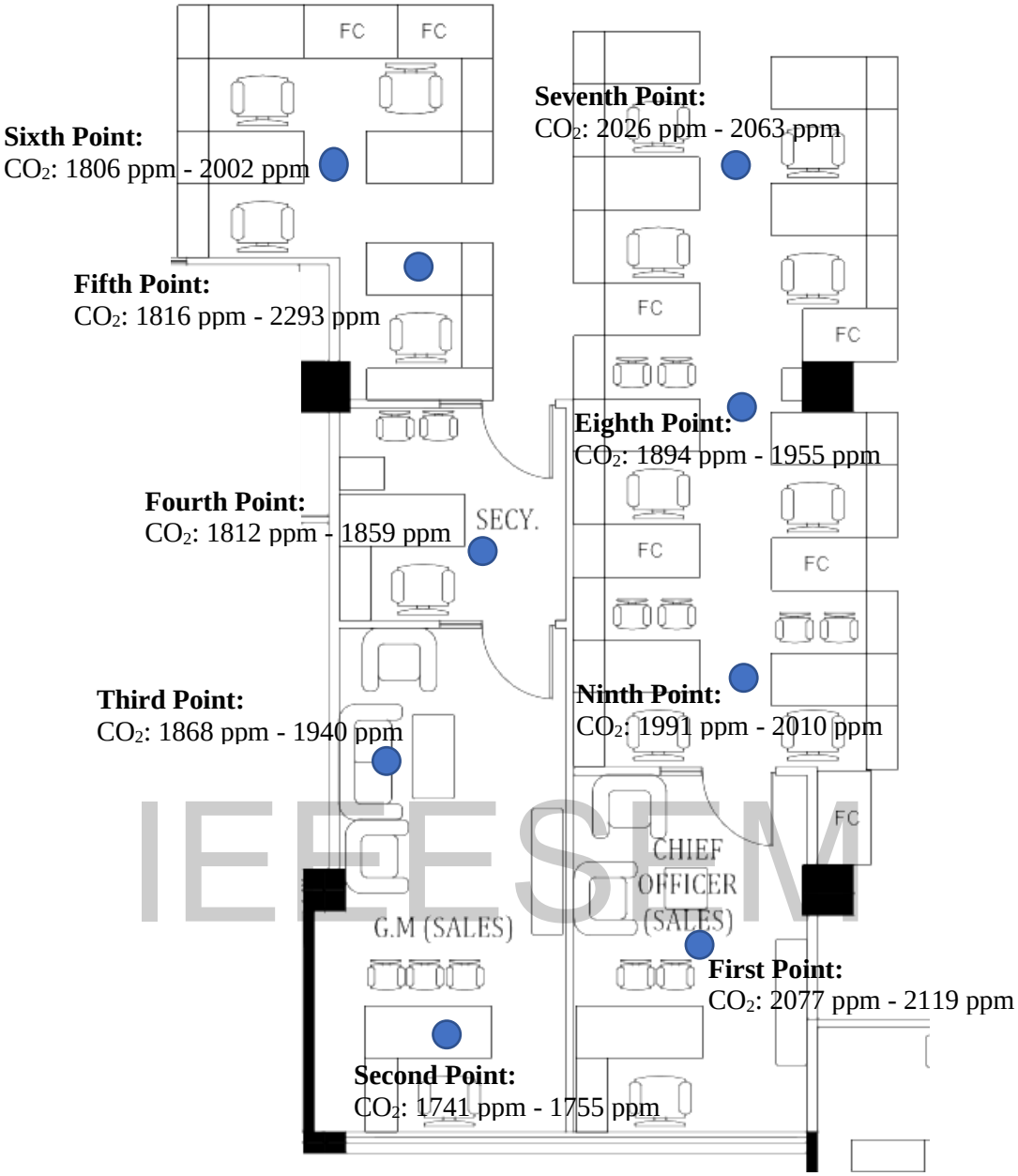

Figure 3.9: GM+Chief Officer (Sales) in the Third Floor Plan (SNGPL)
Source: Head Office SNGPL, Lahore

In Figure 3.9, it is apparent that Chief Officer Room accumulates carbon dioxide from 2077 ppm to 2119 ppm. G.M. Sales room contains carbon dioxide levels between 1741 ppm and 1940 ppm. Secretary Room has got CO_2 levels between 1812 and 1859 ppm. Working space adjoined with Secretary Room and Chief Officer (Sales) Room has CO_2 levels going above 1800 ppm. These rooms need mechanical ventilation system or HVAC with higher ventilation efficiency and appropriate exhaust air flow rate.

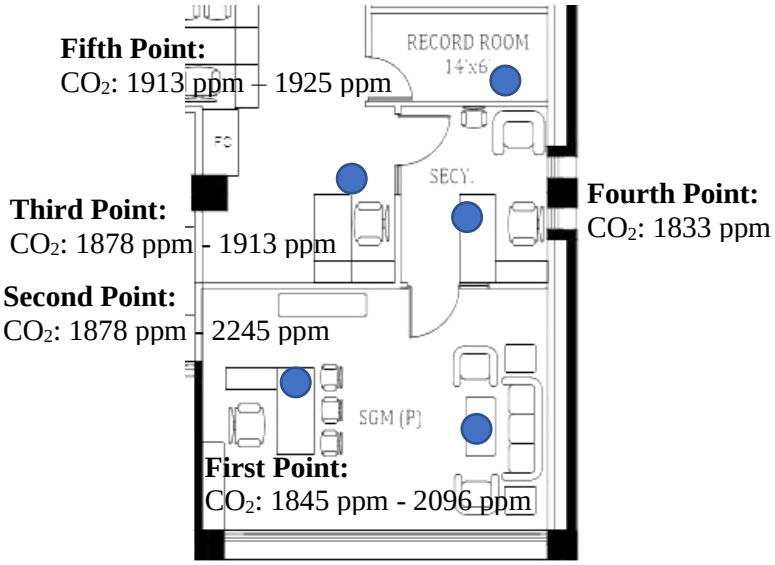

Figure 3.10: SGM (P)+Record Room in the Third Floor Plan (SNGPL)
Source: Head Office SNGPL, Lahore

All these interior spaces, shown in Figure 3.10, need mechanical ventilation system with high ventilation efficiency and good exhaust air flow rate.

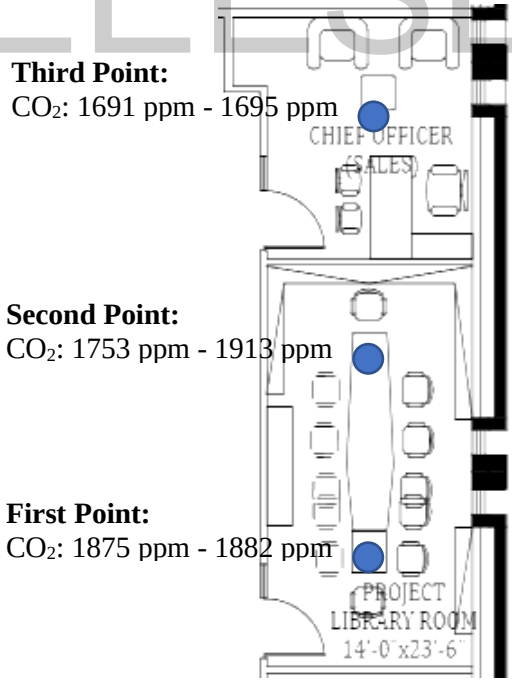

Figure 3.11: Project Library+Chief Off. in the Third Floor Plan (SNGPL)
Source: Head Office SNGPL, Lahore

All these interior spaces, shown in Figure 3.11, need mechanical ventilation systems.

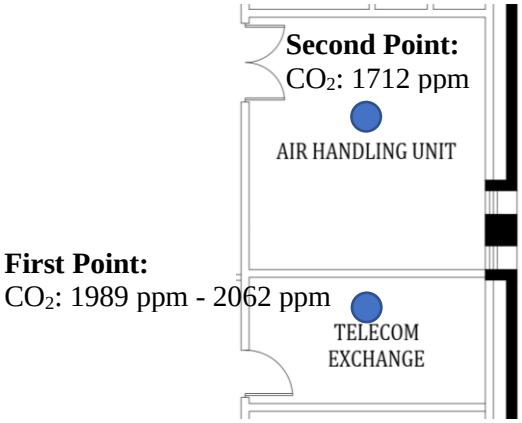

Figure 3.12: Telecom EXCH.2+AHU in the Third Floor Plan (SNGPL)
Source: Head Office SNGPL, Lahore

All these interior spaces, displayed in Figure 3.12, have higher CO_2 levels above 1700 ppm. Mechanical ventilation system with exhaust air flow rate is required according to the number of people occupying these spaces regularly.

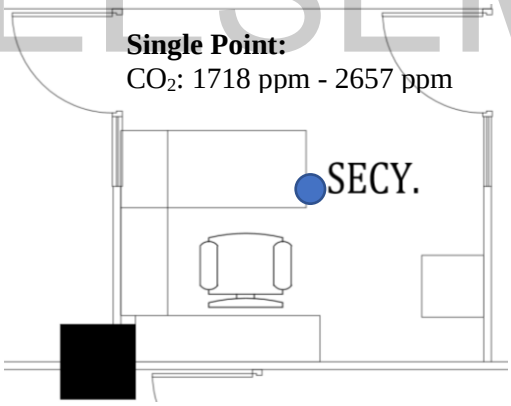

Figure 3.13: Secretary Room near GM (PC&D) in the Third Floor Plan (SNGPL)
Source: Head Office SNGPL, Lahore

In Figure 3.13, the recorded carbon dioxide levels were ranging from 1718 ppm to 2657 ppm. Mechanical ventilation systems with higher ventilation efficiency and recommended exhaust air flow rate is required in accordance with the number of occupants in order to limit carbon dioxide between 600 ppm and 800 ppm in indoor spaces.

The above results, shown above, indicate that the occupants working in the rooms built on the third floor of the SNGPL Head Office, Lahore are not comfortable due to the presence of excessive carbon dioxide fluctuating between 1200 ppm and 3500 ppm. CO_2 pollution is mostly generated by human beings since they are working on indoor spaces regularly for more than eight hours a day. Since occupants are the main sources of CO_2 pollution, so it is recommended that exhaust vents with right exhaust airflow rate should collect carbon dioxide directly from occupants and drive out CO_2 gas with other unknown pollutants of the indoor environment. It is not enough to install air handling unit without knowing its pollutant-removing performance.

It is vitally important that CO_2 monitoring should be performed before and after installing HVAC system or air distribution system or any other mechanical ventilation system with equivalent performance in order to find out the quantity of indoor carbon dioxide and remove it consistently in regularly occupied spaces during working hours through the high exhaust airflow rate of mechanical ventilation system.

4. CONCLUSION

All the collected results pointed to the conclusion that CO_2 assessment should be done in all indoor spaces with handheld CO_2 meters for monitoring the performance of HVAC system in indoor spaces during office hours once a week because maintaining IAQ is a continuous job. In this way, fresh air can be supplied without air-borne pollutants in indoor spaces.

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