



How Indoor Air Quality Affect Employees Health and Performance in Different Level Companies.

كيف تؤثر جودة هواء في بيئة العمل الداخلية على صحة الموظفين وأدائهم في شركات مختلفة المستوى

by

**KHALOUD MOHAMMED SULIMAN HAMDAN
ALMEZEININ**

**Dissertation submitted in partial fulfilment
of the requirements for the degree of
MSc SUSTAINABLE DESIGN OF THE BUILT
ENVIRONMENT**

at

The British University in Dubai

June 2023

DECLARATION

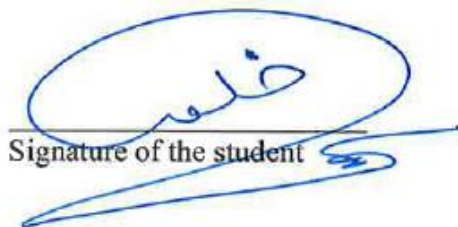
I guarantee that the research's content is entirely original to me and that any use of previously published or unpublished copyright material in it complies with legal restrictions set forth by international copyright conventions.

I am aware that a copy of my study will be given to the university library for long-term storage.

I hereby agree that The British University in Dubai may copy and distribute the contents of this dissertation, for which I am the author and owner of the copyrights, for the purposes of research, private study, or education, and that The British University in Dubai may, as appropriate, recoup from purchasers the costs associated with such copying and distribution.

I am aware that a digital version might be made available in the institutional repository by The British University in Dubai.

I am aware that I may apply to the University to keep the right to withhold or restrict access to my thesis for a period that ordinarily does not exceed four calendar years from the congregation at which the degree is conferred. The application must specify the length of the period as well as the precise justifications for doing so.



Signature of the student

COPYRIGHT AND INFORMATION TO USERS

The British University in Dubai has been granted permission by the author, whose copyright is stated on the title page of the work, to create partial or single copies of the work for educational and research purposes, to make it available as an open source, and to lend it to library users.

The author has also given the university permission to create or retain a digital copy of the work for similar uses and for the purpose of digital preservation.

The author, the Registrar, or the Dean alone may consent to multiple copies of this work being made for research reasons.

Copying for commercial purposes is only permitted with the author's express consent.

Any use of this work, whether in full or in part, must respect the author's moral rights to credit and reflect the authorship and meaning of the work honestly and without detracting from it.

ABSTRACT

Employee performance and health are significantly impacted by the work environment. Indoor air quality (IAQ) has a significant impact on employees' health and productivity in the office setting. Due to the lack of studies done to evaluate IAQ influence inside low and high-cost companies in UAE, this study was motivated to fill this gap and to evaluate the effects of IAQ within two different levels of working environments. Poor Indoor Air Quality is a relevant area of concern which has a direct impact on an employee's performance (Azuma et al., 2017). The purpose of this study was to examine the relationship between IAQ exposure and associated risks on employee health and performance in two different companies' levels. Two different levels of companies were chosen as a case study where the best methodology applied. Data were collected using quantitative method (Field measurement) where we utilized three devices in order to reach the problem causes and to know more about our research question like (4 in 1 Environmental Meter, Air quality CO2 meter, and a sound level alert), a survey questionnaire utilized to know employee's satisfaction and reaction with surrounding working environment, and finally a employees interview were conduct to elaborate more on their perspective regarding indoor air quality. The survey questionnaire which was distributed to all employees who were working in those companies revealed multiple evidence and facts. The questioning where mainly focusing on employee's perspective to multiple aspects like: the amount of time that employees spend in their workplace, glare presence, windows availability, presence of printers/photocopiers, and scanners, wet ceilings, ventilation system, type of furniture, thermal comfort, as well as flooring materials. Respondents from low cost company showed that there was evidence of inadequate indoor quality from different aspects, while high-cost company showed that there was sufficient indoor quality from many manners perspective. Field

measurements shed light on specific areas like: the levels of carbon dioxide (CO₂) in the workplace, humidity levels, air velocity, temperature, and noise source. These measurements discovered the presence of multi factors in low cost companies associated in causing poor indoor quality. Moving forward the results revealed that there are many different problems derived from working environments. This paper correspondingly presents some new ideas and scopes that will help engineering companies to recognize the impact of poor IAQ on their employees and analyze the reasons that lead to weak IAQ in their companies as well as to know this issue could be addressed in order to maintain positive atmosphere that enhance employee's performance and health.

ملخص البحث

يمكن أن يكون لضعف جودة الهواء الداخلي تأثير سلبي على أداء الموظف ، حيث يمكن أن يؤدي إلى مجموعة من المشاكل الصحية مثل مشاكل الجهاز التنفسي والحساسية والصداع. يمكن أن تؤدي هذه المشكلات إلى جعل الموظفين أقل إنتاجية وغائبًا بشكل متكرر. من ناحية أخرى ، يمكن أن تسهم جودة الهواء الداخلي الجيد في تحسين أداء الموظفين من خلال تعزيز الصحة والراحة الجيدة ، مما قد يؤدي إلى زيادة الإنتاجية والرضا العام في منطقة مكان العمل.

في ظل هذه الخلفية ، كان الدافع لهذه الدراسة لدراسة تأثيرات جودة الهواء الداخلي على موظفي المكاتب الهندسية في فئتين من الشركات: الشركات منخفضة التكلفة وعالية التكلفة. تعتمد الدراسة نهج الواقعية النقدية. يتضمن النهج القياسات الميدانية واستبيان جمع البيانات لأداء جودة الهواء الداخلي والموظف. تم إجراء قياسات ميدانية في البداية لاستكشاف الوضع الفعلي لبيئة العمل ومستوى جودة الهواء الداخلي في تلك الشركات الهندسية مثل الحرارة والرطوبة ونظام التهوية والتلوث. بعد ذلك ، تم إجراء استبيان استقصائي لقياس انعكاس بيئة العمل هذه على صحة الموظفين ورضاهم وأدائهم. كشفت النتائج عن وجود مشاكل عديدة و مختلفة في كلا بيئات العمل

ستساعد الدراسة الحالية الشركات الهندسية على فهم تأثير ضعف جودة الهواء الداخلي على موظفيها وتحليل الأسباب التي تؤدي إلى ضعف IAQ في شركاتهم لمعرفة كيف يمكنهم معالجة المشكلات والحفاظ على أداء جيد للموظفين و المحافظة على صحتهم.

DEDICATION

I dedicate my dissertation to my loving and supporting parents.

They encouraged me to learn and made sacrifices so that I could have access to high quality education from a young age.

ACKNOWLEDGEMENTS

I want to start by thanking the Almighty God for making it possible for me to complete this dissertation. I want to start by sincerely thanking my supervisor, Dr. Wael Sheta, for his ongoing encouragement of my dissertation study and research, as well as for his patience, inspiration, excitement, and vast knowledge. Along with my supervisor, I would like to thank the other members of the BUID committee, particularly Prof. Hanan Taleb and Prof. Bassam Abu Hijleh, for their support and for making this master's study journey more professional and appealing. My patient parent, who was my supporter by giving me the strength and time to tackle this work effectively, deserves special gratitude for their belief in me.

Last but not least, I want to express my gratitude to the entire staff of the British University in Dubai, as well as to my friends and fellow students. You have all been instrumental in helping me keep my attention on this incredibly valuable and enriching process.

TABLE OF CONTENTS

Chapter 1 : Introduction	1
1.1 Background.....	1
1.2 Problem statement	3
1.3 Motivation of the work	4
1.4 Research aims and objectives	7
1.5 Research questions	7
1.6 Research outlines.....	8
1.7 Importance	9
1.8 Methodology.....	11
1.9 Scope of research.....	12
Chapter 2 : Literature review	13
2.1 Introduction	13
2.2 Indoor air quality	14
2.2.1 Overview	14
2.2.2 Concept of indoor air quality.....	17
2.3 Indoor air pollution effects	17
2.3.1 Building characteristic that affect human health and productivity.....	17

2.3.2 Effect of indoor air pollution on human health	18
2.3.3 Indoor air pollution in work environment	20
2.3.4 Importance of ventilation system	22
2.4 Employee performance	23
2.4.1 Overview of employee performance	23
2.4.2 How can healthy work environment effect employee performance.....	26
2.4.3 Performance measures and indicators	26
2.4.4 Influence of work environment on employee performance.....	28
2.4.5 Impact of workplaces design on employee's performance	29
2.4.6 Impact of workplaces ventilation system on performance	30
2.4.7 Effects of indoor air quality on performance level of employees	33
2.4.8 Effects of indoor air pollution in an office environment on performance level of employees.....	34
2.5 Importance of IAQ in workplace.....	37
2.5.1 Effect of indoor air quality on employee satisfaction.....	37
2.6 Importance of IAQ on health and employee's performance	40
2.6.1 Healthy work environment and employees' performance on engineering consultant offices in UAE	40
2.6.2 Air pollution and health on engineering consultant workplace in UAE.....	43

2.6.3 Economy impact of poor IAQ in UAE	46
2.6.4 Building characteristic	49
2.6.5 Buildings type	49
2.6.6 Well certified and noncertified building.....	50
2.7 Classifications of engineering workplace in the UAE.....	51
2.7.1 Company's selection principles:.....	51
Chapter 3 : Methodology	55
3.1 Overview	55
3.2 Literature review of methodology	55
3.3 Simulation methodology.....	56
3.4 Experimental methodology.....	56
3.5 Survey methodology.....	57
3.6 Research methodologies pros and cons	58
3.7 Design research philosophy	63
3.8 The population	67
3.9 Sampling technique	67
3.10 Data collection method	68
3.10.1 Quantitative method (field measurement)	69

3.10.2 Questionnaire.....	70
3.11 Investigation	74
3.11.1 4 in 1 Environmental meter device.....	74
3.11.2 Air quality CO2 meter device.....	74
3.11.3 Sound level alert device.....	75
3.12 Data analysis.....	75
3.12.1 In this stage, the researchers must exercise critical thought to assess the reliability of the data they have gathered and examined. The statistical analysis will generate tables and figures to turn the data into statistical value. The statistical information can then be used to provide clarifications.	76
3.12.2 Frequency distributions and descriptive statistics	76
3.12.3 Reliability and validity	78
3.13 Chapter summary.....	79
Chapter 4 : Case studies and measurements.....	80
4.1 Background.....	80
4.2 Case studies	80
4.2.1 Case study # 1.....	82
4.2.2 Case study # 2.....	83
4.2.3 Case study # 3.....	85

4.2.4 Case study # 4.....	86
4.2.5 Case study # 5.....	87
4.2.6 Case study # 6.....	89
4.3 Field measurements	90
4.3.1 4 in 1 environmental meter.....	91
4.3.2 Air quality CO2 meter	92
4.3.3 Sound level alert	93
4.4 Office environment air velocity.....	93
4.5 Standard office temperature.....	98
4.6 How can humidity levels affect employees?	98
4.7 How can lightning levels affect employees' health and productivity?	100
4.8 How can office sound level and sources of noise affect employees?.....	102
4.9 How can office CO2 level affect employees?	104
4.10 Air velocity readings	108
4.10.1 Low-cost company 01	108
4.10.2 Low-cost company 02	109
4.10.3 Low-cost company 03	110
4.10.4 High-cost company 01.....	111

4.10.5 High-cost company 02.....	112
4.10.6 High-cost company 03.....	113
4.11 Temperature and Relative Humidity readings.....	114
4.11.1 Low-cost company 01	114
4.11.2 Low-cost company 02	115
4.11.3 Low-cost company 03	116
4.11.4 High-cost company 01.....	117
4.11.5 High-cost company 02.....	118
4.11.6 High-cost company 03.....	119
4.12 Lighting level readings	120
4.12.1 Low-cost company 01	120
4.12.2 Low-cost company 02	121
4.12.3 Low-cost company 03	122
4.12.4 High-cost company 01.....	123
4.12.5 High-cost company 02.....	124
4.12.6 High-cost company 03.....	125
4.13 Sound level alert meter readings	126
4.13.1 Low-cost company 01	126
4.13.2 Low-cost company 02	127

4.13.3 Low-cost company 03	128
4.13.4 High-cost company 01	129
4.13.5 High-cost company 02	130
4.13.6 High-cost company 03	131
4.14 Indoor environment CO2 meter readings	132
4.14.1 Low-cost company 01	132
4.14.2 Low-cost company 02	133
4.14.3 Low-cost company 03	134
4.14.4 High-cost company 01	135
4.14.5 High-cost company 02	136
4.14.6 High-cost company 03	137
Chapter 5 : Result and discussions	138
5.1 Background	138
5.2 Objectives and clear explanation of findings.	138
5.3 Finding and results	139
5.3.1 How I analyzed survey	139
5.3.2 Summary results of survey findings in low-cost companies	139
5.3.3 Summary results of survey findings in high-cost companies	153
5.3.4 Survey analysis and descriptive	166

5.4 Filed measurement 4 in 1 environmental meters.....	177
5.4.1 Filed measurement 4 in 1 environmental meter in low-cost company.....	177
5.4.2 Filed measurement 4 in 1 environmental meter in high-cost company.....	179
5.4.3 Sound level alert meter in low and high-cost companies.	181
5.4.4 Indoor environment CO2 meter in low and high-cost companies.....	182
5.5 Explanations of results.....	184
5.5.1 Air velocity	184
5.5.2 Temperature and humidity.....	185
5.5.3 Lights	186
5.5.4 Sound levels alert meters.....	188
5.5.5 CO2.....	189
5.6 General Comparison between low and high-cost company in term of 4 in 1 and the CO2 and sound level	190
5.6.1 Create a comfortable office environment in terms of CO2, air velocity, humidity, temperature, and sound level for employees in order to increase their health and productivity	192
5.6.2 Paying attention to the office's indoor environment quality?	194
5.7 Comparison between 4 in 1 environmental meter and other devices	195
5.7.1 4 in 1 and the CO2 environmental meter device	195

5.7.2 4 in 1 environmental meter device and the sound level alert meter device.....	196
5.8 Comparison CO2 environmental meter device to the other devices	197
5.8.1 CO2 indoor environments meter device and sound levels device.....	197
5.8.2 CO2 indoor environment meter device and 4 in 1 environments meter device.....	198
5.9 Why is the sound level too high in offices, and how to solve this problem?	201
5.10 How to solve the CO2 problems?.....	204
5.11 How to reduce the humidity levels?	206
5.12 How to increase the air velocity in spaces?	209
5.13 How does the moderate lightning level that affect employees?	210
5.14 How does filed measurements readings support surveys	213
5.15 Why to do interviews.....	223
5.16 Misplaced device in filed measurements.....	223
5.17 Final remarks	225
Chapter 6 : Conclusions.....	227
6.1 Conclusions and recommendations	227
6.2 Recommendations and further research	227
6.3 Limitations or constraints in my research.....	228

6.3.1 Access	228
6.3.2 Samples size:	229
6.3.3 Lack of prior study on the topic.....	229
6.3.4 Bias	229
6.4 Ethical consideration	229
References	231
Survey	249

LIST OF TABLES

Table 1: Research Questions, Objectives, and Methods. (Author)	11
Table 2: Principles of selected companies. (Khaloud, 2023)	53
Table 3: pros and cons of different methodologies. (Khaloud, 2023).....	58
Table 4: summary of companies' areas, locations, types, and number of employees.....	80
Table 5: Filed measurement 4 in 1 environmental meter in low-cost company result.....	179
Table 6: Filed measurement 4 in 1 environmental meter in high-cost company result.	180
Table 7: Sound level alert meter in low and high-cost companies.....	181
Table 8: Result of indoor environment CO2 meter in low and high-cost companies.	183
Table 9: Comparison between survey answers and field measurements.	214
Table 10: Between survey answers and field measurements.	215
Table 11: Between survey answers and field measurements.	216
Table 12: Between survey answers and field measurements.	217
Table 13: Between survey answers and field measurements.	218
Table 14: Between survey answers and field measurements.	219
Table 15: Between survey answers and field measurements.	220
Table 16: Between survey answers and field measurements.	221
Table 17: Between survey answers and field measurements.	222
Table 18: Between survey answers from different level companies.....	223

LIST OF FIGURES

Figure 1: IAQ contaminate. (<i>Indoor air quality estimator,2006</i>)	16
Figure 2: Pictorial representation of the research onion.....	61
Figure 3: Critical realism philosophy of IAQ research. (<i>source: Khaloud, 2023</i>).....	64
Figure 4: Low-cost company analyses.	82
Figure 5: Low-cost company analyses with real photos.	83
Figure 6: Low-cost company analyses.	84
Figure 7: Low-cost company analyses with real photos.	84
Figure 8: Low-cost company plan analyses.	85
Figure 9: Low-cost company analyses with real photos.	86
Figure 10: High-cost company plan analyses.....	87
Figure 11: High-cost company plan analyses with real photos.....	87
Figure 12: High-cost company plan analyses.....	88
Figure 13: High-cost company plan analyses with real photos.....	88
Figure 14: High-cost company plan analyses.....	89
Figure 15: high-cost company plan analyses with real photos.....	89
Figure 16: 4 in 1 Environmental Meter.	91
Figure 17: Air quality CO2 meter.	92
Figure 18: Sound Level Alert.	92

Figure 19: Results of air velocity in low-cost company 01.....	108
Figure 20: Results of air velocity in low-cost company 02.....	109
Figure 21: Results of air velocity in low-cost company 03.....	110
Figure 22: Results of air velocity in high-cost company 01.....	111
Figure 23: Results of air velocity in high-cost company 02.....	112
Figure 24: Results of air velocity in high-cost company 03.....	113
Figure 25: Results of temperature and relative humidity in low-cost company 01.....	114
Figure 26: Results of temperature and relative humidity in low-cost company 02.....	115
Figure 27: Results of temperature and relative humidity in low-cost company 03.....	116
Figure 28: High-cost company 01 results of Temperature and relative humidity.....	117
Figure 29: High-cost company 02 results of Temperature and relative humidity.....	118
Figure 30: High-cost company 03 results of Temperature and relative humidity.....	119
Figure 31: Results of lights in low-cost company 01.	120
Figure 32: Results of lights in low-cost company 02.	121
Figure 33: Results of lights in low-cost company 03.	122
Figure 34: High-cost company 01 results of lights.	123
Figure 35: High-cost company 02 results of lights.	124
Figure 36: High-cost company 03 results of lights.	125
Figure 37: Results of sound level alert meter in low-cost company 0	126

Figure 38: Results of sound level alert meter in low-cost company 02.	127
Figure 39: Results of sound level alert meter in low-cost company 03.	128
Figure 40: Results of sound level alert meter in high-cost company 01	129
Figure 41: Results of sound level alert meter in high-cost company 02.	130
Figure 42: Results of sound level alert meter in high-cost company 03.	131
Figure 43: Low-cost company 01 indoor environment CO2 meter results.	132
Figure 44: Low-cost company 02 indoor environment CO2 meter results.	133
Figure 45: Low-cost company 03 indoor environment CO2 meter results.	134
Figure 46: High-cost company 01 indoor environment CO2 meter results.	135
Figure 47: High-cost company 02 indoor environment CO2 meter results.	136
Figure 48: High-cost company 03 indoor environment CO2 meter results.	137
Figure 50: Present employees' age.	140
Figure 49: Present gender type.	140
Figure 51: Specifying the period of working in this company.	141
Figure 52: Present employee's time spending in the office.	141
Figure 53: Present the percentage of the amount of glare.	142
Figure 54: Present the number of windows.	142
Figure 55: specifying the place of equipment.	143
Figure 57: Present the damaged floor because of leaked water.	143

Figure 56: Present the percentage of wet ceilings because of leaked water.....	143
Figure 59: Present the amount of floor cleaning	144
Figure 58: Present the availability of houseplant in the office.	144
Figure 60: Specifying period of keeping windows open.....	144
Figure 61: Describing indoor air quality.	145
Figure 62: Specifying glare from light reflection.....	145
Figure 63: Present an acoustic and noisy in the office.	146
Figure 64: Present the relationship between tired and IEQ.....	147
Figure 65: Present how IAQ can impact employees and have health symptoms.....	147
Figure 66: Specifying the employees comfortable with the furniture.....	148
Figure 67: Present the employees satisfaction with the interior environment.....	148
Figure 68: Present the satisfaction of employees' overhead electrical light.	149
Figure 69: Present the satisfaction of employees about the thermal comfort.....	150
Figure 70: Present the ability to control or block daylight.	150
Figure 71: Present the employee's number in 3 meters.	151
Figure 72: Specifying the flooring materials.....	151
Figure 73: Specifying wall surface materials.	151
Figure 74: Present employee's health problems.....	152
Figure 75: Present the building certified or not.....	153

Figure 76. Present gender type.	153
Figure 77. Present employees' age.	153
Figure 78. specifying the period of working in this company.	154
Figure 79. Present employees' time spent in the office.	154
Figure 80: Present the amount of glare in the office.	155
Figure 81: Specifying the number of windows in the office.	155
Figure 82: Specifying the place of equipment.	156
Figure 84: Present the percentage of damage floors due to leaky water.	156
Figure 83: present the percentage of wet ceilings due to leaky water.	156
Figure 86: Present the amount of floor cleaning.	157
Figure 85: Present if the office contains a houseplant.	157
Figure 87: Present the period of keeping windows open.	157
Figure 88: Describing the IAQ.	158
Figure 89: Describing the glare from light reflection.	158
Figure 90: Specifying the acoustic in the office.	159
Figure 91: Present relationship between IAQ and employees tired.	160
Figure 92: present how IAQ can impact employees and have health symptoms.	160
Figure 93: Specifying the employees comfortable with the furniture.	161
Figure 94: Employees' satisfaction with the interior environment.	161

Figure 95: Employees' satisfaction with overhead electrical light.	162
Figure 96: Employees' satisfaction with thermal comfort.	163
Figure 97: Employees' ability to control or block daylight.	163
Figure 98: Present number of employees in 3 meters.	164
Figure 99: Specifying floor materials in the office.	164
Figure 100: Specifying surface materials in the office.	165
Figure 101: Present employee's health problems.	165
Figure 102: Present the building certified or not.	166
Figure 103: standards of temperature and air velocity.	184
Figure 104: Relationship between temperature and air velocity in high-cost company	184
Figure 105: Relationship between humidity and temperature in low-cost company	185
Figure 106: Relationship between temperature and humidity in high-cost company.	186
Figure 107: deeply comparison between high and low-cost companies in term of lights in each space.	187
Figure 108: General comparison between high and low-cost companies in term of lights.	187
Figure 109: Deeply sound level comparison between low and high-cost companies	188
Figure 110: Sound level comparison between low and high-cost engineering consultant companies.	189
Figure 111: High and Low-quality company indoor environment CO2 meter results.	190

Figure 112: Misplaced sound alert meter device in filed measurement.	225
---	-----

Chapter 1 : Introduction

1.1 Background

Health is the condition of social, physical, and mental well-being, and a healthy workplace, should be developed considering all relevant factors. Studies display that employee motivation is very important for the growth and success of an organization and multiple factors play an important role in motivating employees (Carrer & Wolkoff 2018). Out of different factors, the healthy work environment is an integral factor that is in the limelight nowadays by respective authorities and global organizations in this connection. World Health Organization and Regulatory bodies, working for different industries have issued different guidelines and instructions for managing a healthy work environment. For example, office employees should be provided with a working environment enriched with good IAQ (Azuma et al. 2017).

Indoor Air Quality (IAQ) is very essential for public health and excellent performance as well. Key regulation has to be considered by authorities that all companies are responsible for providing suitable office environments, considering all levels of safety for instance IAQ levels, design of office, ventilation system, and HAVC facilities (Cheng et al. 2022a). An unhealthy work environment is one of the major reasons resulting in negative and inconvenient consequences on employee revenue and health issues for workers. Employees are exposed to a wide range of loads like biological, physical, ergonomics, and social causing varied effects on health, comfort, and performance (Lob dell, 2022).

Many health issues are connected to the exposure to indoor air pollution. Indoor Air Pollution has been characterized as one of the top five environmental health hazards of the atmosphere. In the USA, American spends 90 percent of their time indoors, where air quality is 2 to 5 times worse as compared with the outdoors (Chang et al. 2019a). There are diverse

sources of indoor air pollution worldwide and most of these pollutants are about building materials and human activities for instance cleaning agents, carpets, office furniture, air fresheners, adhesives, as well as biological containments from poor ventilation systems (Roh et al. 2021). Using of multi-chemical pollutants, inadequate ventilation systems, and biological contaminants like mold and bacteria all contribute to low indoor air quality. Poor indoor air quality has a major impact on human health, including respiratory problems, allergies, and other cardiovascular illnesses. Improving indoor air quality can be achieved via a range number of steps such as utilizing air filtration, proper ventilation system, and minimize using of pesticides, and other household cleaners (Zukri & Nazir 2018).

The UAE National Vision lists air quality as one of its top priorities. To do this, the Ministry of Climate Change and Environment employs a number of tactics, including the use of state-of-the-art tools and methods and the implementation of best practices. These consist of establishing and enhancing national standards for air pollution and compliance management, transitioning to a green economy and escalating the use of clean energy, and depending increasingly on renewable energy sources.(United Arab Emirates National Committee on Sustainable Development Goals 2017).

Inadequate studies were conducted to evaluate IAQ influence inside low- and high-cost companies in the UAE. This study was motivated to fill this gap and evaluate the effects of IAQ within these two different levels of work environments and their impacts on employees' health and performance. Therefore, our problem statement sheds light on the impacts of IAQ on employees' health and their performance at different company levels. This research is conducted to determine indoor air quality standards in the workplace and to evaluate the impacts of having low indoor air quality standards. The strategy of this study is outlined to fit the research questions and research aim. A comprehensive literature review

could help in extracting relevant and meaningful information from different journal articles and published information.

The study methodology used a quantitative manner (field measurement) where I utilized three devices in order to reach the problem causes and to know more about our research question, like (4 in 1 environmental meter, an air quality CO₂ meter, and a sound level alert; a survey questionnaire was utilized to know employees satisfaction and reactions with the surrounding working environment; and finally, an employee interview was conducted to elaborate more on their perspective regarding indoor air quality

The results received from a survey, field measurements, and interview were compared to get a better analysis of the information received. The methodology helped in assessing indoor air quality in workplaces, issues, effects of air pollution, and impacts on the health and performance of employees.

1.2 Problem statement

Poor indoor air quality refers to the presence of pollutants and contaminants in the air inside a building or enclosed space that can negatively impact the health and wellbeing of the occupants. Common sources of indoor air pollutants include mold, dust, tobacco smoke, chemical fumes, and allergens. Poor ventilation can also contribute to poor indoor air quality by allowing pollutants to accumulate (Alinaitwe, Mwakali & Hansson 2007). Breathing in polluted indoor air can cause a range of health problems, including allergies, respiratory infections, headaches, dizziness, and fatigue. Prolonged exposure to indoor air pollutants can also increase the risk of more serious health conditions such as asthma, lung cancer, and heart disease (Chang et al. 2019b). The issue of poor indoor air quality is of particular concern in buildings where occupants spend a significant amount of time, such as homes, schools, and offices. It is important for building owners and occupants to take steps

to improve indoor air quality by reducing or eliminating sources of indoor air pollutants, ensuring proper ventilation, and regularly maintaining heating, ventilation, and air conditioning (HVAC) systems (Chang et al. 2019c).

Poor indoor air quality can result in health issues for employees that ultimately impact their performance and their personal lives, and this is the main focus of our research. However, in addition to the poor performance of employees, there are many other related issues faced by companies. For example, the negative brand image of such companies and regulatory punishments (Alinaitwe, Mwakali & Hansson 2007). Therefore, it is imperative to say that this research is based on an important problem that should be investigated with strong reasoning and findings. The problem statement of this study might be expressed as follows:

What is the impact of indoor air quality on employees' health and performance working for two different levels of companies?

1.3 Motivation of the work

UAE citizens place a high priority on indoor air quality. When deciding where to live, work, or send their children to school. 75% of residents believe indoor air quality to be very important for their daily health, and 90% believe it to be vital. There are several advantages to making sure that the air we breathe is as pure as it can be. Including advantages for office workers and inhabitants of residences (Abdulrahman 2022).

It costs money to produce better indoor air, but the investment is worthwhile. Conventional air conditioners are susceptible to mold buildup in their ductwork, which over time allows germs to develop and spread before circulating through homes, workplaces, and educational facilities. For building designers and owners, upgrading the ducting used in UAE

buildings and ensuring that any projects under development employ the most modern ductwork must be top priorities (Abdulrahman 2022).

Parallel to this important step, directives must be established to include all parties and ensure the success of such suggestions. This agenda should start with the desired level of achievement and include the best strategies and scenarios. It should also include an investigation of any current and potential future obstacles, such as financial, political, social, and resource limitations.

Numerous studies have been carried out all over the world to demonstrate the effectiveness of indoor air on workers' health and productivity, with varying resources and limitations related to the size of the companies, location, accessibility of materials and resources, government subsidies, and investments. Uncomfortable indoor environments can lead to increased stress levels, which can negatively impact employee well-being and performance. Leaders mostly focus on different areas or strategies that could help employees work better and exploit their potential. But the provision of a clean, neat, and relaxed working environment is also a very important factor that should not be ignored. There have been many studies conducted previously on this topic; for example, as per the American Lung Association, U.S. adults miss almost 14.5 million workdays because of asthma. Further, the U.S. Centers for Disease Control and Prevention estimate that sinus infection sufferers are absent every year for an average of four working days. There are many other research studies that show an average productivity loss because of poor indoor air quality ranging from 3% to 7% or higher, along with employee productivity losses of 33%. The World Health Organization also estimated that almost 64 million US office employees and teachers are at risk of suffering from sick building syndrome. The total cost to the U.S. economy due to poor indoor air quality is as high as \$168 billion on an annual basis (Lobdell, 2022).

The basis for job motivation will be the glaring dearth of data and samples provided when research is undertaken on the impact of indoor air quality on office workers' health in the UAE. Therefore, this paper will deeply explore this topic in the UAE and dig deep to discover to what extent IAQ does impact the employee's performance. For this research, a large number of publications and research articles have been reviewed in order to get sufficient information pertaining to indoor air quality in an office environment and its effect on employees' health. From the information obtained through the literature review, we may get meaningful information about the impacts of indoor air quality, leading to an increase in pollutants impacting indoor office environments. However, some researchers used only limited research sources, like secondary research, sources only, or observations. The information presented by the literature is meaningful, but this needs to be investigated in detail, considering both primary and secondary information. Therefore, we have used different tools to get information, for example, a literature review and a survey, from a significant number of employees working in different companies. The comprehensiveness of the information and research elements has helped us conduct this research successfully and in an effective manner. Therefore, the rationales behind this research are quite strong, justified, and supportive.

The paper will explore several methodologies, analyzing the potentials and limitations of each, to figure out the best options that can be utilized in different levels of companies to increase the employees' energy and efficiency. The study will focus on buildings or businesses with two levels that were built in the UAE, along with the operational systems that were used as analysis inputs for the chosen research methodology. The same will be taken into account as the base case. With the calculated findings, the direction of improvement will be evident, and several scenarios, including minor and significant changes under a controlled cost plan and particular local and worldwide sustainable norms, will be

applied. The final results, which will include the best case studies, will result in appropriate recommendations that can be used to advance the nation's goal of having a safe and healthy workplace by the middle of this century in addition to helping to launch the guidelines that are being issued by the appropriate authority.

1.4 Research aims and objectives

The paper's major and main goals are to evaluate indoor air quality (IAQ) in office environments in Abu Dhabi, United Arab Emirates, and the effects of IAQ on workers' health and productivity at two distinct tiers of businesses. All of that will be done within certain parameters and guidelines, including the level of the company's resources and materials, as well as local environmental and social factors. As a result, the research will follow the following guidelines and goals:

RO1: To determine the types of contaminants found inside the office environment in Abu Dhabi.

RO2: To assess the perception and levels of satisfaction of employees working in low- and high-cost companies on their office ventilation systems and IAQ in Abu Dhabi.

RO3: To investigate health issues and the performance of the employees under the IAQ circumstances.

1.5 Research questions

The focus of the study topic is on the significance of indoor air quality in office settings and how it affects workers' health and productivity. It is evident that the performance of employees is based on multiple factors that are required to be considered by employers and their leaders. Most high-quality companies are concerned with the adoption of better tools and processes that are helpful for the health of their employees, resulting in

good performance, but in many cases, we can see that small offices or low-cost companies don't consider all such factors. Therefore, the research question of this research is based on the research objectives, as we have defined above. The research question for this research is mentioned below:

“What is the impact of the IAQ on employee health and performance in different companies?”

This research poses three questions which will be answered based on the work of this study:

RQ1: What are the types of contaminants found inside the office environment in Abu Dhabi?

RQ2: What are the levels of satisfaction of employees regarding the ventilation system and IAQ in low-cost and high-cost companies in Abu Dhabi?

RQ3: To what extent IAQ do impact the employee's performance?

1.6 Research outlines

The dissertation is divided into five main chapters, and below is a general summary of what each chapter includes. Chapter one includes an overview of the research, the research objectives, the importance of the research, research work motivation, and the research outline. The second chapter will include a comprehensive literature review comprised of multiple themes relevant to the key subject area for research. Moving to the third chapter, which includes the methodology used for this research, we will define the research design, research process, and research methodology used for conducting this research. Chapter 4 will present the case studies and readings that I will take in each company. Chapter 5 will contain the findings, results, and analysis of the information obtained by using research

sources. This will be a detailed and lengthy chapter because it will contain the results of the survey conducted, an analysis of the information obtained from the survey, synchronization of the information obtained through a survey and literature, etc. The last chapter, Chapter 6, is about the conclusion of the study along with relevant recommendations to be followed in the coming years by respective stakeholders. In this chapter, the future scope of the study is also added, and the limitations of the present study are also briefly discussed. Every chapter is based on different sub-sections that are used for presenting information in a well-maintained and justified manner. The chapters are categorized based on a standard format used for the research study, and it is taken care that the research is comprehensive and contains meaningful information based on logic and proper evidence.

1.7 Importance

Since people spend most of their time inside, indoor air quality is essential for maintaining public health. Because office workers perform important tasks, indoor air quality in settings that resemble offices is a growing problem. According to Al-Omari and Okasheh (2017), office workers, who make up the majority of the labor force in many nations, are occupationally exposed to physical, biological, chemical, ergonomic, and psychological/social loads that can have a variety of effects on comfort, sick leave, work-related health issues, and deterioration of work performance.

By understanding about the factors that influence employee retention and how to increase it, businesses may avoid the unfavorable effects of excessive attrition. The management of human resources as well as maintaining and fulfilling those resources are currently the main difficulties facing organizations. Every corporation must work to retain and secure a competent workforce because, in the current business climate, having an edge on the competition means having people with the right skills and knowledge. The idea of "well-

being" unifies and promotes a number of factors that affect workers' health and quality of life (Kersemaekers et al. 2018).

Accordingly, this research is very important and helpful for engineering companies that are not maintaining healthy working environments in their workplace to revise their present working environment in order to increase employee happiness, achieve professional success, boost job satisfaction, and motivate them to work more.

Different strategies can be followed for creating a healthy indoor environment, including reducing sources of pollution, installing good ventilation systems, and diluting indoor airborne pollutants (Palacios et al., 2021). The research is very significant as it has highlighted an important area that has been researched in a limited manner but has serious consequences for the health of employees.

Therefore, the gaps in the research have motivated us to work on this area and conduct detailed research that can generate evidence and proofs about the effects of healthy indoor air work environments on the performance of employees and organizations. This research is valuable for multiple stakeholders, as well as the governments, as they can benefit from the findings of this research and make amendments to their laws and regulations to be complied with by every organization working in a private or government capacity.

The health of the employees should be one of the top priorities of the leaders of companies. So that their workers can experience a good working environment based on all the required facilities. The better health of employees will have a positive impact on their mood, motivation level, behaviors, loyalty to the organization, and decision to stay with their company for a longer period of times (Baradel, Murphy & Schmid 2019).

1.8 Methodology

The research's approach is based on mixed methods. We will be using primary and secondary research sources. For the primary research, a survey questionnaire is developed, including different questions relevant to our topic of study. This questionnaire will be distributed among employees working at two different levels in Abu Dhabi companies. These companies will be selected to assess their standards and processes for maintaining indoor air quality in their offices. Different employees will be shared with the survey questionnaire, who will fill it out and share the required information. For the secondary research, an extensive literature review is used based on different sub-themes and sub-sections relevant to our area of research. Reliable and published journal articles are used for this purpose so that meaningful and reliable information or views shared by other researchers can be obtained.

Table 1: Research Questions, Objectives, and Methods. (Author)

RQ	RO	Method
RQ1: What are the types of contaminants found inside the office environment in Abu Dhabi?	RO1: To determine the types of contaminants found inside the office environment in Abu Dhabi.	Field measurements.
RQ2: What are the levels of satisfaction of employees regarding the ventilation system and IAQ in low-cost and high-cost companies in Abu Dhabi?	RO2: To assess the perception and levels of satisfaction of employee, working in low-cost and high-cost companies on their office	Survey Questionnaire.

	ventilation system and IAQ in Abu Dhabi.	
RQ3: To what extent IAQ do impact the employee's performance?	RO3: To investigate health issues and performance of the employees under the IAQ circumstance.	Interview

1.9 Scope of research

While the negative health problems related to exposure to poor indoor air quality have been well documented, the impact of indoor air quality on employees' health and performance at different levels of companies is poorly understood. In view of this situation, the aim of this study is to report and investigate the aspects that lead to poor indoor air quality and cause adverse effects. The scope of the study is limited to two levels of engineering consulting companies.

The scope of the study is restricted to the employees who are working for those chosen companies. The empirical study in this research is restricted to six companies located in Abu Dhabi, where the opinions of employees were studied in interview sessions or questions. Further, the study also involves an analysis of employees' perspectives on the role of indoor air quality. Therefore, the scope of this study is limited specifically to those employees working in these selected companies. The factors that define indoor air quality (IAQ) are temperature, humidity, ventilation, and contaminants. One of these contaminants is CO₂, which is often used to express air quality.

Chapter 2 : Literature Review

2.1 Introduction

A literature review is created by looking at the earlier studies, where the researchers consider approaches to enhance indoor air quality and its impact on workers' health and productivity. Indoor air quality (IAQ) is the term used to describe the air quality within and outside of buildings and other structures, particularly with regard to the health and comfort of building inhabitants. IAQ can be affected by various factors, such as emissions from indoor sources such as tobacco smoke, building materials, furnishings, and cleaning agents, as well as outdoor sources such as radon, pesticides, and outdoor air pollution (Awad & Jung 2021).

Studies have shown that poor IAQ can have negative impacts on health, including an increased risk of respiratory problems, headaches, and eye, nose, and throat irritation. In severe cases, exposure to indoor air pollutants can lead to more serious health effects such as cancer and neurological damage, increased risk of infections and viruses, and heart disease (Wierzbicka et al. 2022).

To improve IAQ, several strategies can be employed, including proper ventilation, source control, and air cleaning. Ventilation can help dilute indoor air pollutants and improve air exchange with outdoor air. Source control involves identifying and removing sources of indoor air pollutants. Air cleaning can help remove pollutants from the air, using techniques such as filtration, absorption, and photolytic oxidation (Wolkoff 2018).

It is important for building owners and occupants to be aware of the potential impacts of poor IAQ and to take steps to improve it. This may include regular monitoring and assessment of IAQ as well as implementing strategies to reduce exposure to indoor air pollutants (Carrer & Wolkoff 2018).

2.2 Indoor air quality

2.2.1 Overview

Environmental air quality (EAQ) refers to the condition of the air around us, including the presence of various gases, particles, and pollutants that can impact the health and well-being of humans, animals, and the natural environment. Poor air quality can result from a range of sources, including vehicle and industrial emissions, the burning of fossil fuels, and natural events like wildfires and volcanic eruptions (Azuma et al. 2017).

Carbon monoxide, nitrogen dioxide, sulfur dioxide, ozone, and particulate matter are common air pollutants that can all have a negative impact on health, especially for populations that are more susceptible, like children, the elderly, and people who have chronic respiratory or cardiovascular diseases (Chan & Kaka n.d.).

To monitor and improve air quality, governments and organizations around the world use a range of tools and technologies, including air quality indexes, air pollution sensors, and emissions regulations. Individuals can also take steps to reduce their impact on air quality, such as using public transportation, reducing energy consumption, and avoiding the burning of fossil fuels (Kersemaekers et al. 2018).

Air quality refers to the degree to which the air around us is free of pollutants and other harmful substances. Good air quality means that the air is clean and has low levels of pollutants. Poor air quality, on the other hand, means that the air is contaminated with higher levels of pollutants (Azuma et al. 2017). Numerous natural and man-made factors, as well as each other, can have an impact on air quality. Wildfires, dust storms, and volcanic eruptions are a few examples of natural sources of air pollution. Transportation, industry, and energy generation are examples of man-made sources (Chang et al. 2019a).

Poor air quality can cause a range of health problems, including respiratory issues, allergies, headaches, and fatigue. Long-term exposure to high levels of pollutants can even lead to more serious health problems. That's why it's important to monitor and improve air quality, both indoors and outdoors, to protect human health and the environment (Ali, Chua & Lim 2015).

Humans need a steady supply of food, water, and air to survive and thrive. For example, an adult needs over 10,000 liters of air to breathe. Approximately 20,000 times a day. A human spends up to 90% of our time indoors, whether at home, at work, or in learning environments, shops, restaurants, and other activities Recreation. However, very few people know that indoor air can be up to five times more polluted than outdoor air. Polluted air is a serious problem, but it's hidden from human eyes. People can't realize it until it starts damaging their health (Santomauro et al. 2021). Stated that with the COVID-19 crisis, people's fears have become evident, and everyone is looking for health safety and, above all, indoor air quality. Air quality has become a source of anxiety for many people, as they spend most of their time in the work environment (Gosain et al. 2020).

Inadequate ventilation of the indoor environment is one of the main sources of the spread of the virus, which threatens human health. And it affects the quality of their work, because it directly impacts the 9% decrease in performance, which means more absenteeism, and many complaints of headaches and eye diseases. Indoor air has a direct impact on human health and performance, which means companies will reduce, and therefore decrease, their productivity (performance) and profit. Some indoor environments have pollution levels two to five times higher than outdoor environments (Attar, Gupta & Desai 2012).

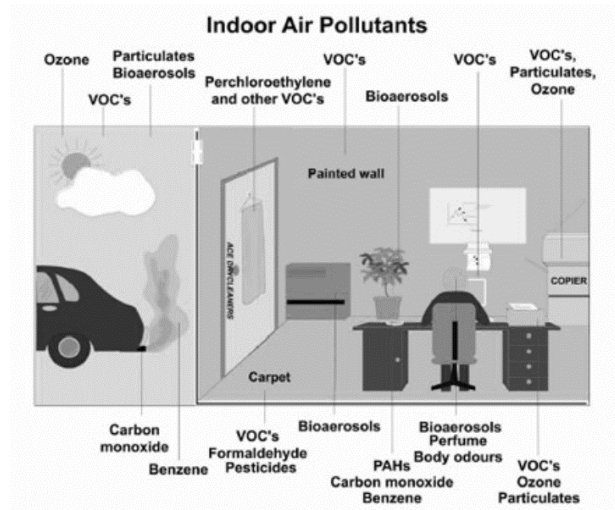


Figure 1: IAQ contaminate. (*Indoor air quality estimator,2006*)

Indoor spaces usually contain several pollutants that are considered to be the main reason for poor indoor air quality: mold, radon, volatile organic compounds (VOCs), carbon monoxide, and dust particles. Many factors affect air quality, including emissions from building materials such as granite, radon formation, mold growth from high humidity, and volatile organic compounds (VOCs) from gases, cleaning, and dehumidifiers, Carbon monoxide can also be produced by generators, boilers, and exhaust gases (Ghoddousi & Hosseini 2012). Cars parked near buildings and dust particles can form from interior paints, the use of stoves, smoking, and finally volatile organic compounds (VOCs) produced by cleaning materials from furniture and carpet. With a lack of ventilation or poor indoor ventilation, people have to constantly inhale and breathe the same air again, which means that someone infected with a virus can easily transmit it to others because they breathe the same air. The EPA, ASHRAE (American Society of Heating, Refrigerating, and Air Conditioning Engineers) and LEED (Leadership in Energy and Environmental Design) agree on quality standards for indoor air (Alashwal n.d.).

2.2.2 Concept of indoor air quality

The phrase "indoor air quality" (IAQ) is used to describe the many attributes of the air within a home, building, or interior space and is regarded as an important indication of the comfort and health of the inhabitants. For several years, indoor air quality has been acknowledged as a key risk factor and health concern. Humidity, temperature, sources and concentrations of chemical contaminants, ventilation, and biological sources (such as dust mites, mold, pollen, etc.) are all significant aspects of indoor air quality. Due to the extended periods of exposure, it is hazardous to human health. Because people spend so much time inside, interior air pollution is inescapable, just as outside air pollution is unavoidable (Cheng et al. 2022b). Indoor contamination levels mostly exceed air levels, and the majority of the time, the employees may enhance their time inside the organization. The most possible reasons are the indoor pollutants, that make the air quality poor, and these are asbestos, radon, environmental tobacco smoke, inorganic material, biological radiation, and non-ionizing radiation. Other types of pollutants may include odors and dust; for example, critical discomfort and feelings of unwillingness can lead to a reduction in job performance and productivity for employees. (Lolli et al. 2022).

2.3 Indoor air pollution effects

2.3.1 Building characteristic that affect human health and productivity

There are many building characteristics that can affect human health and productivity. As we know, poor indoor air quality can cause a range of health problems, including respiratory issues, allergies, headaches, and fatigue. Good ventilation, air filtration, and control of pollutants are key to maintaining good indoor air quality (Azuma et al. 2017).

Also, the amount and quality of natural and artificial light in a building can have a significant impact on productivity and well-being. Too little or too much light can cause eye strain, headaches, and fatigue, while poor-quality light can disrupt sleep and mood. Furthermore, maintaining a comfortable temperature and humidity level is important for both health and productivity. Extreme temperatures can cause discomfort and stress, while high humidity can lead to mold growth and other issues. In addition, excessive noise levels can be a major distraction and source of stress, and they can even lead to hearing loss over time. Proper sound insulation and noise-reducing measures can help minimize noise levels in a building (Chan & Kaka n.d.).

Moreover, the layout and design of a building can also impact productivity and well-being. Factors such as natural light, access to green space, and ergonomic workstations can all contribute to a more positive and productive work environment. Finally, a clean and hygienic building is important for preventing the spread of illness and maintaining a healthy work environment. Regular cleaning and disinfecting can help reduce the risk of infection and promote good health (Usukhbayar & Choi 2018).

2.3.2 Effect of indoor air pollution on human health

Cocârță in 2021 researched the fact that indoor air pollution can impact the well-being of people. Irritation of the eyes, nose, and throat is one of the negative health impacts of indoor air pollution. Along with fatigue, dizziness, headaches, respiratory illnesses, cardiovascular issues, and cancer. The sources of indoor pollution with particulate matter (PM) are considered outdoor particles and indoor causes, for example, the use of cleaning products, construction materials, heating, air fresheners, poor ventilation, poor indoor air quality, and other activities. The health impacts of outdoor exposure to particulate matter have been a major concern of different researchers for many years. Research was conducted by the

Global Burden of Diseases, wherein it was found that more than 1.6 million people have died prematurely because of indoor air pollution. The health effects of outdoor exposure are subject to regulatory actions and decisions taken by the authorities. In critical situations, for example, the current pandemic, patients, the health of the population, and employees working in society are vulnerable groups, and authorities are required to work on their environment so that overall indoor air quality can be improved (Kamaruzzaman et al. 2011). The incidence of sick building syndrome, which is examined by the mathematical decision tree model, was described by Sarkhosh in 2021. According to study, sick building syndrome reduces employee productivity in workplaces through significant or general symptoms, and it also has an annual economic impact due to a rise in employee absenteeism. In 2021, Sarkhosh provided a description of the prevalence of sick building syndrome, which is investigated by the mathematical decision tree model. Sick building syndrome, according to a study, has an annual economic cost due to a spike in employee absenteeism as well as substantial or general symptoms that lower employee productivity in the workplace. The results showed that the prevalence of SBS was noted at 75%, and a major relationship was observed between this syndrome and the current organizational workplace, including poor ventilation systems and poor indoor air quality (IAQ). Therefore, the companies need to provide control measures and corrective actions on a long-term basis (Sarkhosh et al. 2021).

Carrer & Wolkoff in 2018 said that low indoor air humidity can cause vulnerable eyes and airways due to less efficient clearance. Poor indoor air quality and air pollution can cause elevation of the most common mucus membrane-related issues, for example, tired and dry eyes that deteriorate the performance of employees. Clinical and experimental studies have shown that intervention in dry indoor air conditions by humidification can alleviate the symptoms of airways and dry air, fatigue, dizziness, and other issues that can compromise work performance. Poor air quality can increase the risk of infections, and dry air conditions

can also create infections because of reduced viability and transmission of the influenza virus. Ventilation can lessen the risk of chronic and acute health issues, and this can improve work performance because exposure is lessened by the dilute notion of indoor air pollutants. Furthermore, emission source control strategies can also be helpful in this regard. Health-based ventilation rates in buildings should meet the air quality standards set by the World Health Organization so that an acceptable level of perceived indoor air quality can be managed. Ventilation is the modifying factor that should be integrated with indoor air quality and room temperature in strategy control so that health can be improved and the work performance of employees can also be improved while minimizing the risk of infection (Carrer & Wolkoff 2018).

2.3.3 Indoor air pollution in work environment

Cheng in 2022 shared views about the indoor air environment and the significance of indoor air quality (IAQ) for office buildings in different locations or for citizens of China, including indoor air pollutants concentration and their related interactions with the feelings of employees and health issues that can give a basis to enhance the indoor air quality (IAQ) in office buildings. Thermal parameters and pollutant concentrations were observed on various floors of sample office buildings (Cheng et al. 2022b). The survey questionnaire was also utilized to study human perceptions about indoor air quality (IAQ)-related diseases, like sick building syndrome. Further, cancer risk assessments in such office buildings were carried out as per onsite air pollution information. The results revealed that indoor and outdoor pollutant concentrations are related to each other, and pollutant concentration levels also vary over time (Mannan & Al-Ghamdi 2021). The results of the survey revealed that actions should be taken to enhance the indoor environment of the office building and enrich the ventilation system, which is the most important strategy. The risk assessment results

reflected that health issues can create issues for people. Although pollutant concentration levels in the indoor environment were within standard limits. It is finally noted that outdoor fresh air with filters should be followed by companies to lessen indoor pollutant concentrations (Mannan & Al-Ghamdi 2021).

This research investigates indoor air quality (IAQ) inside office buildings by evaluating pollutant concentration and health risk, identifying types of contaminants found inside the office environment, and collecting employee feedback about their perceptions of the indoor environment.

As per the studies, different types of contamination can be found within office buildings, like indoor combustion and burning of solid fuels, cigarette smoke, outside air pollution, emissions from building materials and furniture, and inadequate ventilation and air maintenance. The use of office gear, such as printing machines and other office equipment, generates a variety of harmful pollutants. These include volatile organic compounds (VOCs), ozone gas, and particulate matter. In addition to carbon dioxide and carbon monoxide, other air contaminants that can be found in the workplace include nitrogen dioxide, formaldehyde, radon, and airborne microorganisms (Baldocchi et al. 2001).

Spinazzè, Cattaneo & Cavallo 2020 examined the fact that indoor offices have a high percentage of occupancy, and as a result of that, they experience indoor air quality issues. The workplace environment is one of the vital considerations that must be taken by each organization for improving its air quality. The study also showed that poor indoor air quality is generated by the presence of airborne contaminants. Such airborne pollutants range in severity, and they can have major impacts on the health of employees and their performance. The organizations are responsible for managing such issues related to indoor air quality by

implementing portable air purifiers and providing better HVAC systems (Spinazzè, Cattaneo & Cavallo 2020).

Kurgat in 2019 explored that viral illnesses have major direct and indirect impacts on employees within the workplace and can also contribute to high healthcare costs, absenteeism, and poor performance. The direct contact between employees and the contamination spaces may contribute to the spread of viruses within the work environment. This research study quantifies the impacts of the office wellness intervention to reduce viral load in the workplace. Office wellness intervention encompasses the use of a disinfectant spray in high-touch places and implementing a safe working environment so that viral transmission can be avoided (Ngenoh et al. 2019).

2.3.4 Importance of ventilation system

The total amount of outdoor air ventilation within any building is the most valuable determinant of indoor air quality. Ventilation systems play a vital role in working offices, and research has focused on the significance of ventilation and odor perception in offices. There is a high need for implementing a sufficient amount of ventilation structure in the offices in order to promote employees health and improve indoor air quality (IAQ) (Rindi et al. 2018). Managing actual ventilation performance in buildings requires special measurements. The ventilation rates are required to be measured, and results showed that there are major gaps in implications for the design intent and actual performance. As a result, this can have major implications for indoor air quality (IAQ). Ventilation is very important, and this is the area where more research is required (Persily & Leber 2006).

Investigating the airborne transmission of coronavirus disease in 2019 was observed to be of high interest for many researchers. After the emergence of the COVID-19 pandemic, Sarkhosh et al 2021 conducted research about the importance of well-structured ventilation

systems in office buildings. The ventilation system in the Dutch Nursing School was evaluated for the transition of aerosol. It was observed that more than 17 people in this location were found to have COVID-19, and it was confirmed by transcription polymerase chain reaction. Health care professionals were concerned about that situation and the impact of an inadequate ventilation system. As a result, assessing and implementing a proper ventilation system is vital to avoiding airborne diseases and viruses like COVID-19 transmission (Sarkhosh et al. 2021).

Due to the limitations of resources and equipment, unfortunately, ventilation systems will not be measured and highlighted in this study.

2.4 Employee performance

2.4.1 Overview of employee performance

Employee productivity is a measurement of how efficiently and effectively employees are able to perform their job duties and responsibilities. Higher levels of productivity typically result in greater output and higher quality work, which can translate into increased revenue and profitability for a company (Ali, Chua & Lim 2015).

Employee performance can be summed up as their ability to carry out all of their duties in line with the organization's expectations. No matter how good or ineffective a leader is, it is possible to gauge it by looking at how well their team performs and how their organization grows (Ayundasari, Sudiro & Irawanto 2017).

According to Pattanayak (2005), an employee's total performance may be affected by how they behave while working, which is something that is simple to watch and evaluate. Employee performance is essentially defined by Pattanayak as "the contribution of an individual towards the realization of organizational goals and objectives". A variety of

metrics, including profit margins, productivity, return on investment, finished job quality, market share, etc., can be used to objectively assess employee performance. However, from a subjective perspective, an employee's success can be judged by changes in their manner, their ability to master and improve, and their level of dedication (Hakan Erkutlu, 2008). There is no doubt that employee performance affects leadership and corporate effectiveness. Every organization's main goal is to encourage its workers' total work performance to the maximum level possible in order to survive in a relentlessly competitive market that is by nature competitive (Lim, D. S., Morse, E. A., Mitchell, R. K., & Seawright, K. K. *Ins* 34(3) 2010).

"Performance" is defined by Kuragu, Baiden, and Badu (2014) as "a system's valued, useful output of goods or services." When the word "performance" is used, it implies that there is a goal to meet specific benchmarks and metrics in order to meet the needs and expectations of potential customers. However, "performance" can also be defined in terms of skills as the behavioral abilities necessary for project-based businesses to achieve their long- and short-term business goals (Ahadzie, Proverbs, & Sarkodie-Poku 2014). The word "performance" is often used in the management world. They made reference to Kennerley and Neely (2002) when they stated that performance might be assessed using figures and phrases, which could reflect the project's true condition. and displays the results of an action taken after adding value. Similar to that, it can assist or encourage the establishment of a result. Additionally, according to a set of standards, it can be used to compare internal and external results. The most common method for assessing the effectiveness of management (i.e., work, corporate strategy, and human resources) is performance evaluation. "If you cannot measure it, you cannot control it" sums up the significance of performance evaluation in modern work and management situations (Wilhelm et al. 2006). A set of standards is used in performance measurement to gauge an action's efficacy. As a result, it can be described

as the process of determining an activity or action's effectiveness and efficiency, or as an indicator or metric used to determine those attributes. Neely et al. (1995) identified three general methods for gauging performance: Individual performance, which is determined by one's knowledge and skills. Systems for measuring performance that use a number of indicators and benchmarks. Connecting the working environment to the performance measurement system. The following are typical uses of performance measurement in businesses: Evaluation: Monitoring project outputs and results provides the business with important information about the project's state and the amount of progress made toward its goals. Additionally, it is employed to evaluate and contrast the firm with other market rivals (Behn 2003). Regulation and control: The only way to keep project activities under control is to define performance criteria, which are then utilized to coordinate work and spot errors. If an indicator during the review process deviates from a predetermined standard, there is a problem (Sharahi & Abedian 2009). Review: Prior to carrying out an intervention to enhance the workflow within a project or an organization as a whole, measuring indications are typically used to establish the initial diagnosis. These metrics are used to pinpoint strengths, shortcomings, and dysfunctions. Implementing improvement actions receives priority during this phase (Sink and Tuttle 1995). Motivation: Through ongoing follow-up and individualized feedback, performance evaluation could also be used to inspire employees, boost their productivity, and maintain ongoing improvements throughout their employment (Sink and Tuttle 1995). Promotion: By using performance measurements, success can be ensured, more staff can be attracted, and stakeholders are satisfied in a way that is consistent with the results attained. Additionally, it can help in understanding and organizing staff members' responsibilities both inside and outside the company (Behn 2003). Learning: Performance measurements offer data that can be used for both evaluation and learning and improvement. Measuring is done to determine what is being done and what is not. For

instance, figuring out why would be the goal of learning (Behn 2003). Measurements are also used to look at how improvement actions affect an activity's performance (Sink and Tuttle 1995). After establishing targets through indicators (i.e., utilizing benchmarks as a guide), organizations start their actions (Sink and Tuttle 1995). The standards of the measurements and the discipline used in the correlation analysis between clients, activities, and results both simultaneously indicate the importance of performance assessment. Understanding the relationships between metrics helps people focus more intently on achieving the organization's goals, missions, and objectives. Performance is divided into various types in the literature evaluated for this study. The four basic forms of performance, according to NIST (2014), are operational, financial and market, customer-focused, and products and services. However, the depiction of performance in terms of the 10 skills to fulfill and meet corporate goals and objectives, as well as clients' wants and expectations, is a recurring subject. (2019, Arabia).

2.4.2 How can healthy work environment effect employee performance

Employee performance can benefit from a healthy work environment in a number of ways. It can increase job satisfaction, motivation, and engagement, which can lead to higher productivity and better work quality. It can also reduce stress and workplace-related injuries, which can improve mental and physical well-being and reduce absenteeism. Additionally, a healthy work environment can foster a positive culture that promotes creativity, collaboration, and innovation, leading to a more successful and competitive organization.

2.4.3 Performance measures and indicators

A performance measure is generally regarded as a short-term assessment tool that gives users indications of performance in the material that has been studied. NIST (2014) says that

measures and indicators are both numerical metrics that quantify the input and output of an organization's processes or operations, despite some literature making a distinction between the two. But the application of such measurements is consistent with the idea of SMART management practices (specific, measurable, attainable, relevant, and timely) (Robinson, Carrillo, Anumba, and Ghassani, 2005). The availability of a sizable number of metrics and measures used in the industry globally presents a barrier to the application of performance measures in construction management. The performance measures that support the corporate goals of their firms must be chosen by construction managers. The amount of performance metrics or indicators to be used in evaluating organizational performance, according to Robson (2014), is largely immaterial. He goes on to say that the optimum strategy is to employ the fewest number of performance indicators that may effectively give management information about the state and caliber of business operations. In order to improve the company process and establish a condition of sustainable development, precise performance metrics should be implemented in line with a long-term strategic plan. Although the incorporation of performance measures into business operations management increases business profitability and competitiveness, many organizations are unable to take advantage of the performance measures that are currently available due to the lack of agreement on which measures are the most efficient (Tangen 2003). Kuragu, Baiden, and Badu (2014) claim that reviewing current sets of measures and either adopting them or developing new ones in accordance with the business characteristics of interested firms is a successful strategy for selecting relevant performance metrics to deploy. Shen (2003) looked at the main competitiveness metrics for Chinese building contractors. They created a performance prediction model for building contractors in the UK market using the analytical hierarchy process (AHP) method. Since the model's efficacy has been shown, it is frequently utilized in the UK building sector (Yasar Zakaria Izzat Zaben, 2019)

2.4.4 Influence of work environment on employee performance

The employees prefer to have a healthy and attractive working environment where they can work easily, increase their productivity, and improve their performance. The primary factor affecting an employee's level of performance and the quality of their job is their environment. In order to positively affect employees' abilities and levels of performance motivation, the workplace needs to be interactive with its staff. Employees in human resources must perform well in a world where business competitiveness is escalating on a worldwide scale. It has already been established that having self-satisfaction is just as important as earning a living. A variety of factors, such as the workplace environment, employee motivation, and organizational leadership, have an impact on how well employees accomplish their jobs. Job performance includes Effectiveness (accuracy, thoroughness, and competence) Total amount of exertion (performance level, time management, ability to meet deadlines) Employment experience (skills and knowledge of the job) (skills and understanding of the work) Interpersonal abilities (sociability, verbal or written) in the workplace (Al-Omari & Okasheh 2017).

Another researcher has looked into the workplace because it can include anything that surrounds employees and can impact how they carry out their duties (Robson 2014). The working environment is an internal or external circumstance that may have an impact on the willingness to work and lead to the accomplishment of the task (Muchha 2014). Many factors have a positive impact on the workplace. Including, but not limited to, lightning, water, cleanliness, air quality, interior decoration, security, etc. These factors can help employees stay motivated and increase their productivity (Moreno-Rangel et al. 2020). It is also stated that unsafe and unhealthy working environments can include poor indoor air quality, poor

ventilation, excessive noise, inadequate lighting, etc. All these factors can have a negative impact on the health and behavior of employees (Hsiao, Steve Ching & Ki Wan 2012).

Abdul Raziq in 2015, also researched the impact and importance of the working environment on the performance of the job. It is stated that in the modern era, companies are facing different challenges because of the dynamic nature of the environment. It is a challenge for businesses to satisfy their employees to cope with challenging market situations and comply with the evolving environment, and this is very important for achieving success and remaining competitive. The purpose of this research was to review the impacts of the working environment on employees' job satisfaction. This study used quantitative methodology and data obtained through a survey. Results showed that there is a positive relationship between the working environment and the job satisfaction of the employees. This research is based on important prospects. For example, companies are required to realize the value of a good working environment for increasing job satisfaction. This is essential for companies to motivate their workers, and this can also be possible by offering a good working environment (Raziq & Maulabakhsh 2015).

2.4.5 Impact of workplaces design on employee's performance

Leblebici in 2012. Research shows that the relationships between employers and employees can be observed as important things, and there are different opportunities available for employees. And employees want to work for companies that can offer a better working environment. HR executives are required to consider new policies and strategies that can retain employees for longer periods in companies. Higher salaries, compensation benefits, and promotions are also very important factors for the growth of employees, but a healthy working environment and comfortable sitting arrangements offered to employees are also very important for employees to stay in companies for a longer period of time. The

quality of the physical working environment has a strong impact on the ability of organizations to recruit and retain talented employees. Many factors are responsible for making a working environment healthy and competitive. For example, engagement of employees, productivity of employees, comfort level, morale of employees, proper indoor air quality, etc. Convenient workplace conditions are the major requirements for improving quality and productivity results, as working conditions in companies can show a lack of health issues, a lack of safety, and a lack of comfort. For example, poor ventilation systems, improper lighting, excessive noise, and bad sitting exposure. People working in such environments can result in low employee performance, and employees can also face occupational health diseases that cause high employee turnover and employee absenteeism. (Leblebici 2012.pdf n.d.).

2.4.6 Impact of workplaces ventilation system on performance

Ventilation is necessary for a safe and healthy indoor workplace. This is because ventilation removes pollutants generated or manufactured inside the structure. In office buildings, eliminating indoor air pollution sources such as flooring, aging and outdated supply air filters, and computers, machines, and equipment may have a major impact on worker performance and productivity. Moreover, it is beneficial to keep these pollutants in clean and organized areas, as this may enhance ventilation, allowing the supply of fresh, outside air per person to increase from 3 to 10 and might reach 30 l s⁻¹. (Nazaroff 2013).

González-Leonardo et al 2022 discussed the comparison of better building design and operations to other corporate strategies for enhancing organizational performance and productivity. It is important to discuss that better buildings are aimed at improving employees' well-being and other valuable organizational productivity levels. However, such effects are very critical for companies. This research paper uses new approaches to create

frameworks for valuing the positive effects of companies. The organizational productivity performance metrics are considered to be employee turnover intent, absenteeism, health and well-being, job satisfaction, and self-assessed performance. The effects of different ways of improving building design and operations are compared with the other corporate strategies used by companies. The factors that can improve employee job satisfaction concerning the design of the buildings may include enhanced lighting conditions and proper ventilation systems. Standards HVAC systems and green buildings, and these factors improve organizational performance and productivity (González-Leonardo et al. 2022).

Feige in 2013 researched the buildings and their designs, which have an impact on the comfort level of employees. There are positive impacts from different features. For example, operable windows and the absence of air conditioning are clearly identified. Productivity performance is not directly related to comfort levels and working engagements. The results of the research showed that specific building aspects appear to have major impacts on the comfort of employees and also on their performance and productivity levels (Funminiyi 2018). This is very important for employers to understand the factors that can make the company's environment healthy and competitive. It is very important, and there is a high connection between employees and organizations, while defining high user comfort can lessen the turnover rate of employees. Therefore, there is a need for more planning toward the comfort of employees and social sustainability so that better returns can be generated.(Feige 2013 n.d.).

Specific building-related disorders refer to a collection of diseases having a common clinical presentation, observable abnormalities on clinical or laboratory examination, and a known cause or agents. Depending on the source, these substances might induce infections, immunological issues, and allergic reactions (Brgoszewska 2018 n.d.). Since the late 1970s, acute health problems experienced by building inhabitants have been referred to as "sick

building syndrome." This phrase refers to a variety of ailments caused by prolonged indoor exposure. In contrast to conditions such as hypersensitivity pneumonitis or infection, SBS symptoms are often vague and confined to certain buildings and workplaces (Lolli et al. 2022).

Castral et al in 2008 investigated the fact that improving indoor air quality (IAQ) from the mediocre level prevalent in different buildings in the world can improve the performance of office work by employees or adults and the performance of school work by children. The results of this research develop a strong incentive to offer indoor air quality that is better than the minimum levels needed by the presented standards. Indoor air quality (IAQ) can be improved by the relevant companies by lessening the pollution load in the air and by selecting low-polluting buildings. This is also required for building improvements and furnishing the materials in such a way that pollution can be reduced by using ventilation systems and increasing the outdoor air supply rate (Castral et al. 2008).

Roelofsen in 2002 discussed that one of the major human requirements is a working environment that can help people perform their work optimally under comfortable conditions. The buildings and air conditioning systems should work properly in such a way that they are developed considering the level of comfort. This can raise the key question: what is the effect of comfort level on the performance of employees working in an office environment? The objective of this research is to quantify the relationships as support for choosing a working environment at a strategic level in the facilities management process, with a special focus on work conditions and thermal temperatures (Roelofsen 2002). The telephone survey conducted by the Building Owners and Managers Association International working in real estate management and facility management in the US showed that the indoor environment is a major issue in the scope of building management, design, and maintenance. The respondents also raised their voices about expectations that the indoor

working environment should be improved, leading to a major rise in performance and productivity in companies (Roelofsen 2002).

2.4.7 Effects of indoor air quality on performance level of employees

Wyon in 2005 discussed the effects of indoor air quality on the behavior of employees, the performance of organizations, and the productivity of companies. Modern sciences have developed by using buildings to manage the working environment, so that work performance in companies is no longer dependent on weather, time of year, or time of day. Buildings are the largest capital investments made by society, and more energy is used to enable buildings so that they can transform the outdoor climate into the indoor climate for different purposes. On average, more than 40% of all energy is utilized to manage the indoor climate in buildings. This is used to develop buildings to cool, heat, and light them as needed and to ventilate them. Each of such processes should be accomplished as effectively as possible, and cost-benefit analysis should be reviewed along with the matter of energy conservation. Optimization can be accomplished if the results of each process can be quantified in terms of how people and their activities are impacted. The effects of indoor air quality (IAQ) on employees performance include Poor indoor air quality (IAQ) can cause employees to take more sick days, leading to decreased productivity and increased costs for the company. In addition, it can impair cognitive function, leading to decreased concentration, problem-solving ability, and decision-making skills. Also, it can cause fatigue and lethargy, leading to decreased motivation and productivity. Furthermore, it can lead to increased stress levels, which can negatively impact employee well-being and performance.

2.4.8 Effects of indoor air pollution in an office environment on performance level of employees

Wyon & Wargocki in 2013 revealed that poor indoor quality can lessen the performance of office work. There are many sources of indoor air pollution, and used supply air filters are one of them. There are many sources of indoor air pollution, and used supply air filters are one of them. Field intervention experiments define the decrement in performance that can be seen in practice as compared to the laboratory simulation experiment. There is an almost linear relationship between the percentage of people dissatisfied with indoor air quality (IAQ) and the measured decline in performance. Negative environmental effects on performance are also related to negative effects on performance. (Wyon & Wargocki 2013).

Tanir in 2022 also researched the fact that workplace indoor factors are the factors that affect the health of employees in almost all industries. The important factor is the air quality in organizations. There are different main groups of indoor pollutants in the workplace. For example, biological ones, particles that are non-biological, and chemical ones. These were grouped into the following categories: lead, wood smoke, environmental tobacco, volatile organic compounds, odor, humidity, carbon monoxide, biological pollutants, carbon dioxide, formaldehyde, and nitrogen dioxide. The main indoor air contaminants that have a significant impact on health and the ability to deteriorate employees' health are those found in the workplace. Healthy indoor air quality (IAQ) is defined as indoor air that doesn't contain hazardous substances and doesn't create a sense of discomfort for almost 80% of employees in organizations. Poor indoor air quality can result in a variety of health issues, from headaches, nausea, and dizziness to cardiovascular diseases, asthma, cancer, and death. (Tanir 2022 n.d.).

Poor indoor air quality (IAQ) can worsen asthma and allergies, cause throat irritation, nose irritation, and eye irritation, and also result in nausea, fatigue, and illness. The health impacts of such symptoms can lead to poor work performance and reduced productivity among the employees, and this can also impact their well-being. These symptoms and impacts can lead to missed work, sickness, and loss of income. (Field 2010 6 444-453.pdf n.d.). People mostly observe their feelings and symptoms after different hours at work, and they feel better after leaving buildings, when they are away from the buildings for a vacation, and when they are weak. Different symptoms can also lead to other health issues, including flu and colds, and these are not necessarily because of poor indoor air quality. This can make identifying and resolving indoor air quality (IAQ) issues more difficult. Further, the social habits of people can impact the quality of air in organizations. Employees want a healthy and pleasant working environment to work in, as a healthy working environment can improve the health of employees and their behavior. (Roh et al. 2021).

Parmaksiz in 2021 and other researchers also discussed the fact that indoor air quality (IAQ) is an increasing concern and that most people spend their time indoors. It has been observed that indoor air quality in office buildings can impact people's health. Employment consultancy companies are considered important agencies, and these are working on identifying the impacts of indoor air quality (IAQ) on the health of employees in organizations. HR consulting firms are one of the most valuable companies because more than 1,000 employees visit and conduct interviews. Measurements were done to evaluate the indoor air quality (IAQ) that employees are exposed to, and the findings were compared with the standards set by the World Health Organization (WHO). The survey questionnaire was used for employees to gain insight into exposure, which can help in determining the impacts on their health. Particulate air pollution appears to be the reason for many health issues, and indoor exposure to airborne pollutants is not only dependent on pollution from various

indoor sources but also dependent on pollutants received from outdoors that are intensified by filtration and ventilation. Local aerosol sources in urban locations involve soil, road dust, the combustion of automotive gas, the processing of energy and industrial processes, etc. The exposure of office employees to health-related air pollutants is not completely defined, and recent research has attempted to search for different issues focused on indoor air quality (IAQ) in organizations.(Parmaksiz, Rastgeldi Dogan & Yesilnacar 2021).

For reviewing the impacts of indoor air quality on office workplaces, another piece of research was conducted, wherein it was discussed that indoor air quality (IAQ) is an important concern for companies, tenants, building managers, and employees as well. Because this can impact the comfort, health, well-being, and productivity of the building occupants. Most Americans spend more than 90% of their time indoors, and most of that time is spent in their working environment. (Sciences et al. 2009).

Different research studies have been conducted by the USA Environmental Protection Agency and others that show that indoors can have pollutants levels that are higher than the levels observed outside. Pollutants in the indoor environment can also enhance the risk of illness, and different studies have been conducted by countries, researchers, and independent research companies that have ranked indoor air pollution as an important environmental health issue. Most buildings don't have severe indoor air quality (IAQ) issues, and even well-run buildings can also face different incidents of poor IAQ). According to the 1989 EPA report to Congress, improved indoor air quality (IAQ) can result in higher productivity levels and can also result in less absenteeism. The USA Environmental Protection Agency projected that poor indoor air quality (IAQ) can cost huge investments every year in lost employee productivity, medical costs, etc. (Fang, Lin & Lee 2008).

Mata et al 2022 research the effects of indoor air quality (IAQ) on elderly people. It is known that the population of the world is aging, especially in developed nations, with a major increase in the percentage of people over 60 years of age. Indoor air quality (IAQ) is the most important topic nowadays, and elders spend most of their time indoors compared to younger generations. Therefore, the recent COVID-19 pandemic has also contributed hugely to the increasing awareness of the importance and value of breathing air quality for people's health. Further, it is also known from research that indoor air is the source of airborne infections.(Mata et al. 2022).

2.5 Importance of IAQ in workplace

2.5.1 Effect of indoor air quality on employee satisfaction

Kamaruzzaman in 2011 researched the fact that indoor air quality in buildings is very important for ensuring the health and comfort level of the people sitting in such buildings. It is because work productivity can be interrupted because of polluted environmental conditions and bad indoor air quality. Both factors may lead to bad health and physical issues, which can result in low work productivity. This research study presented the understanding and knowledge of indoor air quality as it affects psychological performance and health impacts for the residents living in such buildings. The research has selected four high-rise government office buildings situated in Kuala Lumpur Malaysia. The questionnaire forms were also distributed among the building residents to obtain feedback related to satisfaction with the IAQ performance of the buildings. The data obtained were reviewed using SPSS software. This research showed that the majority of the respondents are not satisfied with the office's current indoor air quality, and this condition revealed that it impacts badly on the work productivity (performance) of the residents and can increase stress levels. This research provided a better understanding of and information about how

indoor air quality can impact the psychological performance and health conditions of residents in office buildings. The research has recommended that indoor air quality be improved so that a comfortable working environment can be offered to the employees. (Kamaruzzaman et al. 2011).

Licina in 2021 researched air pollution exposure in a workplace environment that is related to the health and cognitive outcomes of employees. The green building certification programs are instrumental in promoting indoor air quality, and the literature has indicated inconsistent findings and evidence that will be further researched in this research. The recent emergence and proliferation of different programs like the WELL certification program can prioritize human health for effectiveness in indoor air quality. To research the effectiveness of such certifications, the research has quantifiably compared the results of indoor air quality before and after the relocation of the certified office buildings that have used such occupants. There was no major concentration difference between WELL-certified buildings and non-WELL buildings, and the WELL-certified buildings have a higher level of total volatile organic compounds related to paints. Afterward, there were major improvements observed in indoor air quality satisfaction after moving employees into WELL buildings, irrespective of the air pollution levels.(Pisello et al. 2021).

Nur in 2012 stated that sick building syndrome is primarily characterized by different criteria; for example, people in the same building complain of different issues like eye, nose, and throat irritation, dizziness, headaches, and difficulty breathing. These symptoms are easily relieved after moving into a building with adequate indoor air quality. The Sick Building Syndrome defines a situation wherein building residents face acute health or comfort effects that seem to be linked to time spent in a respective building but for which no illness or cause can be identified. The survey for this research has found that most of the employees seem not to be aware of sick building syndrome because they understand that it

has nothing to do with their health since they get better when they leave that building or their workplace. The low level of indoor air quality in the old buildings may be related to the high building occupancy with 30 or more employees in an open space area, as compared with 4 to 15 employees in new buildings. It is also observed that particles are also produced during the operation of office equipment, for example, printers, because printer machines are not isolated from workspace locations in old buildings, and this can be an important factor for indoor air pollutants. (Nur 2012 n.d.).

Surawattanasakul in 2022 researched the negative impacts of poor indoor air quality and the importance of managing better air quality in office environments. Sick Building Syndrome is the most important disease that should be avoided by offering better working conditions to employees in offices. SBS is directly related to indoor air quality, and there are different determinants, for example, in buildings. Identifying and controlling factors is also important for studies related to this disease, and this is very essential for improving the health of employees and increasing their efficiency. There is a need to conduct a cross-functional study so that the prevalence of respiratory systems and other skin-related diseases can be studied and their relationship with indoor air quality can also be checked, considering the employees of the offices. The researchers have used the survey questionnaire to evaluate the perceptions of employees, working conditions, and the environment of companies. The building assessment was also performed through a walk-through survey and the measurement of IAQ. (Surawattanasakul et al. 2022).

Breathing quality indoor air is very important for people's good health. The companies spend money on their indoors, for example, in their offices, their homes, and other types of buildings. Gases, pollutants, and other chemicals can cause eye irritation, headaches, allergies, and other health issues like fatigue (Spengler 2012). Breathing is the first instinctive action and the most natural thing. There can be more than 900 toxins that are

polluting the quality of indoor air, and more than 81% of people are at risk of respiratory conditions because of the poor indoor air quality. It is very important to research how this can affect health, and we need to find out ways to improve the indoor environment. Indoor air pollutants can have major issues and long-term health effects on the body. (Lowther et al. 2021).

2.6 Importance of IAQ on health and employee's performance

2.6.1 Healthy work environment and employees' performance on engineering consultant offices in UAE

Leitão et al in 2021 have revealed the assessment of the effects of burnout as a moderator of the relationship between the quality of work and their perceptions of the contributions to the productivity of organizations by integrating the QWL factors into the trichotomy of motivators of productivity in workplaces. The empirical findings resulted from OLS multiple regression with different terms applied to the survey administered to 514 employers in six European countries based on two important insights, which are QWL hygiene factors and burnout demotivation. These factors majorly moderate the relationships between contribution to productivity and quality of work life. The research has highlighted the importance of a safe and healthy working environment so that overall performance can be managed, absenteeism can be reduced, and mental issues faced by employees can be avoided. The poor working environment negatively impacts the quality of life and performance of companies, etc. The cost of the companies is also increased because talented employees then leave such companies and try to move to other suitable companies where the working environment is healthy and supportive. Therefore, we may see that an overall quality working environment is very important for companies to manage their overall

business activities and to perform better in this competitive working environment. (Leitão 2021).

Öhrn in 2021 researched the fact that there are many areas and factors that make an organization very attractive and healthy for companies. Many things should be considered by line managers when actively managing the productivity of employees, satisfaction, working environment, and health after relocation. The activity-based flex office has been taken as a case study in this report. The implementation of activity-based flex offices is also becoming increasingly important, and the purpose of this study is to assess the effects of activity-based flex offices on perceived satisfaction, quality of work, productivity, health, and the working environment. This research study has assessed a public company that is relocating its employees either to cell offices or to activity-based flexible offices. The employees working in activity-based flex offices with bad working environments faced decreased productivity and were also less satisfied with their office design. There was a lack of privacy and increased noise disturbance, and working posture and pollution were high. The study has highlighted the importance of a flexible and healthy working environment so that employees can work better and grow in all directions, etc. (Öhrn et al. 2021).

As per the views shared by Rafique Tahir in 2015, it is observed that the working environment plays an important role in companies. Most of the issues experienced by employees are about the working environment. The level of productivity can be enhanced by developing a healthy working environment in companies. The important purpose of the research is to investigate the impact of the working environment on the productivity of employees. Companies like banks and insurance companies are used for investigation purposes in this study. Researchers have used the closed-ended questionnaire, which was developed to get feedback from the target audience, and different statistical methods have also been used to generate results from the collected data. It was noted that different factors

like the support of a supervisor, proper indoor air quality in the working environment, relationships with employees, healthy competition, training, developments, and incentives are very important for developing an energetic organization, and this can have a positive impact on the level of productivity of employees.(Tahir & Ghafoor Awan 2015).

Another research study is focused on the working environment of companies, and the leaders are required to focus on the mental and physical health of the employees. These two areas are very essential for developing a healthy work environment where employees can achieve better results, and there is a need to keep the place clean and hygienic. The companies have to focus on developing their working environment, considering all the required facilities. Apart from working benefits like challenging work, job descriptions, and learning facilities, the provision of good sitting places, ventilation systems, standard HVAC systems, and other facilities is important to make an environment comfortable and relaxed for employees. These facilities are essential for the health of employees and helpful for their growth so that they can stay loyal to the companies and their health status also stays manageable. The companies are also observing the importance of natural light as a green environment because sunlight has Vitamin D, which is important for the immune system of humans to work properly. The further ventilation system is very important, along with air quality, so that people can work better and stay active all the time. (Cherian et al. 2021).

A healthy and positive working environment attracts top talent to companies, and employees understand that a positive workplace is essential not only for the employees but also for the leaders of the organization. The reason is that employees can stay motivated and increase their productivity level, and leaders can have talented employees for a longer period of time in their companies. Employees want healthy and beautiful working environments, and they like leaders that can enhance their creativity and also provide a professional working environment so that the overall relationship between employees and employers can

be improved. Another important advantage of a healthy working environment is lower absenteeism. People can stay more healthy and happy when they feel that they are working in a healthy environment where the risk of illness is quite low. The negative and inactive working environment can make employees tired and unhappy and cannot offer high productivity to them. There is a need to have happy and motivated employees in companies for their growth and motivation. (Santomauro et al. 2021).

2.6.2 Air pollution and health on engineering consultant workplace in UAE

According to the United Nations (UN), the United Arab Emirates (UAE) contains several types of pollutants. Due to the desert location of the United Arab Emirates, dust and sandstorms contribute considerably to the nation's overall air pollution. A second cause is the production of greenhouse gases and other pollutants by a variety of industries, particularly the construction industry. The inefficient control of IAQ is mostly due to local factors, such as the country's poor air quality and its rising urbanization, transportation networks, industrialization, lack of information, and lack of institutional skills. Also problematic is the country's poor air quality. As a direct result of the fact that inhabitants of the UAE spend more than 90 percent of their time inside, poor indoor air quality has become a significant problem. Due to the region's extreme warmth, reliance on artificial climate control, inadequate ventilation, and continual exposure to sandstorms and nearby construction dust, the Middle East is particularly conducive to the development of a wide variety of indoor pollutants. This makes the region more vulnerable to certain health risks (Yoon et al. 2022).

The United Arab Emirates is one of the world's wealthiest countries as a direct consequence of the large quantities of money poured into its economy as a result of its success in the oil trade. As a direct consequence, a large variety of distinct domains have

been allowed the power to expand rapidly without being required to go through the usual developmental phases that comprise the first cycle. The growth cycle has helped several professions, including economic, social, educational, medical, and architectural disciplines. This remarkable accomplishment may be documented in the annals of world records as a barometer of the developed world's path toward the highest standards in almost every aspect of life. It is possible, and perhaps even probable, that rapid expansion without adequate planning might result in a significant reversal of the growth process at some point. People's efforts to construct their country will have unintended effects on the surrounding ecology. Before the high-rise buildings could be built on the site, they had to be significantly modified. Numerous development measures have been carried out to realize the development vision's apex. Several environmental and health problems have evolved as a consequence of these acts (Amoatey & Baawain 2019).

Increased air pollution is a result of urbanization and industrialization. According to the most current study by the International Energy Agency, annual CO₂ emissions climbed from 51.6 million tons in 1990 to 130.6 million tons in 2007. (IEA). The alarming increase in CO₂ emissions foreshadows the imminent disaster of outdoor air pollution. The most harmful forms of air pollution are produced by a variety of natural and man-made sources. In addition to forest fires, wind erosion, and the evaporation of organic molecules, there are several other natural sources of pollution. Air pollution generated by humans includes the burning of fossil fuels, the release of fertilizer dust and pesticides, and the use of tobacco products. According to past studies, the most major cause of urban air pollution in Dubai and Abu Dhabi, the subject of this investigation, is automotive emissions (Lansari, Tubaishat & Mahmoud Al-Rawi 2007). Several factors affect human air quality, including carbon monoxide (CO), nitrous oxide (NO_x), volatile organic compounds (VOCs), and particulate matter emissions (PM₁₀). Regardless of its source, air pollution is a significant issue that has a direct influence

on people's health. This is true regardless of the source of pollution. "Doses absorbed by people" are far more relevant than "emissions and outdoor concentrations" in terms of health effects. Consequently, "doses" are determined by the duration of a person's exposure to a certain quantity of radiation, regardless of whether the exposure occurs inside or outside (Moreno-Rangel et al. 2020).

Although the UAE has recently focused on the interior air quality of buildings and workplaces, The introduction and widespread use of a variety of electronic technologies, most notably printing machines, have dramatically transformed the character and organizational structure of modern workplaces (e.g., laser-jet printers and ink-jet printers). In today's technologically advanced and technologically focused work environment, technology has become an intrinsic part of daily tasks. Since their introduction to the general public, almost all kinds of office printers have been used almost continuously. However, the increased usage of this technology in the workplace has created a potentially dangerous working environment. There is a wide array of possible adverse effects, including persistent headaches, nose and mouth dryness, itchy and flaky skin, and other symptoms of dehydration. (Abdo et al. 2020).

The United Arab Emirates (UAE) is developing houses and businesses with smaller floor plans in an attempt to save energy. Although this method has the potential to cut energy usage, little consideration has been given to its influence on the quality of the interior environment. Imagine spending at least eight hours a day in a confined workplace with a high concentration of indoor contaminants, including dust, scents, equipment, volatile organic compounds, and other such substances, in addition to the typical ventilation maintenance difficulties. This is but one example of the dangers connected with working in such an atmosphere (Soomro & Shah 2019).

The United Arab Emirates (UAE) has not reached the required particle matter standards. Multiple causes contribute to the degradation of air quality. On around 30% of the days analyzed, particle matter statistics show that areas such as Abu Dhabi may have air toxins, pollutants, and ozone concentrations that exceed limits. According to studies of indoor air quality, some contaminants, such as ozone, may enter a building through the HVAC system. Additionally, they may enter via windows, doors, and other naturally ventilated openings (Jung & Awad 2021).

Due to the severe climate in the UAE, air conditioners and heaters are required for the bulk of the population. Numerous studies have shown, however, that bad design, a lack of maintenance, and an incorrect HVAC system may significantly contribute to poor indoor air quality. Design concepts and laws about indoor air quality must be enforced appropriately. Sadly, many UAE emirates are not as cautious as they should be on these issues. Despite the clear dangers presented by polluters, few limitations have been implemented (Mannan & Al-Ghamdi 2021).

2.6.3 Economy impact of poor IAQ in UAE

Inadequate indoor air quality impacts not just a person's physical health but also their social and economic well-being. The vast majority of individuals are unaware of the extent to which their daily activities in confined spaces may alter the air quality they breathe. It's not that employees in a region with bad air quality don't do their jobs; rather, they call in sick more often and miss more work than normal, which negatively impacts the company's bottom line. The significant increase in sick days used by employees, as well as the decline in performance and productivity, are strong signs of the massive financial losses any company incurs owing to poor indoor air quality (IAQ). Even though it may be difficult to get exact data on the financial impact of poor indoor air quality (IAQ), the rise in sick days

used by employees, and the decline in performance and productivity, companies must address this problem (Arar & Jung 2021).

Nonetheless, not only may rising CO₂ levels create such issues, but even outmoded furniture or carpet can have a substantial impact on an employee's production. If this issue is not addressed and resolved expeditiously, substantial economic damage will follow. As a result of Dubai's free zone legislation, the city is home to a large number of commercial offices, which causes an issue in the form of an unusually high number of asthmatic workers owing to the poor indoor air quality. Numerous firms continue to overlook improving air quality, despite the well-documented negative effects on employee health and business. Consequently, poor indoor air quality is one of the key issues that might hinder an employee from performing to the highest standards of the profession, resulting in a serious economic loss for the employee's company and an uncontrollable disaster (Jung & Awad 2021).

In terms of indoor environmental safety, off-gassing construction materials are comparable to interior decorative materials. The "reactive" components of construction materials are the principal generators of volatile organic compounds (VOCs). In the first phase of space layout and design planning, the behaviors and daily tasks of the space's inhabitants are identified to determine how the space will be used. Stones of various sizes and shapes used in the building of masonry or concrete are important sources of radon gas emissions. It is crucial to recognize the inseparable connection between the interior of a structure and its residents. (Abdo et al. 2020).

The majority of studies examine how indoor pollution affects human health or productivity, but they often overlook the notion that human activities produce pollutants such as volatile organic compounds (VOCs) and carbon monoxide (CO). Sneezing, coughing, breathing, and speaking are all examples of respiratory actions that might

disseminate and infect others with viruses in a confined indoor setting. As self-directed behaviors, some habits, such as smoking, are simpler to regulate from a health protection standpoint. According to a World Health Organization fact sheet, chronic obstructive pulmonary illnesses kill one in ten people globally (WHO). Multiple studies have shown that the concentration of "five carcinogenic elements (Cr, Ni, As, Cd, and Pb)" is much greater in a smoking environment compared to a nonsmoking one. In addition, 53,000 nonsmokers die annually in the United States due to secondhand smoke exposure. To preserve public health and the environment, the United Arab Emirates has implemented a policy prohibiting indoor smoking. Individuals who breach the smoking ban will be punished between 1,000 and 8,000 AED, while businesses might face penalties ranging from 10,000 to 80,000 AED (Andargie & Azar 2019).

Without public participation, it will be impossible to maintain indoor air quality at an acceptable level. There is a growing knowledge gap in the United Arab Emirates (UAE) about the environmental health concerns associated with poor indoor air quality. There are very few public education efforts. People may be aware of the dangers that are present outside, but they may not be aware that the air they breathe at home may potentially be fatal. They should be made aware of the potential dangers associated with air conditioning equipment (as these are adversely used in the UAE owing to the high external temperatures) (Wong et al. 2008). To reduce energy expenses, businesses should be made aware of the need to prioritize employee health, particularly indoor air quality. As noted earlier, the energy economy has been prioritized above the safety of the building's tenants. Employers should be aware that if their workers are exposed to poor air quality at work, productivity is likely to fall, which might result in substantial financial losses for the company (Teklu et al. 2013).

2.6.4 Building characteristic

Building characteristics refer to the physical and structural features of a building. The size and layout of a building are important factors in its design. Building size can impact factors such as energy efficiency, cost of construction, and functionality. The layout of a building can impact how people move through the space, access amenities, and interact with others. Also, building materials can impact the durability, energy efficiency, and aesthetic appeal of a building. Common building materials include concrete, steel, brick, and wood. Also, HVAC systems are designed to regulate temperature, humidity, and air quality within a building. HVAC systems can impact energy efficiency and air quality, which can have a direct impact on the health and comfort of building occupants. Moreover, lighting is an important aspect of building design as it impacts both the aesthetic appeal and functionality of a space. Proper lighting can also impact employees' productivity and reduce energy costs. As the building is accessible, it is important for individuals with disabilities or mobility issues. Accessible buildings must be designed to meet certain standards that promote safe and efficient movement throughout the space. These building characteristics are just a few of the many factors that can impact building design and functionality. By considering these factors and others, architects and designers can create buildings that are safe, efficient, and aesthetically pleasing.

2.6.5 Buildings type

Buildings can be categorized into various types based on their structure, design, use, and construction materials. Here are some of the most common building types: Residential buildings, commercial buildings, industrial buildings, recreational buildings, religious buildings, and agricultural buildings

2.6.6 Well certified and noncertified building

A well-certified building is one that has achieved certification through the International Well Building Institute's (IWBI) WELL Building Standard. The Well building standard is a performance-based certification system that focuses on enhancing people's health and well-being in the built environment. To become well certified, a building must undergo a rigorous testing and verification process that evaluates its performance in several key areas, including air and water quality, nourishment, light, fitness, comfort, and mind. The certification process involves an on-site audit and performance testing to verify that the building meets the standard's requirements.

A non-Well-certified building is simply a building that has not undergone the certification process of the International Well Building Institute's (IWBI) WELL Building Standard. Such buildings may or may not incorporate design strategies and features that promote the health and well-being of their occupants. While non-Well certified buildings may still meet minimum requirements for health and safety, they may not have implemented advanced strategies to optimize indoor air quality (IAQ), lighting, acoustics, thermal comfort, and other factors that can affect occupant health and well-being. In addition, non-certified buildings may not have undergone a third-party verification process to confirm their performance in these areas.

Non-Well-certified buildings can still incorporate features and strategies that promote health and well-being, such as green spaces, natural light, and ergonomic furniture.

2.7 Classifications of engineering workplace in the UAE

2.7.1 Company's selection principles:

To investigate the IAQ, I have chosen two types of companies. According to the Department of Urban Planning and Municipalities in Abu Dhabi, engineering consulting offices are classified into different categories: private, first, and second.

To start with the first type, private category companies, as per the rules, must have at least a capital of 2 million dirhams. The projects incomes should not exceed 240 million, provided that the value of one of the projects is not less than 30 million. Also, the owners of these companies can participate in all project types. They have the capability to build an unlimited number of floors.(Municipalities 2018).

The second type, which is called the first category, must have a capital of one million dirhams. Provided that the value of one of the projects is not less than \$5 million. The owners of these companies can also participate in projects that do not exceed \$60 million. They have the capability to build up to nine floors.(Municipalities 2018).

The third category is called second," and it can be established without capital and a pocket that has an insurance policy of \$500,000. They have the capability to build up to the 3rd floor, and there is no specific value for any project. (Municipalities 2018).

For the purpose of this research, a second-category company is considered a low-cost company. The private and first categories are considered high-cost companies. (Municipalities 2018)

Many employees are affected by the air quality of the indoor environment, and there are many offices that are divided into two sections, and this is what we will study in this research. The low-cost offices have an area not exceeding 150 square meters and a number of

employees that does not exceed 100. They are located on the upper floors of buildings that are both residential and commercial at the same time. The maintenance is considered non-periodic, and the maintenance company is contacted only. When needed, which means that it does not need to put a large budget aside for periodic maintenance? As the ratio of lighting and ventilation usually does not match the conditions and specifications, and there are usually closed offices that do not have any view of windows or anything else. Also, in these companies, inferior and low-cost materials are used, and the furniture is usually old and made from materials that are not environmentally friendly, which causes psychological and health damage to the health of employees. Internal distribution also plays the largest role in these companies. And some of these companies lack certificates and qualifications.

As for the high-cost companies, they have an area of more than 200 square meters and a number of employees exceeding 150. They are located in a separate building and have a number of parking spaces for car owners. In these companies, a budget is usually allocated for periodic maintenance, and the maintenance company has periodic visits to follow up on the condition of the building. Since the ratio of lighting and ventilation usually matches the conditions and specifications, these offices lack closed offices that do not have any view. Usually in these companies, high-quality materials are used, which have a high cost, and the furniture is usually modern and made of environmentally friendly materials and colors that open the soul, which helps reduce psychological and health damage to the health of employees and contributes to increasing performance as well as internal distribution. The biggest role in these companies is that some of them are divided and others are put together and have offices open to each other. What distinguishes these companies is that they have several certificates and qualifications.

Table 2: Principles of selected companies. (Khaloud, 2023)

Company	Low- cost	High cost
Building type	Usually locate on mezzanine floors and above.	Mostly its stand-alone building.
Employee	Usually have not less than 5 employee and not more than 50 employees.	Usually have around 60 employee and more.
Area	Office area does not exceed 150 sqm.	Office area start from 160 sqm and above.
Certified building	Most of the companies located on building that are not certified.	Building must be certified.
Maintenance	It happens when they call for maintenance.	It happens regularly Because of some mess.
Ac type	Most of them used duct type.	All of them used different type of ac duct.
Furniture type	Most of them used modern and classic.	Most of them used modern and classic.
Equipment	Not more than 3 large printer and not more than 8 small side disk printers.	More than 5 large printers More than 10 side desk printers.

Material used	Some of them used carpet on floors. Others used ceramic tile floors. Most of them they used wallpaper and some of them used wall paint and wood decoration.	All of them they used ceramic tile floors. All of them they used glass in division. The small offices, Cement board wall to divide the offices, Used wall paint colors and wooden decoration.
Type of light	Celling light.	Strip light and spotlight.
Ratio of ventilation	Some of them less than its required and others accomplish the regulations which is 8% ventilation.	Always meet the regulation of 8% ventilation.

Chapter 3 : Methodology

3.1 Overview

The methodology of the research refers to the systematic process used to identify and solve a problem or answer a research question. It involves steps such as defining the research problem, reviewing literature, formulating hypotheses, choosing the appropriate research design, collecting and analyzing data, and drawing conclusions. The choice of methodology depends on the nature of the research problem and the research objectives, which can range from qualitative methods, such as observation and interviews, to quantitative methods, such as surveys and experiments. The ultimate goal of the methodology is to provide a robust and credible basis for the findings of the research. (Kunst et al. 2012).

Methodology refers to the systematic, theoretical analysis of the methods applied to a field of study. It is a framework or set of guidelines used to conduct research and solve a problem. The methodology defines the methods and techniques used to gather, analyze, and interpret data, and to make conclusions or recommendations. In general, a methodology provides a structure for conducting research, which makes it more reliable, valid, and repeatable (Valkenburg, Peter & Schouten 2006).

3.2 Literature review of methodology

A literature review methodology is a comprehensive analysis and evaluation of previous research studies and their methods. The purpose of a literature review of methodology is to understand the different approaches used in previous studies and identify the strengths and limitations of each method. This review allows researchers to gain insights into the best practices and make informed decisions on which methodology to use for their own research. A literature review of methodology can also help identify gaps in previous research and

suggest new areas for investigation. It is an important step in the research process and helps ensure that the chosen methodology is appropriate, rigorous, and relevant to the research (Abbott et al. 2019).

3.3 Simulation methodology

Simulation methodology is the set of methods and techniques used to model and analyze complex systems, processes, or phenomena using computer simulations. It involves creating a virtual representation of a real-world system and using mathematical algorithms and computational models to simulate its behavior over time. The goal of simulation methodology is to gain insights into the behavior of the system, make predictions about its future behavior, and optimize its performance (John 2018 n.d.).

Simulation methodology involves several stages, including defining the system to be modeled, selecting the appropriate simulation model, developing a computational algorithm, conducting the simulation, analyzing the results, and interpreting the findings. The choice of simulation methodology depends on the complexity of the system, the availability of data, and the research question being addressed. Some of the commonly used simulation methodologies include discrete event simulation, continuous simulation, agent-based simulation, and system dynamics simulation (Britannica 2023 n.d.).

3.4 Experimental methodology

Experimental methodology is a systematic approach used to design and conduct experiments to test a hypothesis or explore cause-and-effect relationships. It involves manipulating one or more independent variables to observe their effect on a dependent variable. The goal of experimental methodology is to establish causality, by establishing a causal link between the independent and dependent variables (Abazajian et al. 2009).

Experimental methodology typically involves several stages, including formulating a hypothesis, selecting the sample, manipulating the independent variable(s), controlling extraneous variables, measuring the dependent variable(s), analyzing the data, and interpreting the results. The choice of experimental methodology depends on the research question being addressed and the type of data being collected. Some of the commonly used experimental methodologies include true experiments, quasi-experiments, and natural experiments (Joseph 2009).

In a true experiment, the researcher has full control over the independent variable(s) and the conditions under which the experiment is conducted. In a quasi-experiment, the researcher does not have full control over the independent variable(s), and extraneous variables may influence the results. In a natural experiment, the researcher takes advantage of naturally occurring events or circumstances to study the effect of an independent variable on a dependent variable (Costello et al. 2009).

3.5 Survey methodology

Survey methodology refers to the study of methods used in conducting surveys, which are a type of research method used to collect data from a sample of individuals. It involves the design, administration, and analysis of surveys and questionnaires. A survey can be conducted in various forms, including online, by telephone, by mail, or in-person interviews. The survey methodology involves several steps: first defining the research problem and objectives. Second, choosing the sample and determining the sample size. Third, develop the questionnaire or survey instrument. Fourth pretesting the questionnaire. Fifth, administering the survey. Sixth cleaning and analyzing the data, then finally interpreting and reporting the results (Julie 2015).

The goal of survey methodology is to gather accurate and representative data, which can then be used to make valid inferences about the population being studied. The design of the survey and the selection of the sample size are critical to the validity of the results, as are the way in which the questions are framed, and the response options provided. Proper survey methodology helps ensure that the results of the survey are trustworthy and can be used to make informed decisions (Priscilla 2005).

3.6 Research methodologies pros and cons

There are various research methodologies, each with its own set of advantages and disadvantages. Some of the common research methodologies and their pros and cons are highlighted in the table 3 below. (Sharma 2017).

Table 3: pros and cons of different methodologies. (Khaloud, 2023)

Methodologies	Pros	Cons
Survey	• Large sample size. • Cost-effective. • Easy to administer.	• Limited to self-reported data. • Low response rate. • Potential for response bias.
Experiments	• Control over variables. • Ability to establish cause-and-effect relationships. • High internal validity.	• Limited external validity. • Experimenter bias. • Artificiality of experimental environment.

Observational Studies:	• Naturalistic setting. • Ability to study variables as they naturally occur. • Low cost.	• Difficulty establishing cause-and-effect relationships. • Observer bias. • Lack of control over variables.
Case Studies:	• In-depth investigation of a single case • Ability to understand complex phenomena. • High external validity.	• Limited generalizability. • Observer bias. • Difficulty controlling extraneous variables.
Qualitative Research	• In-depth exploration of attitudes, behaviors, and experiences. • Ability to understand complex phenomena. • High external validity.	• Limited generalizability. • Observer bias. • Difficulty measuring and quantifying results.

Mixed Methods Research	• Combines strengths of quantitative and qualitative research. • Ability to address research questions from multiple perspectives. • Increased validity and reliability.	• Increased complexity. • Difficulty integrating results from different methods. • Increased time and resources required.
------------------------	--	---

It's important to choose a methodology that fits the research question and the available resources. Indoor air quality has become an important public health issue in recent decades. People spend most of their time indoors: at home, in the office, at school, and in shopping malls. Many studies showed that the concentration of pollutants in indoor air is higher than in outdoor air due to the presence of indoor sources like (building materials, furniture, air fresheners, detergents, cooking, etc.) (Paciência et al. 2016).

As part of research, to enhance indoor air quality (IAQ), the study has to pass through several levels and recognize procedures that are being tested and proven to have the capability to improve indoor air quality (IAQ) and how it affects the employee's health and performance. This study focuses on different articles that use different methods to prove the best methodologies that mainly concentrate on enhancing indoor air quality and how it affects the employee's health and performance. To set a clear figure that helps to protect the employee's health. It will be easier to figure out the weak points and solve them. The research methodology must be a systematic approach through which the objectives of the research are attained, and the research questions are approached using different kinds of methods.

The research methodology usually opts for different methods and techniques that depend on the purpose and nature of the research. In the current research context, the methods used are based on (Patten & Newhart 2017). The given picture is a pictorial representation of the research onion. It works on principles and helps the researcher look for the appropriate methods for the research (Patten & Newhart 2017). The research plan is made to test the hypothesis and goes from the specific to the universal. The causal connection can be made on the basis of the theory, or the case example can be diverse in different contexts. Also, the logical design can be used to determine why this connection was better in the current context and what a logical design is used to determine the legitimate connection (Oliva & Kotabe 2019). In other words, the deductive approach is concerned with getting the deducing conclusion from the statement and determining it on the basis of the research method. For the current research, both inductive and deductive methods were utilized, and the research used field measurements to move from a general to a specific conclusion. Likewise, the questionnaire was applied to move from a specific to a general context (McGill et al. 2021).

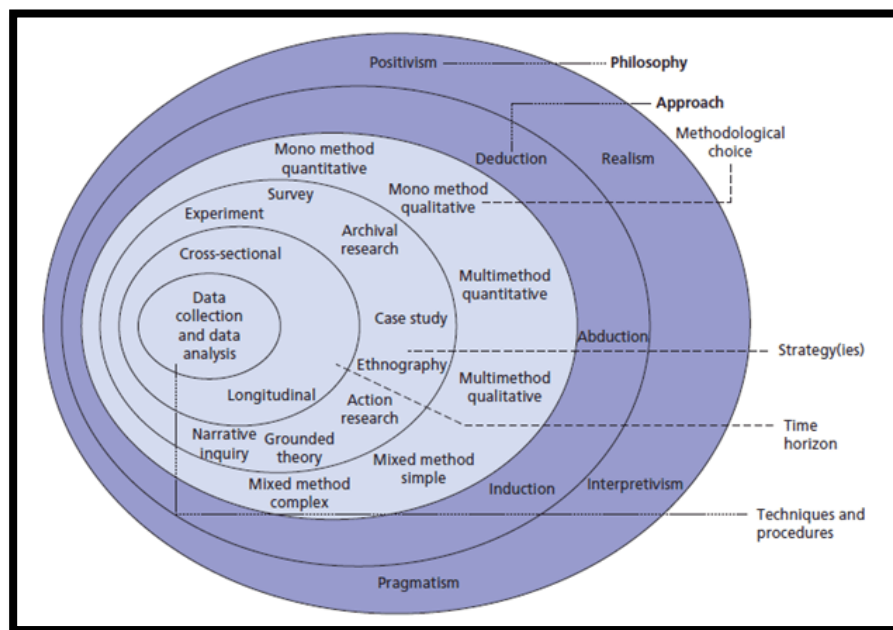


Figure 2: Pictorial representation of the research onion.

(Source: McGill et al. 2021)

The selection of methodology and tools for indoor air quality (IAQ) assessments depends on several factors, including the type of building, the specific contaminants of concern, and the resources available for the assessment. Some common methodologies and tools used in IAQ assessments include:

Thermal Comfort Assessment: Thermal comfort is an expression of satisfaction with the immediate thermal environment, and that satisfaction is assessed subjectively based on the mental state of the individual. Clothes, air temperature, relative humidity, and air speed all have a significant impact on thermal comfort. The occupant's expectations are also thought to be a significant psychological factor. Improvements in indoor air quality (IAQ) have a significant positive impact on productivity in buildings and help to create a healthy atmosphere. Hence, one of the goals of IAQ control is to maintain the ambient environment's temperature and relative humidity within an acceptable range (Marzouk & Atef 2022).

Direct-Reading Instruments: These instruments provide real-time readings of IAQ parameters such as temperature, relative humidity, and air velocity. They can also detect the presence of specific contaminants, such as carbon monoxide (CO₂), nitrogen dioxide (NO₂), and ozone (O₃) (Hirst, Michael, and Dana 2011 n.d.).

Building Assessment Checklists: These checklists are used to evaluate the building envelope, ventilation systems, and other elements that can impact IAQ. The checklists can also be used to identify potential sources of indoor pollutants and recommend actions to reduce their impact (Martin, Mel, and Susan 2015 n.d.).

Computer Simulation Models: These models use mathematical algorithms to simulate the flow of air and the transport of pollutants within a building. They can be used to assess the effectiveness of ventilation systems, predict the concentration of contaminants in different

areas of the building, and evaluate the potential impact of proposed changes to the building (Goyal & Anikender 2011 n.d.).

The selection of methodology and tools should be based on the specific needs of the IAQ assessment and the resources available for the assessment. In some cases, multiple methodologies and tools may be used in combination to provide a comprehensive understanding of IAQ within a building.

3.7 Design research philosophy

This study relied upon the notion of real independence from the human mind and, as such, assumed the scientific method to develop knowledge. Usually, scholars divide philosophy into two classifications: direct realism and critical realism. Direct realism argues that reality is whatever is seen; "what you see is what you get" (Saunders et al 2012). Accordingly, people can only see the world through their senses. In contrast, critical realism supposes that direct vision might display a misleading image of reality. Hence, the scholars of this philosophy believe in a critical analysis of reality (Novikov & Novikov 2012). Moreover, critical realism is an essential philosophy of the multi-level study to show the relationship between the individual and his or her surroundings. Therefore, to make the study more realistic, it is recommended to use the critical realism philosophy instead of direct realism as you can see in fig.3.

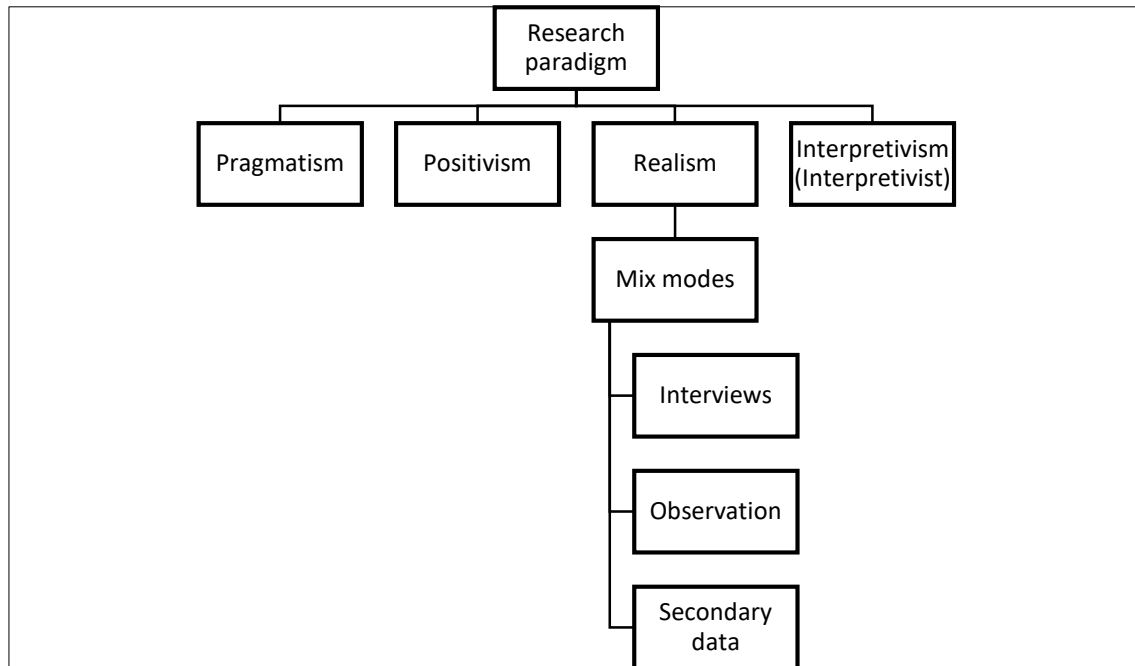


Figure 3: Critical realism philosophy of IAQ research.
(Source: Khaloud, 2023)

Having said that, this study adopted critical realism to investigate the effect of IAQ on employees' health and performance using a quantitative approach based on questionnaire data. This could answer the question, "What?" (Alashwal 2012). Accordingly, this section addresses the satisfaction of employees regarding the IAQ. However, before progressing in answering this question, there is a need for field data to determine the physical situation of the IAQ via numerical measurement. Utilizing this data could also answer the question "what" related to the level of contaminants in both companies' categories. As well as another field measurement related to temperature and humidity.

Since this study relies on mixed methods (quantitative and qualitative surveys), the study strategies should adopt a proper strategy. Scholars mentioned various research strategies such as grounded theory, action research, case studies, experiments, phenomenology, ethnography, and surveys (Denscombe 2010). However, this study adopted a survey and experiments for its quantitative approach. Even though phenomenology, action research, ethnography, and grounded theory are good approaches, they are not suitable for this study

since they concentrate on cultures, social lifestyles, and beliefs (Denscombe 2014; Amos et al. 2020).

Initially, field measurements were conducted to determine the level of contamination inside the buildings of construction companies in Abu Dhabi for both low- and high-cost companies. This measurement will guide the detection of the actual environmental hazards to which the workers may be exposed during their working hours and the hazards that they may face within their surrounding environment.

Additionally, questionnaires were collected from the same building's employees to investigate the extent of their satisfaction in terms of the work environment. The questionnaire is also utilized to investigate the effect of IAQ on employees' health and performance.

At the end, qualitative interview was conducted, open-ended questions were typically used to engage participants in conversation and obtain information about impacts of IAQ on employees' health and performance.

Scholars suppose the research structure is a logical sequence that includes logical questions along with initial data that leads to certain results. The research design could help scholars answer their research questions. Also, the research design introduces the research plan to conduct and achieve each objective, reaching the research aim (Wipt & George 2008; Costello et al. 2009; Lewis et al. 2012; Cheong Peng, Ali & Ahmad 2013; Thornhill & Fincher 2013) In this study, three objectives were developed in order to achieve the aim of the research.

The discussion of the research design argues about the survey and quantitative designs. The quantitative is the one where the data is measurable and countable in nature and thus has been in number form. The main objective of the research design is to find out the answer

to the research question and consider the objective point of view. The reality of this design is that it is objective in nature, and the statistical method is used to deduce the result and establish the relationship between the variables. This also makes the design dependent on existing theories (Rudick & Dannels 2018). On the other hand, the questionnaire method is a research instrument consisting of a series of questions for the purpose of gathering information from respondents. The questionnaire method is a survey research method in which a standardized questionnaire is used to gather data from a sample of individuals. It is convenient for the respondents that they can complete the questionnaire at their own pace, at their own time, and in their own place.

The research process outlined involves three stages. The first stage involves a review of related literature on IAQ and its relationship with employee performance. Secondly, field measurements were also conducted to determine the contaminant values (CO₂) in both companies in Abu Dhabi. Followed by determining the range of IAQ, i.e., temperature, humidity, and ventilation system. The third stage is a questionnaire to determine the health problems resulting from the work environment and IAQ. Followed by determining the effect of IAQ on an employee's performance. The study aims to evaluate the effect of IAQ on two categories of companies in Abu Dhabi. The key elements needed to assess the IAQ are thermal comfort, which includes temperature and relative humidity changes. A key element in regulating the indoor environment is air pressure. Carbon dioxide concentrations show how quickly air moves across tight spaces. A poisonous gas that causes poisoning is carbon monoxide. Several respiratory conditions can develop in people whose lungs have accumulated fine air particles. Finally, a key element in managing interior spaces is the

Interaction between the outdoor and indoor environments. (Marzouk & Atef 2022).

3.8 The population

This study was conducted in Abu Dhabi, UAE. In a more specific context, the population of the study is from the construction and engineering industries. Specifically, consultant companies' employees who work in the offices. To illustrate, the sector was chosen as the construction area is one of the highest driving sectors of the economy in the UAE, and hence the study could help organizations and higher authorities focus on the said variables in the context of the UAE. The participants were chosen according to convenience sampling and quota sampling. Participants were selected based on their availability and willingness to take part in the research. According to Sharma in 2017, quota sampling is very helpful when you are attempting to build a sample that is as representative of the population as possible in order to acquire a probability sample.

3.9 Sampling technique

Sampling is the method that is used based on the method selected, and therefore it could also be chosen based on the convenience of the researcher. To choose the sample from the large population, there can be several methods that can be utilized and analyzed, and depending on the objective of the research, the sampling technique is selected. There are usually two types of sampling techniques. One of them is probability sampling, and the other is known as non-probability sampling. For probability sampling, the most common method is simple random sampling, where all the research participants are usually given the chance to be part of the research and hence are randomly selected. For this research type, the sampling frame is also known, which includes all the important characteristics of the research. The other is non-probability sampling, where the participants in the research are made part of the research based on convenience (Sharma 2017).

This study relies on non-probability sampling. Nonprobability sampling is a sampling technique that does not provide a basis for any opinion. This type of sampling has various research advantages, such as the ease of identifying samples and collecting data. (Elias, Cavana & Jackson 2001). On the other hand, for the purpose of this research, the purposive sampling method is being used to gather the data in order to gain a representation of the study's data. Purposive sampling can be selected based on the purpose of the study and knowledge about the population and its elements. Purposive sampling can be used when the sample possesses desirable information and conforms to some criteria set by the researcher, as stated by. This sampling is suitable when the population of the study is difficult to identify or when there is a trade-off between time and cost (Elias, Cavana & Jackson 2001; Babbie 2010).

The employees within these two companies were chosen for the interest group as they were accessible and could offer the time to react. The research sampling was restricted due to the availability of resources to carry out the investigation. (Hameed: Taherdoost 2016).

The method of data analysis can affect the sample size. For example, Elias, Cavana & Jackson in 2001, recommended that the sample size be several times the number of variables in the study. Hair et al. in 2006 recommended a minimum ratio of 1:5 variables to cases (i.e., respondents). However, the number of cases should not be less than 100 to run multivariate analysis, specifically factor analysis (Hair et al. 2006).

3.10 Data collection method

Data collection is a requirement for performing research. The information needed to investigate a research problem after proper design is referred to as data. The significance of data collection comes from the fact that the research could not be conducted without collecting the necessary data. Both primary and secondary data are possible. Generally, the

techniques of primary data collection in behavioral sciences are directly collected from the participants in the research. Thus, the primary source of data is original, and to achieve the objective of the research, no third party is involved. In this regard, the primary data can be quantitative or qualitative in nature. (Ingwenagu 2016).

In this regard, the data collection instrument is used to collect information from the participants in the research. For this research, a questionnaire, quantitative (field measurement), and face to face interview methods are used to collect the data. (Ingwenagu 2016).

3.10.1 Quantitative method (field measurement)

Quantitative purists articulate an assumption that is consistent with what is commonly called the positivist paradigm and believe that social observations should be treated as entities in much the same way that physical scientists treat physical phenomena. They maintain that social science inquiry should be objective. Quantitative methods are useful in dealing with precise and systematic measurements of verifiable quantities, such as climate data.(Groat and Wang 2013). Researchers in the field of thermal comfort studies have traditionally employed quantitative approaches in data collection and analysis (Humphreys et al 2007). The quantitative approach uses a systematic, standardized approach and employs methods such as surveys. The main advantage of this research method is its richness in use in the comparison of objective indoor thermal conditions with the corresponding subjective thermal comfort responses of participants (Candido et al. 2010; Efeoma 2017). Adopting a quantitative approach in collecting data for this study might be justified since it is useful in dealing with precise and systematic measurements of quantities such as climate data. Moreover, it checks the limitations of the qualitative approach and also the likely biases in interpreting the data, as well as the generalization of the research findings by the researcher.

Researchers in the field of adaptive weather or environment studies often prefer using the quantitative approach (Munonye et al. 2022).

The field measurement technique is used since the purpose of the study is to determine the indoor air quality (IAQ) in the office environment in Abu Dhabi, UAE, as well as the influence of IAQ on employees' health and performance. Field measurements were conducted to gather information about the indoor air environment. The most important parameter taken into consideration to evaluate indoor air quality (IAQ) was thermal comfort, such as temperature and relative humidity, which vary according to occupant preferences, CO₂, and ventilation systems. Since there are few studies in the setting of the UAE, adoption of the field measurement approach can help in discovering a scarcity of information on the issue and extracting precise information. This case and research are based on a real-life research topic. As a result, actual data is collected using a field measurement style.

3.10.2 Questionnaire

Moving to a survey, which is a stage of collecting information through a sample of people, each of whom answers individually, According to Presser in 1984, survey is any data gathering method that collects data by giving respondents a standardized questionnaire. According to Saris and Gallhofer in 2007, surveys are ideal for documenting perceptions, attitudes, beliefs, or knowledge within a well-defined and predetermined sample of people. A "good" open-ended question should be specific enough to provide a coherent answer for all respondents, but broad enough to allow for a wide range of responses. The researchers went on to say that questionnaire surveys frequently involve correlational research or testing among variables. To put it another way, survey research enables researchers to identify correlations between variables (Raulin 2010).

Researchers should examine the quality of the questionnaire before distributing it to the respondents. Before implementing the final questionnaire survey, Davies and Smith in 2005 argued that the questionnaire must first undergo pilot testing. A small sample of respondents from the study population is evaluated during this early stage to assess and enhance the suitability and quality of the questions. There are often several ways to evaluate the questionnaire, such as (Saris & Gallhofer 2007): (a) Verify the questionnaire's face validity; (b) Control the questionnaire's routing; (c) Use an instrument to predict the question quality; (d) Use a pilot study to test the questionnaire. Following that, the questionnaire has to be corrected in accordance with input from its verification and testing. This is to make sure that, following rectification, the reply truly comprehends the question (Sekaran & Bougie 2013). The finished questionnaire can be printed and distributed to the respondents for data collection once it has been finalized and approved. The researchers would analyze and evaluate the information gleaned from the surveys after receiving the completed forms back.

Open-ended or closed-ended questions are two common types of questions that can be included in a questionnaire. Open-ended questions, however, are not appropriate for quantitative methods. As a result, this study utilized closed-ended questions, such as multiple-choice and Likert-scale inquiries. According to Saunders et al. in 2009, answers to closed-ended questions are frequently short and straightforward. The respondent is simply required to select one of the possible replies. In the meantime, they assist the researchers in conveniently coding the material for data analysis (Bougie 2009; Ishaq, Iqbal & Zaheer 2009).

An example of a multiple-choice question is stated as follows (see Appendix A):

How long have you been involved in the building maintenance industry? ☐ Less than 5 years ☐ 6 - 10 years ☐ 11 - 15 years ☐ More than 15 years

In Likert-scale questions, researchers arrange the choices on a continuum, with extreme positions at the end points. Commonly, a 5-point scale is the most commonly used scale in questionnaires (Saunders et al., 2009; Sekaran and Bougie, 2009; Sekaran & Bougie 2013). For instance, respondents might be asked to indicate the degree of influence with a statement as stated below (see Appendix A): Please rate the degree of influence of the "client's commitment" in obtaining an adequate maintenance budget, information, and/or skill and knowledge.

1 2 very low degree 3 4 5 Very high degree

The survey approach was discovered to be appropriate for the goals of this study. So the quantitative data was gathered through a questionnaire survey. Figure 5.4 summarizes the whole questionnaire survey procedure. Pilot research was conducted before the preliminary questionnaire was finalized. Corrections were then made in response to comments and input. The demographic and content questions were grouped into two primary groups for the questionnaire (see Appendix A). Multiple-choice demographic questions included the respondent's specifics and building information.

The collection of the data for the primary source is done using the questionnaire. The questionnaire is important to gather standardized data and draw generalized conclusions. The survey is used to compare the information between both companies' categories and also to get rapid results. Moreover, they are created with care in order to avoid giving the wrong information regarding the topic. The questionnaire was designed keeping in mind the goals and objectives of the research. This method was selected because the questionnaire is one of the most commonly used instruments for collecting data from participants. For this questionnaire, a 5-point Likert scale is used, which ranges from strongly agreeing to strongly disagreeing. Also, the questions included in the questionnaire are closed-ended in nature.

For the interview part, the interview guideline is made up of a pre-set of questions of a semi-structured nature focusing on indoor air quality (IAQ) in the workplace environment. Also, the question will revolve around the impact of IAQ on the employees' health and productivity (Ali & Bhaskar 2016).

For the data collection, the guideline and the questionnaire are sent to the participant to let them know what kind of questions they are expected to answer and what questions are related. This questionnaire would be left with the participant and could be collected back in a week.

The sample that the survey will be distributed to them must be taken randomly, the sample must be moderate to meet the required purpose, and it must be clear and easy. Surveys are usually divided into several sections, including: The first step in making plans is to identify the targets of the investigation. A survey's targets need to be as specific, clear-cut, and unmistakable as possible. Planning the questionnaire is one of the most vital levels of the survey improvement process. All surveys taken critically by social experts and officials use a few forms of random sampling. A critical part of a well-designed survey is to "plan in" along the way. One of the most common planning mistakes is underestimating the time required. A well-designed survey does not come "cheap," despite the fact that some are more cost-efficient than others. Mail surveys are the most common instance of a self-suggested statistical series.

Because the questionnaire is used to get information from two organizations in order to make comparisons between them, the quantitative method is used. Additionally, the case study is applied in order to get information from Abu Dhabi as a high-cost company and as a low-cost company. In order to draw comparisons between the case studies of both firms,

the two types of data were gathered, and comparisons were made based on both types of data, i.e., field data, interview and questionnaires (McGill et al. 2021).

3.11 Investigation

I investigated six companies with field measurement methodology using three devices. In order to reach the causes of the problem and to know more about our research question, all these companies are in Abu Dhabi, and it's a companion between low- and high-cost companies.

3.11.1 4 in 1 Environmental meter device

The environmental meter is used to measure moisture, temperature, air speed, air pressure, and sound level. Environmental quality and the extent of efficiency can be measured through environmental quality polls that help determine the extent of environmental tension and the extent of the impact of internal air. This device guarantees the maintenance of areas where more important environmental factors are under control.(Extech 2009)

The main goal of environmental monitoring is to manage and reduce the impact of the organization's activities on the environment, either to ensure compliance with laws and regulations or to alleviate the risk of harmful effects on the natural environment and protect human health. (Extech 2009)

3.11.2 Air quality CO2 meter device

The presence of high levels of carbon dioxide is often due to insufficient ventilation. Some people in high-level buildings may complain of carbon dioxide that may cause them harm, fatigue, and headaches. The cause of these symptoms can be a mixture of carbon dioxide and many other pollutants that occur in a bad ventilation space. Carbon dioxide in

the air heats the planet, causing climate change. This causes poor work performance and increased health symptoms. This device measures carbon dioxide (CO₂) CO within the spaces. This device issues a warning alarm when the concentration level exceeds. (Extech 2009)

3.11.3 Sound level alert device

The SL130W is a sound level meter with an alarm. It is a device through which sound levels can be continuously monitored throughout the day. This device mounts to a wall, desk, or tripod to give a very clear signal when noise levels are too high. Mains or battery-operated bright LED's alert (flashing red or green) when volume is too high or too low. The green LED lights indicate that the volume is acceptable. (Extech 2009).

3.12 Data analysis

The data analysis method is described as an approach for interpreting and synthesizing qualitative data. For the questionnaire part, the data is first screened and then entered in SPSS version 21 for the analysis to be done. In this regard, the inferential and descriptive statistical analyses are done. The descriptive analysis is done to gain information on the demographic information, and this would give a general overview of the result, including the percentage and frequency of gender, level of education, experience, and number of employees in the organization, along with their position. The second part is the inferential statistics, which include the hypothesis checking relationship between the variables. So that generalizability can be made after a correlation is created. Pearson correlation will be done. Also, regression analysis will be done to get the ANOVA and correlation of the relationship (Ali & Bhaskar 2016).

Once the information has been acquired, the researchers will use it to assess the findings. In the data-analysis phase, statistical processes are frequently employed to define and assess numerical data as well as to assess the importance of data and observations. The statistical findings would then show which variables had a cause-and-effect connection. (Davies and Smith 2005). For instance, researchers frequently use the SPSS program to examine the data using methods like regression analysis and correlation testing. The most popular and effective statistical analysis program, according to Hoxley in 2008, is SPSS. The sort of analysis used must be suitable for the study's objectives and answer the research questions.

In this stage, the researchers must exercise critical thought to assess the reliability of the data they have gathered and examined. The statistical analysis will generate tables and figures to turn the data into statistical value. The statistical information can then be used to provide clarifications.

3.12.1 Frequency distributions and descriptive statistics

For the majority of nominal and ordinal data in research, statistical simplification involving frequency computation is performed. "Frequency distributions" are a technique for categorizing the data, which is typically displayed in table form (Graziano and Raulin, 2010). Since the information gathered from the questionnaire is nominal and ordinal, "frequency distributions" were used for the study's data analysis.

Measures of central tendency, variability, and association in research data are covered by "Descriptive Statistics" (Graziano and Raulin, 2010). This technique was used to evaluate the data collected in this study in order to meet the study's goals, which were to demonstrate a relationship between preventative maintenance and maintenance performance and to construct a prediction model for maintenance performance.

The mean and standard deviation were employed in this study to measure the data. The average or arithmetic average of the scores in a distribution is known as the mean (Diamond and Jefferies, 2006; Graziano and Raulin, 2010). By adding up the scores and dividing by the total number of scores, the mean ($\bar{x}$) is calculated as follows:

where Σx = sum of the X scores; N = the total number of scores.

When the mean is being employed as a measure of average, a standard deviation is used (Diamond and Jefferies, 2006). The difference between a specific observation and the mean, or residuals, is typically represented as the standard deviation. As a result, data are more evenly distributed the higher the standard deviation. A wider distribution of data demonstrates the data's unpredictability and gets rid of the bias problem. The following is the standard deviation (S) equation:

where x = observations; $\bar{x}$ = mean; n = total number of observations.

Bi-Variate Analysis – Spearman Rank-Order Correlation

Correlation, as defined by Diamond and Jefferies in 2006, measures the relationship between two continuous variables. In order to determine the strength of the association between the variables of preventative maintenance, participatory mechanisms, and maintenance performance, this study employed a correlation test. The correlation coefficient (r), which can be used to measure an association, can be computed using the following formula:

Where, $(x - \bar{x})$ = residual of variable X; $(y - \bar{y})$ = residual of variable Y

However, SPSS software can be used to examine the data. For various forms of data, there are frequently a number of correlation coefficients, including Spearman rank-order correlation, Pearson product-moment correlation, and others. The data that were gathered for this study are on a nominal and ordinal scale. According to Graziano and Raulin in 2010,

the suitable coefficient to examine either or both independent and dependent ordinal variables is the Spearman rank order correlation. The following formula is used to determine the Spearman rank-order correlation: n is the quantity of data pairs, and d is the rank difference. As a result, this study used Spearman rank-order correlation (He et al. 2013).

3.12.2 Reliability and validity

Concepts like validity and reliability are used to assess the caliber of research. They demonstrate how effectively a technique, method, or test measures something. Validity is concerned with a measure's accuracy, whereas reliability is concerned with its consistency. The validity of the data is about the completeness and correctness of the data, which are important factors to analyze the data and for the workforce of the organization (Leech & Onwuegbuzie 2011). The integrity of the data is important, which is usually used to manage the quality of the data by ensuring regularity. It is important to ensure that the data in a study is reliable by using a variety of strategies to enhance the quality of the data and increase the accuracy of the analysis. In general, examining the consistency and stability of data helps determine its reliability (Sekaran & Bougie 2013). Cronbach's alpha is frequently used in social science research to assess the accuracy of the data. This metric shows how consistently the data are collected. It is calculated using the average intercorrelations among the items used to measure the result, in other words (Sekaran & Bougie 2013). The average intercorrelation of the test items and the number of test items can be used to calculate Cronbach's alpha. The alpha value should be more than 0.70 to indicate adequate reliability. However, Leech et al. asserted in 2011 that when there are only a few items on the scale, a lower alpha of 0.60 to 0.69 is acceptable. A coefficient of less than 0.60 is regarded as having poor dependability, while a coefficient of more than 0.80 is considered to have acceptable reliability, according to Sekaran and Bougie in 2009.

In this study, the dependability of the gathered data was tested by performing reliability analyses for both the characteristics of scheduled maintenance and condition-based maintenance. The scale and data obtained were reliable, as shown by the Cronbach's alpha coefficients of 0.741 and 0.888 for scheduled maintenance characteristics and condition-based maintenance, respectively.

3.13 Chapter summary

This chapter contains detailed information on the methodology of the research. The first phase of the method consists of the discussion of the research framework, which includes the philosophy, assumptions, research approach, and research design. This is followed by a discussion of the population, sample size, and sampling technique. The research process and data collection method were also discussed, along with the research outline and the research analysis method.

Chapter 4 : Case studies and measurements

4.1 Background

This section will present comprehensive case studies for the companies that I selected for my research. In this division, I will provide an objective interpretation of the plans and office types and the number of employees in each. As well as a clear explanation of the selected spaces that investigated in each company. I will try to present the plans with the selected spaces highlighted with different colors and some real photos that help to understand the actual photos. Furthermore, I will try to describe each device, how it works, and how to get an accurate reading from each device. Finally, I will present the reading that I took from each space in those companies.

4.2 Case studies

The following table present the summary of the selected case studies in term of office areas, locations, types, and number of the employees.

Table 4: summary of companies' areas, locations, types, and number of employees.

company	Area	Location	Type of office	Number of the employees
Low cost 01	100 sqm.	Mussafah	Mezzanine floor	40 employees
Low cost 02	80 sqm.	Abu Dhabi	Mezzanine floor	30 employees

Low cost 03	95 sqm.	Abu Dhabi	Mezzanine floor	35 employees
High cost 01	160 sqm.	Abu Dhabi	Stand alone	155 employees
High cost 02	200 sqm.	Abu Dhabi	Stand alone	120 employees
High cost 03	300 sqm.	Abu Dhabi	Stand alone	250 employees

(Source: Khaloud, 2023)

4.2.1 Case study # 1

Low-Cost Company/Engineering Consultant Company/Located in Abu Dhabi in Mussafah It is a flat on the mezzanine floor that consists of six offices and is around 100 square meters. Consist of 1 reception, 1 waiting area, 6 offices, 2 bathrooms, 1 meeting room, 1 store, and 1 manager's office. The total number of employees working in it is 40.

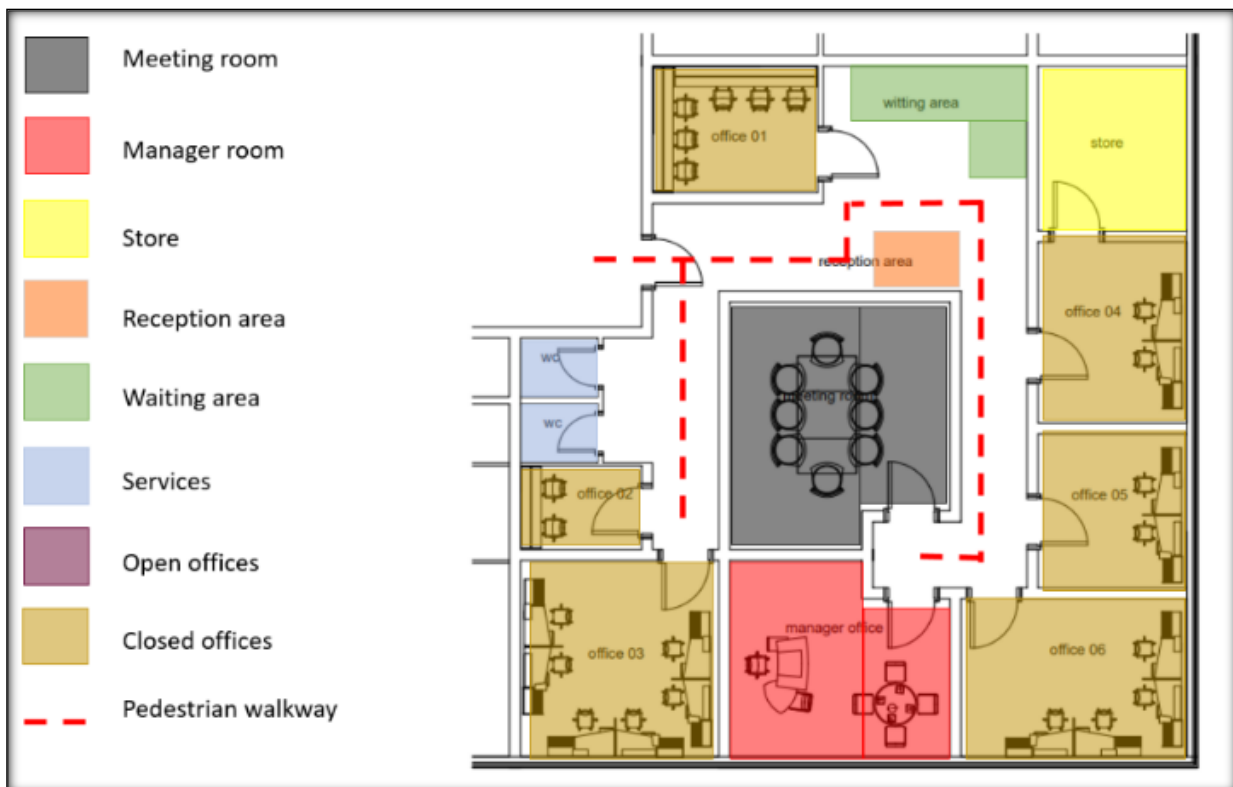


Figure 4: Low-cost company analyses.

(Source: Khaloud, 2023)

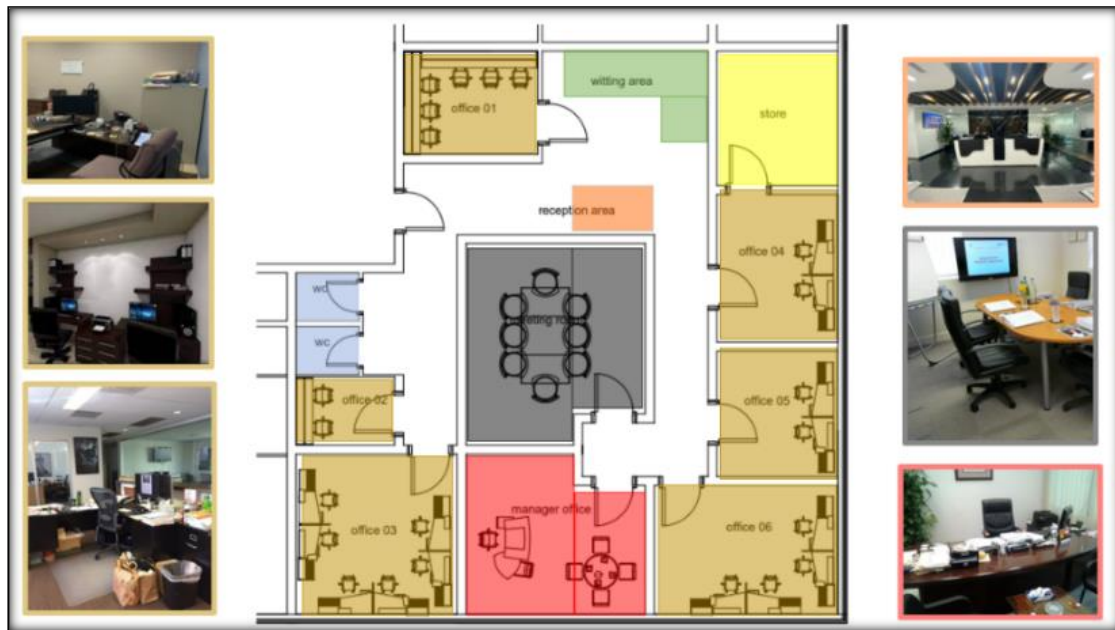


Figure 5: Low-cost company analyses with real photos.

(Source: Khaloud, 2023)

4.2.2 Case study # 2

Low-Cost Company / Engineering Consultant Company/ Located in Abu Dhabi

It is a flat on the mezzanine floor, and it is around 80 square meters. It consists of 4 offices, 1 reception, 1 waiting area, 2 bathrooms, 1 store room, 1 meeting room, and 1 manager room. The total number of employees working in it is 30.

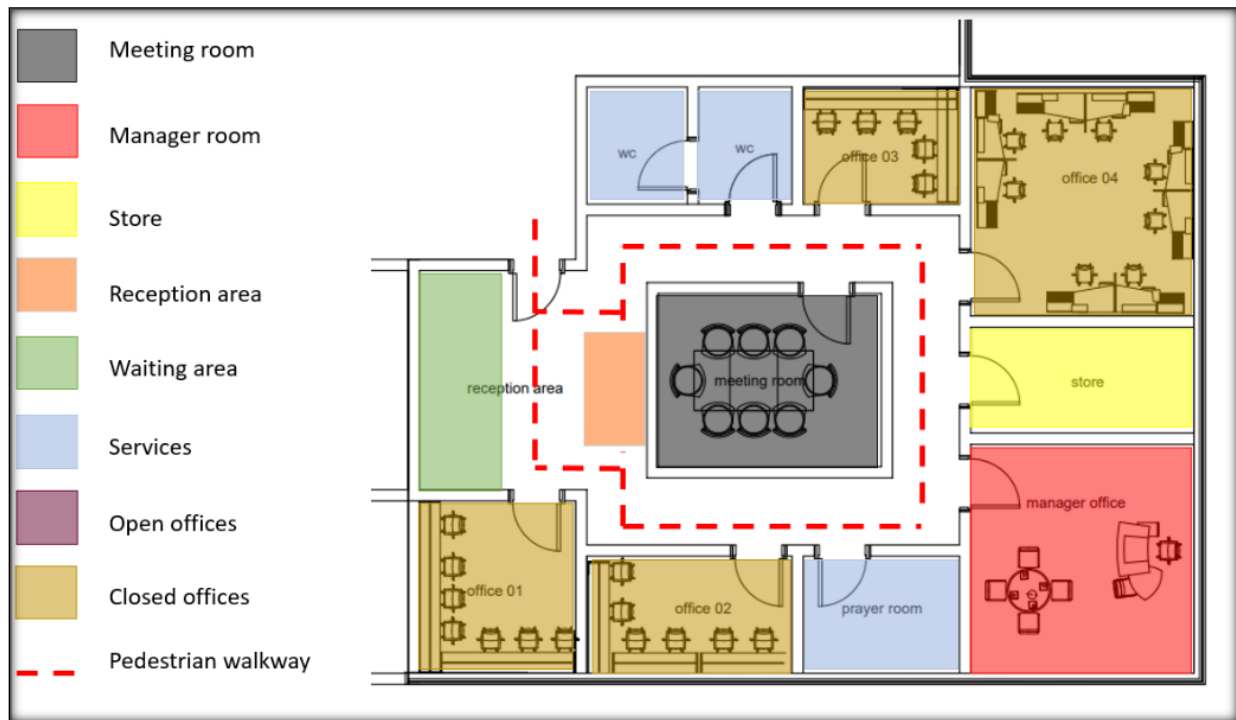


Figure 6: Low-cost company analyses.

(Source: Khaloud, 2023)

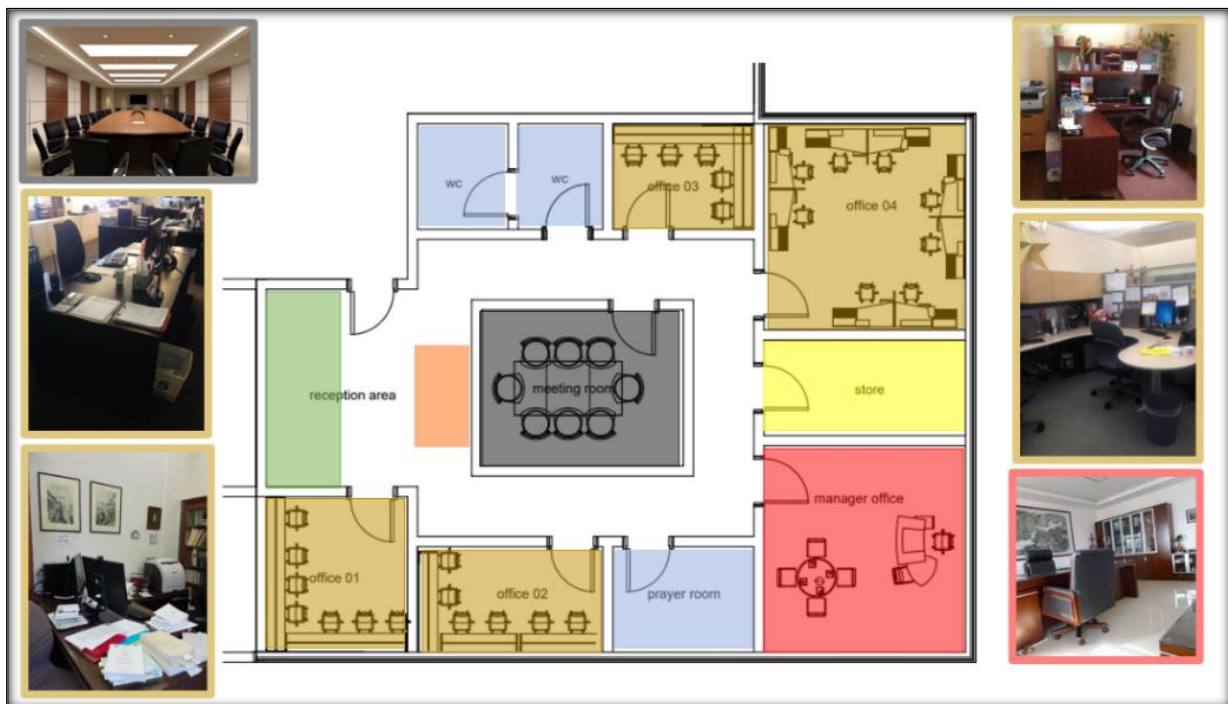


Figure 7: Low-cost company analyses with real photos.

(Source: Khaloud, 2023)

4.2.3 Case study # 3

Low-Cost Company / Engineering Consultant Company/ Located in Abu Dhabi. It is a flat on the mezzanine floor, with a space of around 95 square meters. It consists of 2 offices, 1 reception, 1 waiting area, 1 bathroom, 1 store room, and 1 manager room. There was no meeting room. The total number of employees working in it is 35.

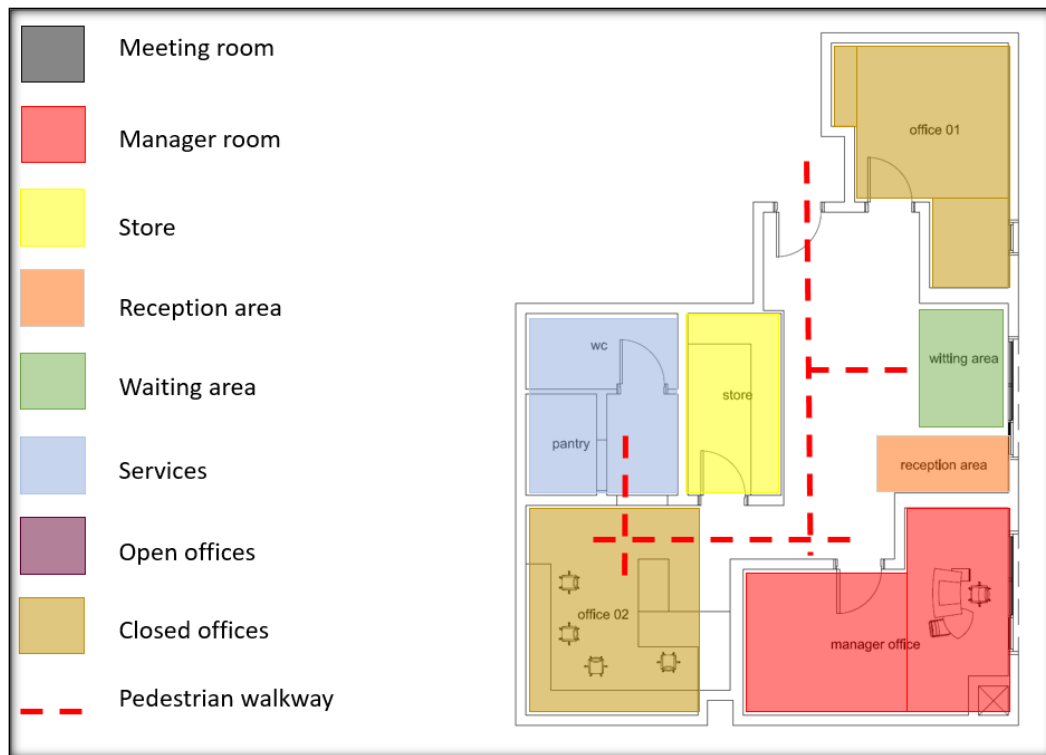


Figure 8: Low-cost company plan analyses.

(Source: Khaloud, 2023)



Figure 9: Low-cost company analyses with real photos.

(Source: Khaloud, 2023)

4.2.4 Case study # 4

High-Cost Company / Engineering Consultant Company/ Located in Abu Dhabi. It is a stand-alone building with one floor. It is around 160 square meters. Consist of 3 offices, 2 large open-plan offices, 2 meeting rooms, one of them with natural daylight and the second one located in the middle space, 3 stores, 1 manager room, 2 bath rooms, 1 prayer room, and a reception area. The total number of employees working in it is 155.

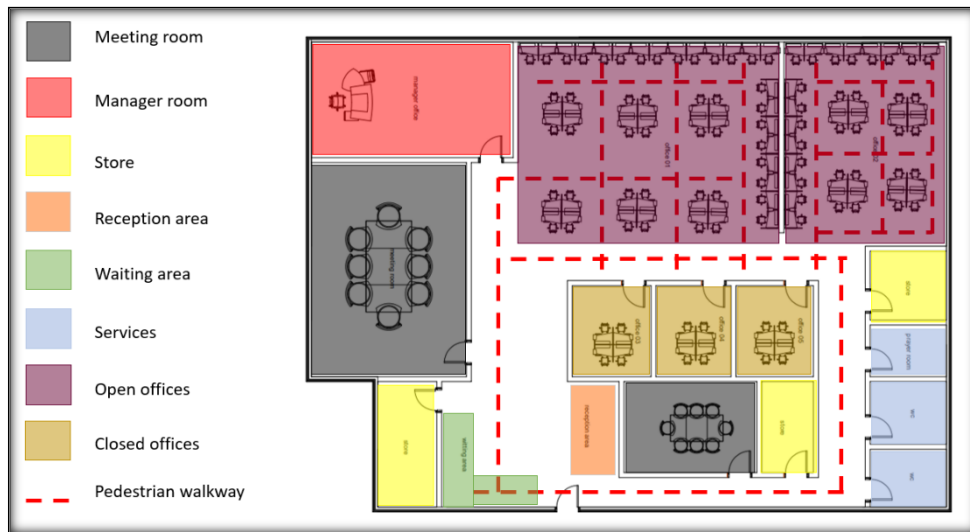


Figure 10: High-cost company plan analyses.

(Source: Khaloud, 2023)

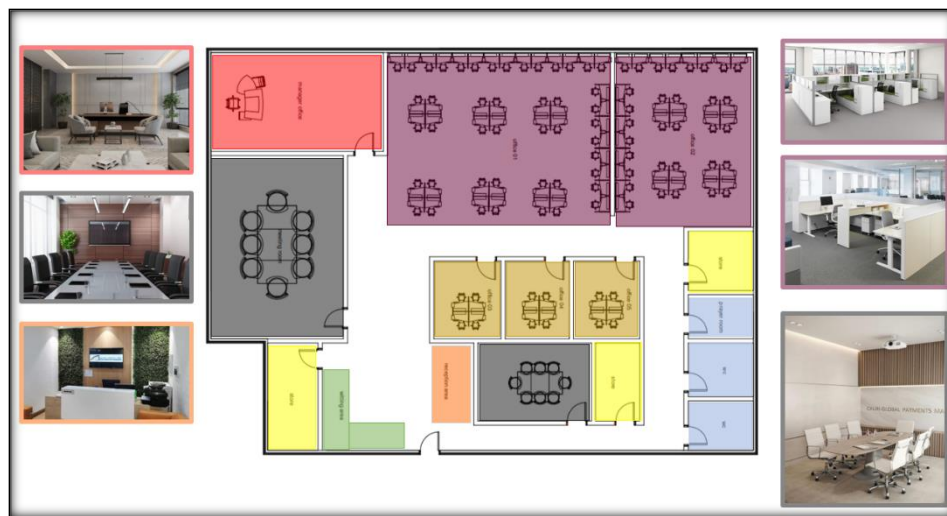


Figure 11: High-cost company plan analyses with real photos

(Source: Khaloud, 2023)

4.2.5 Case study # 5

High-Cost Company / Engineering Consultant Company/ Located in Abu Dhabi. It is a stand-alone building with one floor. It is around 200 square meters. Consist of 5 offices, 1 open-plan office, 2 meeting rooms, each of them with natural daylight, 2 stores, one of them

located in the meeting room and the other in the manager's room, 1 manager's room, 2 bath rooms behind the waiting area, 1 waiting area, and 1 reception area. The total number of employees working in it is 120.

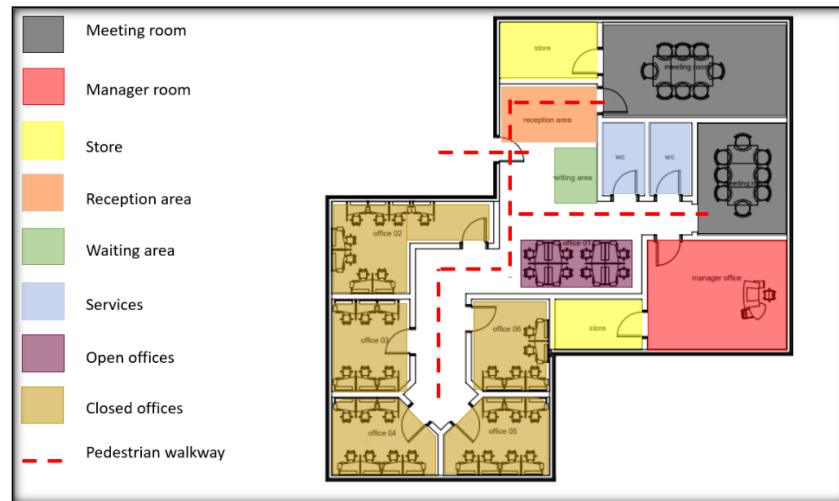


Figure 12: High-cost company plan analyses.

(Source: Khaloud, 2023)

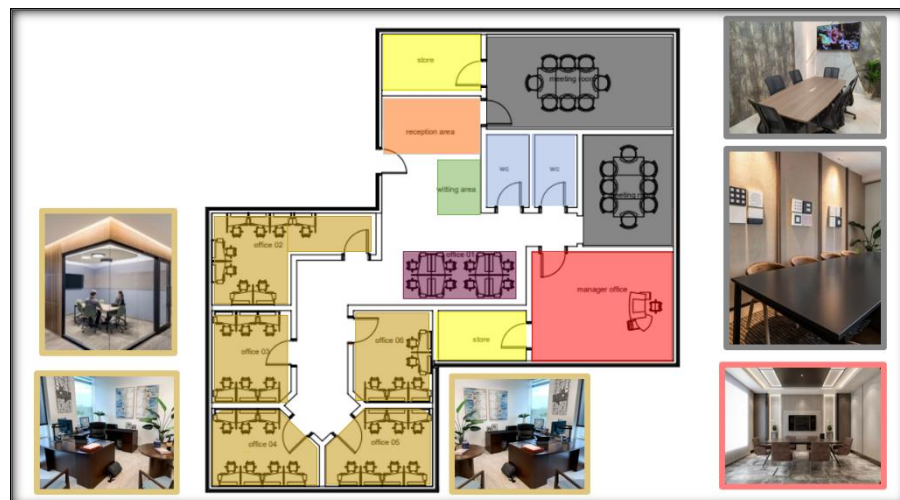


Figure 13: High-cost company plan analyses with real photos.

(Source: Khaloud, 2023)

4.2.6 Case study # 6

High-Cost Company / Engineering Consultant Company/ Located in Abu Dhabi. It is a stand-alone building with one floor. It is around 300 square meters. Consist of 7 offices, 5 open-plan offices, 2 meeting rooms, both of them with natural daylight, no stores, 1 manager room, 2 bath rooms, 1 waiting area, and a reception area. The total number of employees working in it is 250.

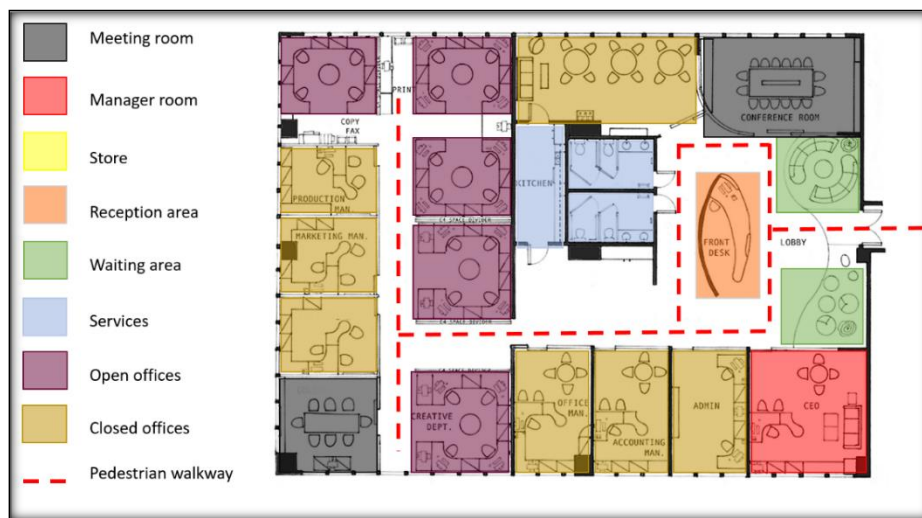


Figure 14: High-cost company plan analyses.

(Source: Khaloud, 2023)

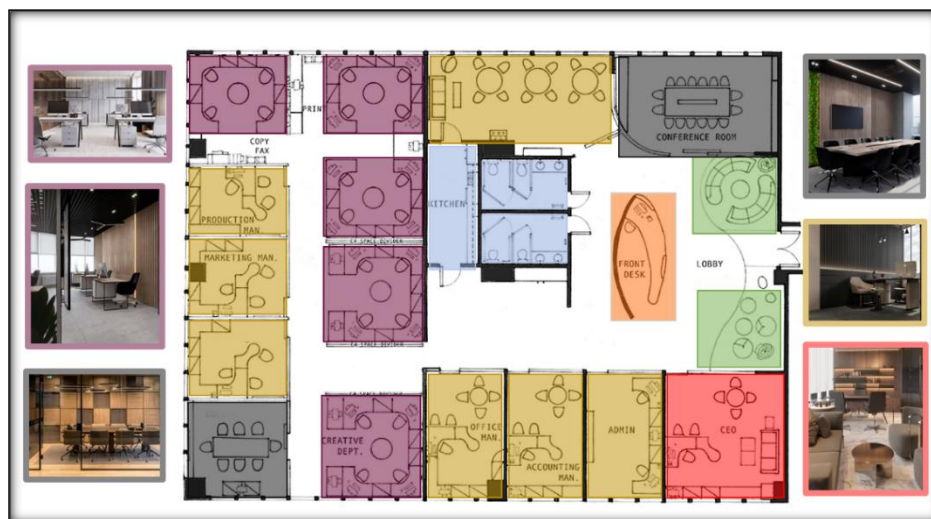


Figure 15: High-cost company plan analyses with real photos.

(Source: Khaloud, 2023)

4.3 Field measurements

Field measurements provide precise information about dimensions, location, and other vital details necessary for my research. This ensures that my work is constructed or designed according to the required specifications.

Additionally, field measurements enable the verification of design accuracy, which is particularly crucial in construction projects where errors or omissions may occur during the design phase. Quality control is another significant aspect, as field measurements allow for monitoring and assessing the quality of construction work, ensuring compliance with design specifications and desired standards. Furthermore, field measurements contribute to safety by identifying potential hazards on a construction site, such as uneven surfaces, excessive heights, or areas prone to falling objects. Cost control is also enhanced through field measurements by identifying material waste and inefficient work practices, ultimately reducing project expenses. In conclusion, field measurements are indispensable for maintaining accuracy, safety, and quality in construction and engineering projects. They provide essential data for design verification, construction monitoring, and overall quality control throughout the project lifecycle.

I interviewed the employees of the six companies through the field measurement that I did. I noticed many people answering frankly and more accurately, so I resorted to conducting personal interviews with the employees. I touched on important issues about the quality of the internal environment and how it might affect their health and productivity, and the matter is evident in my continuing this work with love and effort. In order to achieve accuracy in the information and reach correct and sufficient information, which is considered complete and incomplete information, the most important thing is that this information employs the information that I receive from employees to enhance their satisfaction, the level

of their health and work, and how to develop the internal environment in order to achieve health and productivity.

Throughout the field measurement, I have used three different devices to investigate the IAQ in terms of air velocity, temperature, humidity, lighting, CO2 level, and sound levels.

4.3.1 4 in 1 environmental meter



Figure 16: 4 in 1 Environmental Meter.

The environmental meter is used to measure moisture, temperature, air speed, air pressure, and sound level. Environmental quality and the extent of efficiency can be measured through environmental quality polls that help determine the extent of environmental tension and the extent of the impact of internal air. This device guarantees the maintenance of areas where more important environmental factors are under control. The main goal of environmental monitoring is to manage and reduce the impact of the organization's activities on the environment, either to ensure compliance (with laws and regulations or to alleviate the risk of harmful effects on the natural environment and protect human health. (Extech 2009).

4.3.2 Air quality CO2 meter



Figure 17: Air quality CO2 meter.

The presence of high levels of carbon dioxide is often due to insufficient ventilation. Some people in high-level buildings may complain of carbon dioxide that may cause them harm, fatigue, and headaches. The cause of these symptoms can be a mixture of carbon dioxide and many other pollutants that occur in a bad ventilation space. Carbon dioxide in the air heats the planet, causing climate change. This causes poor work performance and increased health symptoms. This instrument measures carbon dioxide (CO₂) CO in the spaces. This device issues a warning alarm when concentration levels exceed. (Extech 2009).



Figure 18: Sound Level Alert.

4.3.3 Sound level alert

The SL130W is a sound level meter with an alarm. It is a device through which sound levels can be continuously monitored throughout the day. This device mounts to a wall, desk, or tripod to give a very clear signal when noise levels are too high. Mains or battery-operated bright LEDs alert (flashing red or green) when volume is too high or too low. The green LED lights indicate that the volume is acceptable. (Extech 2009).

4.4 Office environment air velocity

Air velocity plays a crucial role in office environments, impacting occupant comfort, health, and productivity. One key consideration is thermal comfort, as air velocity can cause discomfort and drafts at high speeds, while low velocities can result in stagnant air and poor distribution. To maintain optimal thermal comfort, it is generally recommended to aim for air velocities between 0.15 and 0.25 meters per second (30 to 50 feet per minute).

Additionally, air velocity influences indoor air quality. Higher velocities can enhance the spread of pollutants, while lower velocities may lead to the accumulation of pollutants and particulate matter. Proper air circulation is essential for maintaining a healthy indoor environment and preventing the buildup of contaminants.

Employee productivity is also affected by air velocity. High velocities can create distractions and discomfort, negatively impacting cognitive performance and focus. Conversely, low velocities can induce drowsiness and reduce motivation. Striking a balance in air velocity helps promote an environment that supports optimal productivity.

Building design factors contribute to air velocity levels. The location and configuration of air supply and return vents, the use of ceiling fans or other air circulation devices, and the presence of obstructions can all affect the flow of air within the office space.

In summary, maintaining an appropriate air velocity range in office environments is essential for ensuring occupant comfort, supporting good indoor air quality, and fostering productivity. Achieving this balance requires thoughtful building design, well-designed and properly operated HVAC systems, and continuous monitoring and adjustment of air velocity levels.

Air velocity plays a crucial role in establishing a comfortable and healthy indoor environment for employees in office spaces. There are several key considerations associated with air velocity in offices. First and foremost, it is important to distribute the air evenly throughout the office to maintain a consistent temperature and ventilation. Care should be taken to avoid creating drafts or areas with significant temperature variations that may cause discomfort among employees. Additionally, air velocity directly impacts thermal comfort, which refers to individuals' subjective perceptions of warmth or coolness. To ensure optimal thermal comfort, the air velocity should fall within the recommended range of 40–80 feet per minute (fpm) for cooling and 30–50 fpm for heating purposes.

Furthermore, air velocity also has implications for indoor air quality. It can influence the distribution of airborne pollutants such as dust, allergens, and volatile organic compounds (VOCs). By controlling the air velocity appropriately, it is possible to minimize the concentration of these pollutants, thereby improving the overall indoor air quality within the office environment. Additionally, it is important to consider the impact of air velocity on noise levels. High air velocity can contribute to increased noise levels, which can be distracting and have a negative impact on productivity. Thus, it is essential to select air distribution systems that minimize noise generation and to adjust the air velocity to achieve a comfortable and quiet working environment.

In conclusion, careful control of air velocity in offices is vital to ensuring the well-being, comfort, and productivity of employees. Achieving this requires thoughtful design and operation of HVAC systems, along with regular monitoring and adjustment of air velocity as needed. By prioritizing appropriate air velocity management, offices can create an optimal indoor environment that promotes the health and satisfaction of employees.

The best level of air velocity in offices depends on a variety of factors, such as the size and layout of the office space, the number of occupants, the type of work being performed, and the local climate. However, as a general guideline, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) recommends an air velocity of between 40 and 60 feet per minute (0.2 and 0.3 meters per second) for occupied spaces, such as offices.

This level of air velocity can help provide a comfortable and healthy indoor environment by promoting air circulation and reducing the buildup of pollutants. However, it's important to note that air velocity can also have a subjective component, as some individuals may find higher or lower levels of air movement to be more comfortable than others.

Ultimately, it's important to work with a qualified HVAC professional to design an air distribution system that meets the specific needs of your office space and occupants.

High levels of air velocity in offices can affect employees in several ways, depending on the individual and the specific circumstances. Some of the potential effects of high air velocity include discomfort, cold and flu symptoms, fatigue, and allergies and respiratory issues.

High air velocity can create drafts and cause discomfort, particularly when the air movement is directed at employees or if they are positioned in the path of the airflow.

Exposure to high air velocity can also lead to dryness in the nose and throat, increasing the risk of cold and flu symptoms.

Moreover, the rapid movement of air can contribute to fatigue by facilitating heat loss from the body, potentially leading to a drop in core body temperature. This can impair cognitive function and reduce productivity.

Additionally, high air velocity can cause dust and other particles to circulate more rapidly, which may aggravate allergies and respiratory issues in susceptible individuals.

It is important to acknowledge that the effects of air velocity can be subjective, as what one person finds uncomfortable, another may tolerate well. Nevertheless, it is generally recommended to aim for air velocities within the range of 40 to 60 feet per minute (0.2 to 0.3 meters per second) to maintain a comfortable and healthy indoor environment for employees.

Low levels of air velocity in offices can also affect employees in several ways, depending on the individual and specific circumstances. Some potential effects of low air velocity include the presence of stale air, poor temperature distribution, an increased risk of illness, and reduced cognitive function. When air velocity is low, air can become stagnant, resulting in a buildup of pollutants and a decrease in indoor air quality. This can contribute to headaches, fatigue, and other symptoms associated with poor indoor air quality. Additionally, inadequate air movement can lead to poor temperature distribution throughout the office, with some areas feeling too warm while others remain too cold. Such discomfort can negatively impact employee well-being and productivity.

Moreover, low air velocity increases the risk of illness by allowing pollutants, including viruses and bacteria, to accumulate in the air. This can potentially contribute to the spread of infections and respiratory ailments among employees. Furthermore, poor indoor air

quality and uncomfortable temperatures can impair cognitive function, affecting memory, attention, and decision-making abilities.

It is important to recognize that the effects of air velocity can vary depending on the specific circumstances, and individual comfort levels may differ. However, in general, it is recommended to aim for air velocities within the range of 40 to 60 feet per minute (0.2 to 0.3 meters per second) to ensure a comfortable and healthy indoor environment for employees.

The level of air velocity in offices can have a significant impact on employee productivity. When the air velocity is too high or too low, it can cause discomfort and distraction, leading to a reduction in productivity. One of the key factors affecting employee productivity is comfort. When the air velocity is too high, it can create drafts, which can be uncomfortable for employees. Similarly, when the air velocity is too low, it can cause stuffiness and make the air feel stagnant. Both of these conditions can be distracting and reduce employee productivity. Temperature is another factor that can be affected by air velocity. When the air velocity is too low, it can cause areas of the office to feel too warm or too cold, which can be distracting and reduce productivity.

Air quality is also an important factor in employee productivity. When the air velocity is too low, it can cause pollutants, such as dust and allergens, to accumulate in the air. This can lead to respiratory issues and other health problems that can reduce productivity. Moreover, when the air velocity is too high, it can cause fatigue by increasing the rate of heat loss from the body, which can impair cognitive function and reduce productivity.

In conclusion, maintaining a comfortable and healthy indoor environment is critical for promoting employee productivity. This includes ensuring that the air velocity falls within

the recommended range of 40 to 60 feet per minute (0.2 to 0.3 meters per second) and that the temperature and air quality are also optimal.

4.5 Standard office temperature

The ideal temperature in an office can depend on various factors, such as the season, the type of work being done, the number of people in the office, and personal preferences. However, as a general guideline, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) recommends a temperature range of 68–76 °F (20–24 °C) for sedentary office work.

This temperature range should provide a comfortable environment for the majority of people while also maintaining energy efficiency and avoiding excessive cooling or heating costs. It's important to note that individual preferences can vary, so it's a good idea to provide some flexibility in temperature control, such as allowing employees to adjust the temperature in their immediate workspace to suit their needs.

4.6 How can humidity levels affect employees?

The ideal humidity level for an office can depend on various factors, such as the season, the climate, and the type of work being done. However, as a general guideline, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) recommends a relative humidity range of 30–60% for indoor environments.

Maintaining a relative humidity level within this range can help promote a comfortable and healthy indoor environment while also minimizing the risk of moisture-related problems such as mold growth, condensation, and damage to building materials. In addition, maintaining proper humidity levels can also help reduce the spread of airborne viruses and bacteria, which can thrive in overly dry or humid environments.

To maintain proper humidity levels in an office, it's important to ensure that the HVAC system is properly sized and maintained and that any leaks or moisture issues are promptly addressed. In addition, using humidifiers or dehumidifiers as needed can also help regulate humidity levels in specific areas of the office.

Low humidity levels in offices can have several negative effects on employees and the workplace environment. When the air is too dry, it can cause discomfort and health problems such as dry skin, dry eyes, a sore throat, and respiratory issues. It can also worsen existing health conditions such as asthma and allergies.

In addition to health problems, low humidity levels can also damage building materials and office equipment. For example, low humidity can cause wood furniture and flooring to crack or warp, and it can cause static electricity buildup that can damage electronic equipment such as computers and printers.

Low humidity levels can also lead to decreased productivity and increased absenteeism. When employees are uncomfortable and experiencing health problems, they may be more likely to take sick days or be less productive at work.

To mitigate the negative effects of low humidity levels, it's important to maintain proper humidity levels in the office. This can be done by using humidifiers or adjusting the office's HVAC system to maintain a relative humidity level between 30-60%.

High humidity levels in offices can also have negative effects on employees and the workplace environment. When the air is too humid, it can cause discomfort and health problems such as difficulty breathing, fatigue, and heat exhaustion. High humidity can also aggravate existing health conditions such as allergies and asthma.

In addition to health problems, high humidity levels can also lead to mold growth, which can cause further health problems and damage to building materials and equipment. Mold

can grow on walls, ceilings, and floors, and it can also grow inside air ducts, leading to poor indoor air quality.

High humidity levels can also lead to decreased productivity and increased absenteeism. When employees are uncomfortable and experiencing health problems, they may be less productive and more likely to take sick days.

To mitigate the negative effects of high humidity levels, it's important to maintain proper humidity levels in the office. This can be done by using dehumidifiers or adjusting the office's HVAC system to maintain a relative humidity level between 30 and 60%. It's also important to address any moisture issues, such as leaks or condensation, promptly to prevent mold growth.

4.7 How can lighting levels affect employees' health and productivity?

Lighting levels in offices are important for creating a comfortable and productive work environment. The recommended lighting level for offices is generally between 300 and 500 lux (a unit of illuminance), although this can vary depending on factors such as the type of work being performed and the age of the workers.

In general, a higher level of lighting is recommended for tasks that require a high level of visual accuracy, such as reading small text or working with detailed drawings. Conversely, tasks that do not require high visual accuracy may be performed with lower levels of lighting.

It is also important to consider the color temperature of the lighting, which can affect the mood and productivity of workers. A cooler color temperature (5000–6500K) can create a more alert and energized work environment, while a warmer color temperature (2700–3000K) can create a more relaxed and comfortable atmosphere.

Overall, it is important to strike a balance between lighting levels that are comfortable and conducive to productivity, while also minimizing glare and other sources of visual discomfort.

Lighting levels can have a significant impact on employee health and productivity in the workplace. Insufficient lighting can cause eye strain, headaches, and fatigue, which can lead to a decrease in productivity and an increase in errors and accidents. In addition, inadequate lighting can also lead to a poor mood and increased stress levels.

Conversely, excessive lighting can also be problematic, as it can cause visual discomfort, glare, and even headaches and migraines. Overly bright lighting can also disrupt circadian rhythms, which can affect sleep quality and overall health.

The color temperature of lighting can also affect employee health and productivity. Cooler light colors, such as blue and white, can help promote alertness and productivity, while warmer light colors, such as yellow and orange, can promote relaxation and reduce stress.

In summary, it is important to provide appropriate lighting levels and color temperatures in the workplace to promote the health, comfort, and productivity of employees. This can include using a combination of natural and artificial lighting sources, providing task lighting for specific work activities, and adjusting lighting levels based on the time of day and specific tasks being performed.

Lighting levels can have a significant impact on employee health and productivity in the workplace. Insufficient lighting can cause eye strain, headaches, and fatigue, which can lead to a decrease in productivity and an increase in errors and accidents. In addition, inadequate lighting can also lead to a poor mood and increased stress levels.

Conversely, excessive lighting can also be problematic, as it can cause visual discomfort, glare, and even headaches and migraines. Overly bright lighting can also disrupt circadian rhythms, which can affect sleep quality and overall health.

The color temperature of lighting can also affect employee health and productivity. Cooler light colors, such as blue and white, can help promote alertness and productivity, while warmer light colors, such as yellow and orange, can promote relaxation and reduce stress.

In summary, it is important to provide appropriate lighting levels and color temperatures in the workplace to promote the health, comfort, and productivity of employees. This can include using a combination of natural and artificial lighting sources, providing task lighting for specific work activities, and adjusting lighting levels based on the time of day and specific tasks being performed.

4.8 How can office sound level and sources of noise affect employees?

The recommended sound level in offices is typically between 40 and 60 decibels (dB). This range is based on guidelines from organizations such as the Occupational Safety and Health Administration (OSHA) and the American National Standards Institute (ANSI).

Sound levels below 40 dB are generally considered to be too low and may make it difficult to hear and communicate, while levels above 60 dB can be distracting and lead to decreased productivity and increased stress levels.

However, it's important to note that the ideal sound level can vary depending on the type of work being done in the office. For example, tasks that require concentration and focus may require lower sound levels, while tasks that involve collaboration and communication may require slightly higher sound levels.

To ensure a comfortable and productive work environment, it's important to minimize noise levels and control sources of noise, such as loud equipment or traffic outside. This can be done through measures such as soundproofing, using noise-cancelling headphones, or establishing designated quiet areas in the office.

The office environment can be filled with various sources of noise that can significantly impact sound levels and disrupt productivity. Common culprits for noise in offices include HVAC systems, which generate noise through fans, motors, and ductwork. Additionally, office equipment such as printers, copiers, and scanners contribute to noise when in operation. Conversations among colleagues, whether in person or on the phone, can also be a source of distraction. Even foot traffic within the office, especially when individuals wear hard-soled shoes or high heels, adds to the overall noise levels. Furthermore, external noise from sources like traffic and construction can penetrate the office space. While some individuals find music or background noise conducive to concentration, it can be bothersome to others and contribute to elevated sound levels. To mitigate noise in the office, it is essential to identify the sources and implement suitable measures. These may involve the installation of sound-absorbing panels or partitions, the use of noise-cancelling headphones, the creation of designated quiet areas or zones, and the scheduling of noisy activities outside of regular office hours. By addressing these sources of noise, a more tranquil and productive work environment can be established.

Excessive noise levels in the office environment can have detrimental effects on the health, well-being, and productivity of employees. There are several ways in which high sound levels can impact employees in an office setting. Firstly, prolonged exposure to high noise levels can lead to permanent hearing damage, including hearing loss and tinnitus. Secondly, elevated noise levels can cause stress and anxiety among employees, resulting in decreased productivity, increased absenteeism, and higher turnover rates. Additionally,

excessive noise acts as a distraction, making it challenging for employees to concentrate on their tasks, leading to reduced productivity, errors, and delays. Moreover, excessive noise can hinder effective communication among employees and with clients, potentially resulting in misunderstandings, errors, and further delays. Furthermore, high noise levels can trigger physiological responses such as increased blood pressure and heart rate, which can contribute to long-term health issues. To address these concerns, it is imperative for employers to implement measures that aim to reduce noise levels in the office. This can involve the use of sound-absorbing materials, the provision of noise-cancelling headphones, the creation of designated quiet areas, and the implementation of policies that regulate excessive noise. By mitigating noise levels, employers can promote a healthier and more productive work environment for their employees.

4.9 How can office CO2 level affect employees?

The recommended CO2 level in offices is typically between 350 and 1000 parts per million (ppm). This range is based on guidelines from organizations such as the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), which sets standards for indoor air quality.

CO2 levels below 350 ppm are generally considered to be too low and can indicate inadequate ventilation, while levels above 1000 ppm can cause discomfort, reduce productivity, and lead to health problems in some people.

However, it's important to note that CO2 levels alone do not provide a complete picture of indoor air quality. Other factors such as temperature, humidity, and the presence of pollutants such as volatile organic compounds (VOCs) can also affect air quality and should be monitored and controlled as well.

To ensure a healthy and comfortable indoor environment, it's good practice to regularly monitor CO₂ levels and other indoor air quality parameters, and to take appropriate measures to maintain optimal conditions. This may include increasing ventilation, using air purifiers, and controlling sources of pollutants.

High levels of carbon dioxide (CO₂) in the workplace can have detrimental effects on the health and well-being of employees. Various examples illustrate how high CO₂ levels can impact individuals in an office setting. Firstly, studies have shown that elevated CO₂ concentrations can impair cognitive function, including decision-making, problem-solving, and attention span, resulting in reduced productivity and accuracy. Secondly, exposure to high CO₂ levels can cause symptoms such as headaches, dizziness, and general discomfort, negatively affecting employee well-being and overall productivity. Thirdly, fatigue and drowsiness can be induced by high CO₂ levels, leading to decreased productivity and potential safety hazards in the workplace. Additionally, prolonged exposure to high CO₂ concentrations can contribute to respiratory issues, including shortness of breath, wheezing, and coughing. To address these concerns, employers need to prioritize ensuring adequate ventilation in the workplace to prevent CO₂ buildup. This can involve implementing HVAC systems that supply fresh air, promoting natural ventilation by opening windows, and incorporating indoor plants capable of absorbing CO₂. Regularly testing CO₂ levels in the workplace and taking appropriate action if elevated levels are detected is also crucial. By prioritizing these measures, employers can create a healthier and more productive work environment for their employees.

The best way to determine if the CO₂ level is high in an office is to use a CO₂ meter or carbon dioxide monitor. These devices measure the concentration of CO₂ in the air and provide a digital readout of the current CO₂ level.

If a CO₂ meter is not readily available, there are several signs that may indicate a high CO₂ level in an office environment. Firstly, poor air quality characterized by a stale or stuffy atmosphere can suggest inadequate ventilation and elevated CO₂ levels. Secondly, drowsiness, fatigue, and difficulty concentrating are common symptoms associated with high CO₂ levels, potentially impacting productivity and work performance. Additionally, headaches or migraines may be experienced by individuals exposed to elevated CO₂ concentrations. Moreover, people with respiratory conditions, such as asthma, may notice an increase in symptoms when exposed to high levels of CO₂.

However, it is important to acknowledge that these symptoms can also be caused by other factors, including poor air circulation, high humidity, or the presence of other indoor pollutants. Therefore, the most accurate method to determine if the CO₂ level is high in an office remains the use of a CO₂ meter or carbon dioxide monitor. These devices provide precise measurements and offer a reliable assessment of the CO₂ concentration, enabling the necessary actions to improve indoor air quality and ensure a healthy work environment.

The presence of high levels of CO₂ in the air is undetectable by our senses, as carbon dioxide is a colorless, odorless, and tasteless gas. Hence, the use of a CO₂ meter becomes crucial for accurately measuring the concentration of CO₂ in the air.

Nevertheless, prolonged exposure to high levels of CO₂ can lead to various symptoms in some individuals. These symptoms may include headaches, dizziness, fatigue, shortness of breath, nausea, confusion, and, at extremely high levels, loss of consciousness. The manifestation of CO₂ exposure symptoms can vary based on an individual's sensitivity to the gas, the duration and level of exposure, as well as other factors such as age and pre-existing medical conditions.

It is important to note that CO₂ is generally not a significant health concern in indoor environments, as long as the levels remain within the recommended range of 350 to 1000 parts per million (ppm). However, elevated CO₂ levels can serve as an indicator of poor ventilation or other indoor air quality issues, which may have additional health implications. Therefore, it is advisable to regularly monitor CO₂ levels and take appropriate measures to maintain optimal indoor air quality.

A CO₂ meter, also known as a carbon dioxide meter or CO₂ sensor, works by detecting the concentration of carbon dioxide (CO₂) in the air. There are several different types of CO₂ sensors, but most work based on the principle of infrared absorption.

Infrared CO₂ sensors contain an infrared light source, a detector, and an optical filter or chamber. The infrared light source emits a beam of infrared light that passes through the air and into the optical chamber. CO₂ molecules in the air absorb some of the infrared light, causing a reduction in the intensity of the light received by the detector. The amount of light absorbed is proportional to the concentration of CO₂ in the air.

The detector then converts the received light into an electrical signal, which is processed by the sensor's electronics to determine the CO₂ concentration in parts per million (ppm). This information is usually displayed on a screen or transmitted to a connected device, such as a computer or smartphone.

Some CO₂ sensors also incorporate additional sensors, such as temperature and humidity sensors, to provide a more complete picture of indoor air quality. By monitoring CO₂ levels, these sensors can help detect and prevent indoor air quality problems, such as inadequate ventilation, which can lead to discomfort, health issues, and reduced productivity.

4.10 Air velocity readings

4.10.1 Low-cost company 01

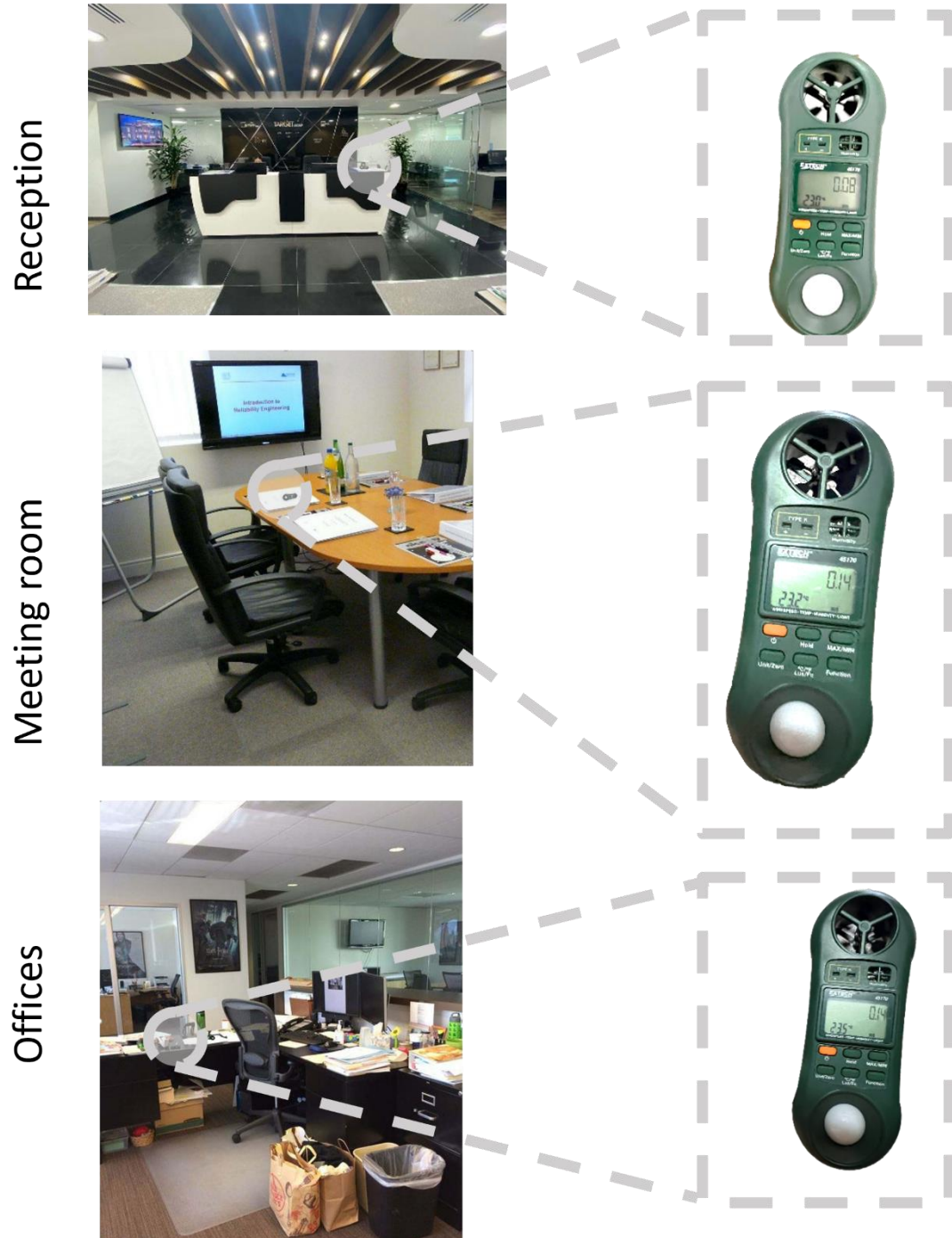


Figure 19: Results of air velocity in low-cost company 01.

(Source: Khaloud, 2023)

4.10.2 Low-cost company 02

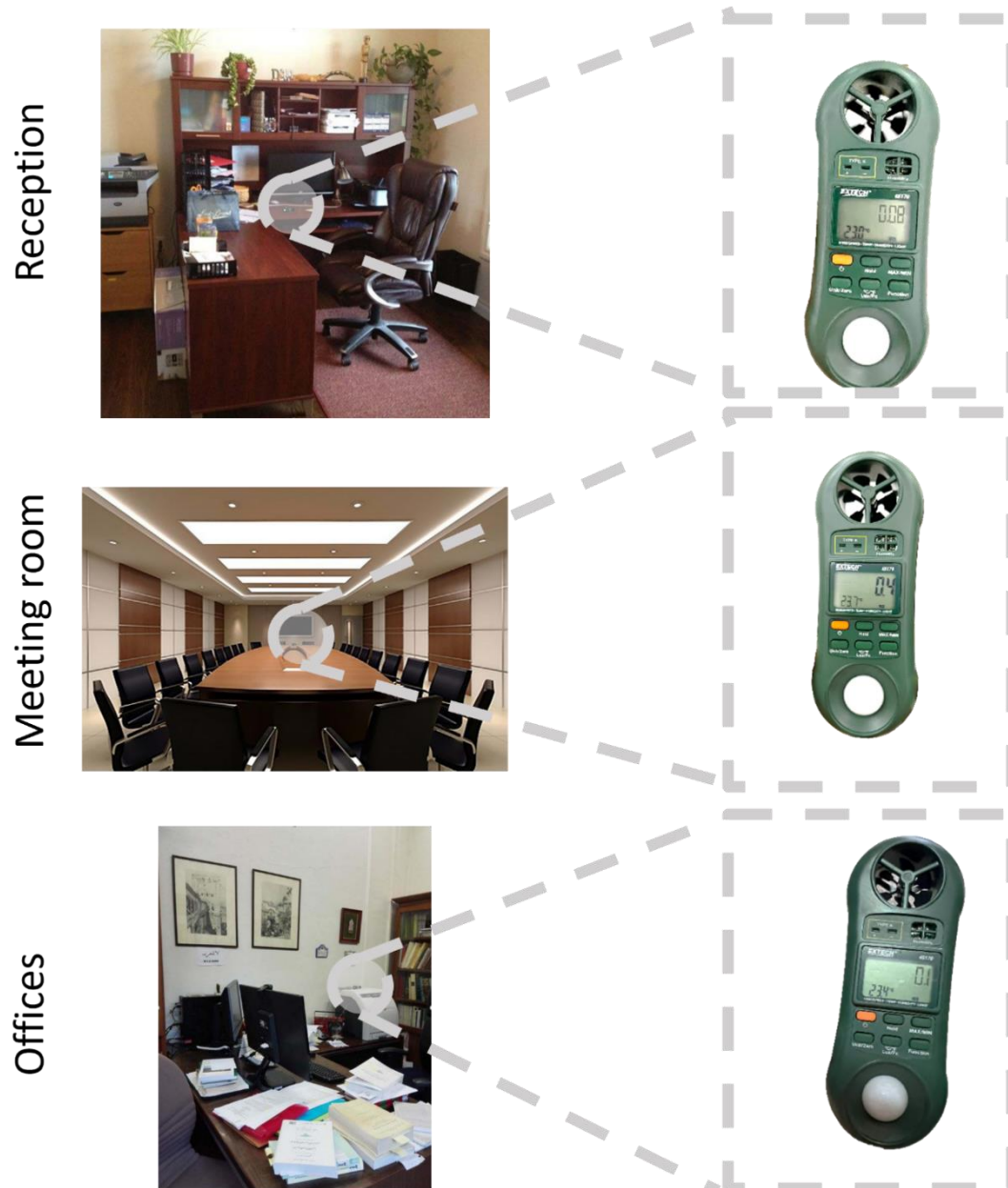


Figure 20: Results of air velocity in low-cost company 02.

(Source: Khaloud, 2023)

4.10.3 Low-cost company 03

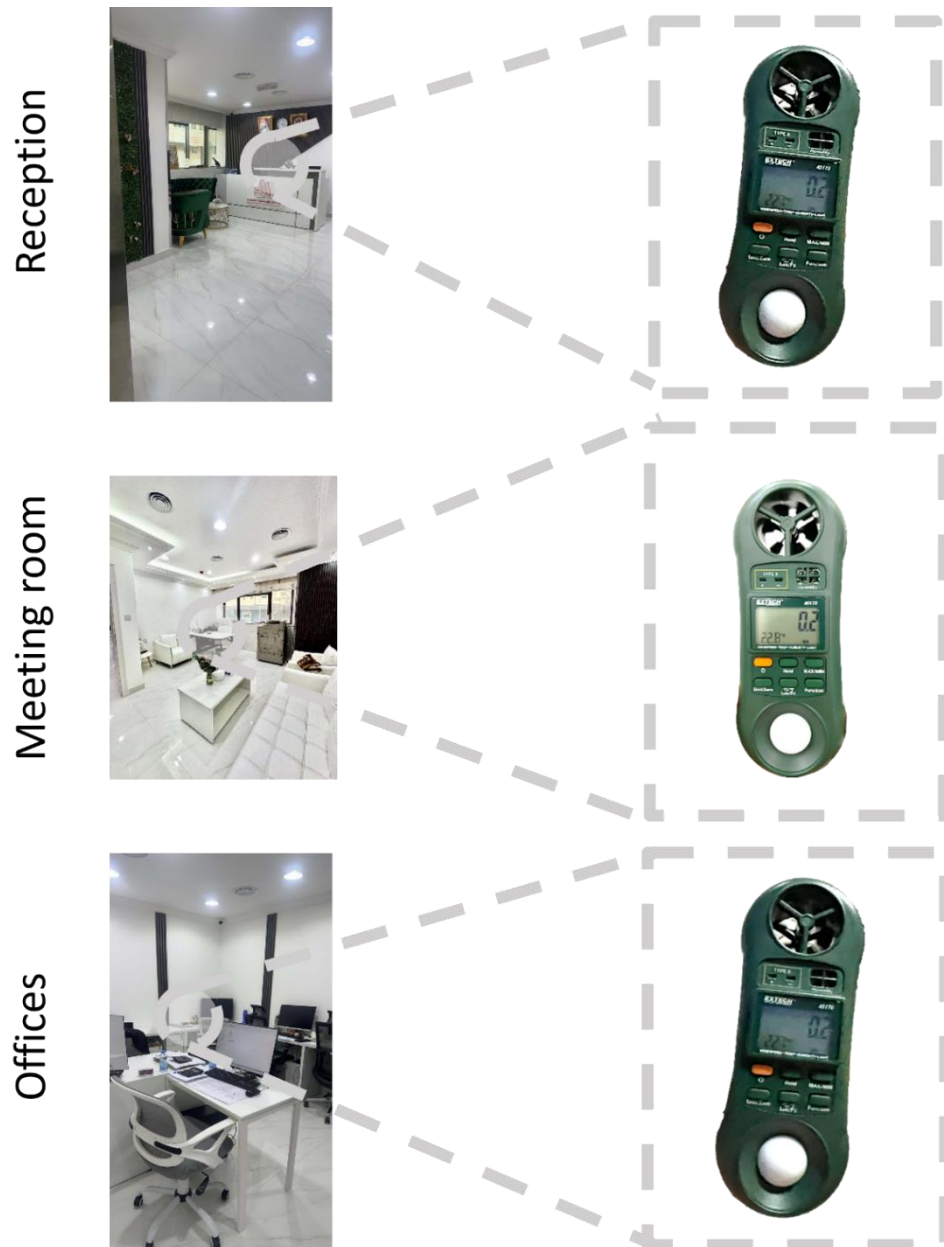


Figure 21: Results of air velocity in low-cost company 03.

(Source: Khaloud, 2023)

4.10.4 High-cost company 01

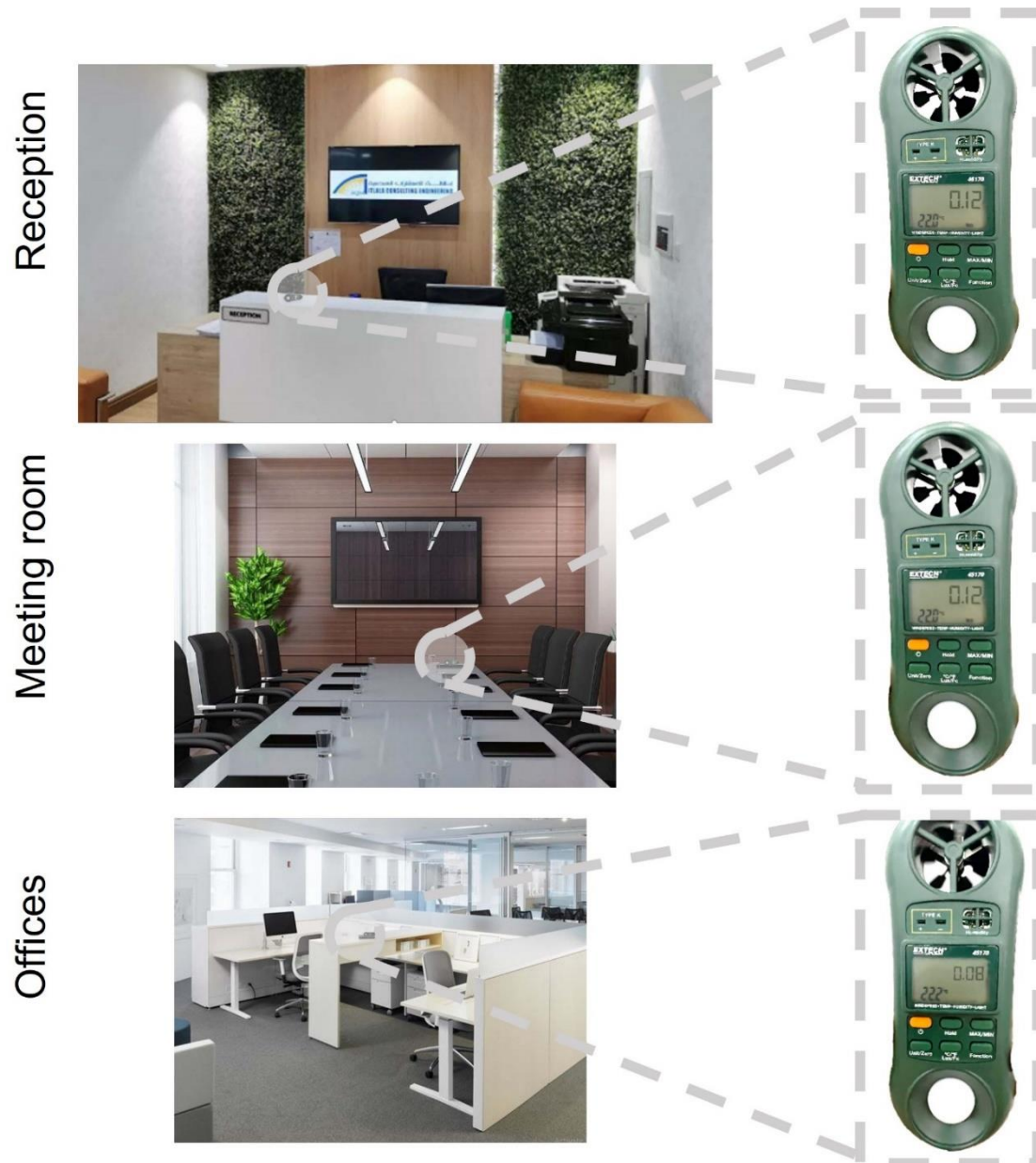


Figure 22: Results of air velocity in high-cost company 01.

(Source: Khaloud, 2023)

4.10.5 High-cost company 02

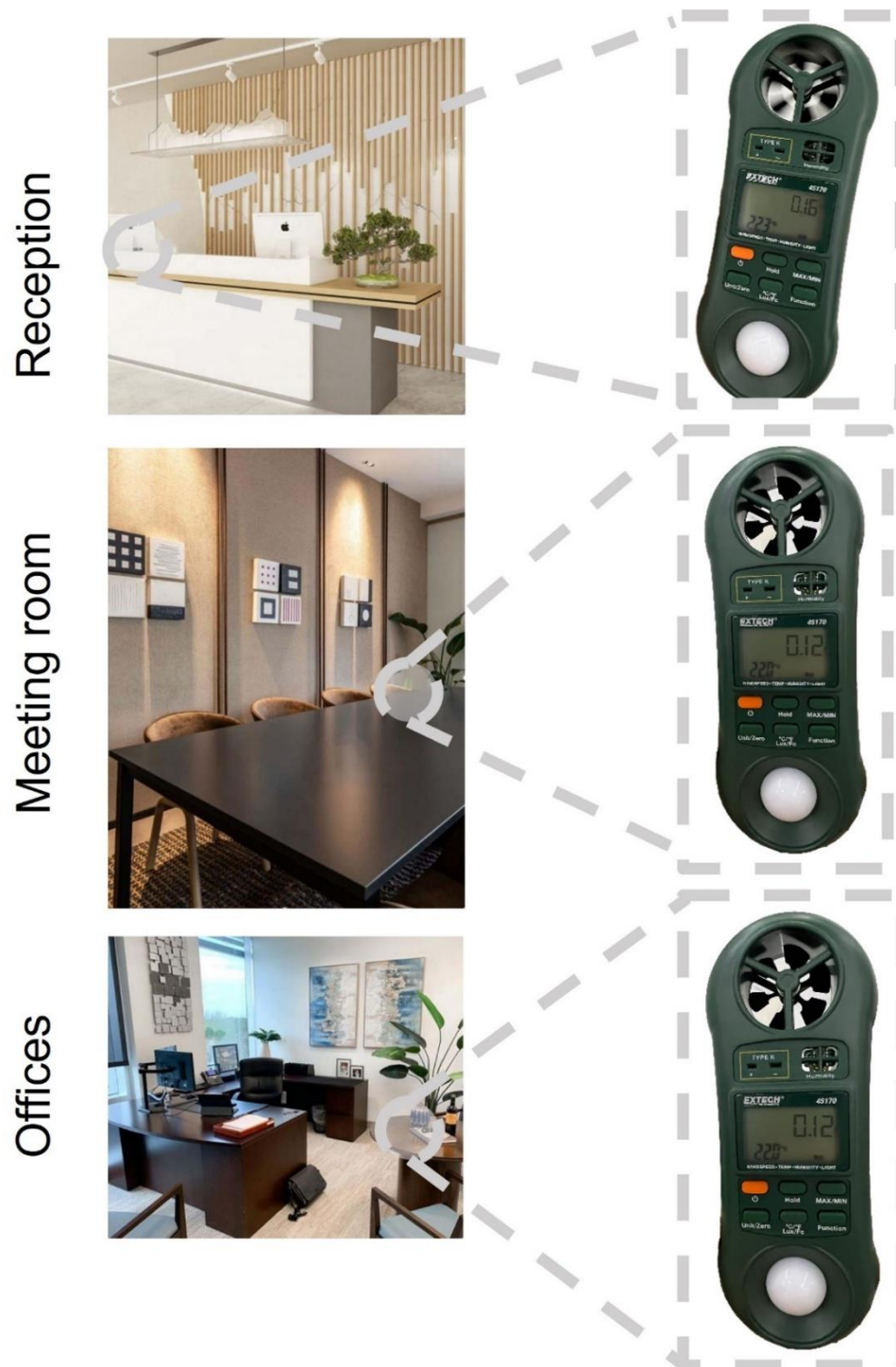


Figure 23: Results of air velocity in high-cost company 02.

(Source: Khaloud, 2023)

4.10.6 High-cost company 03

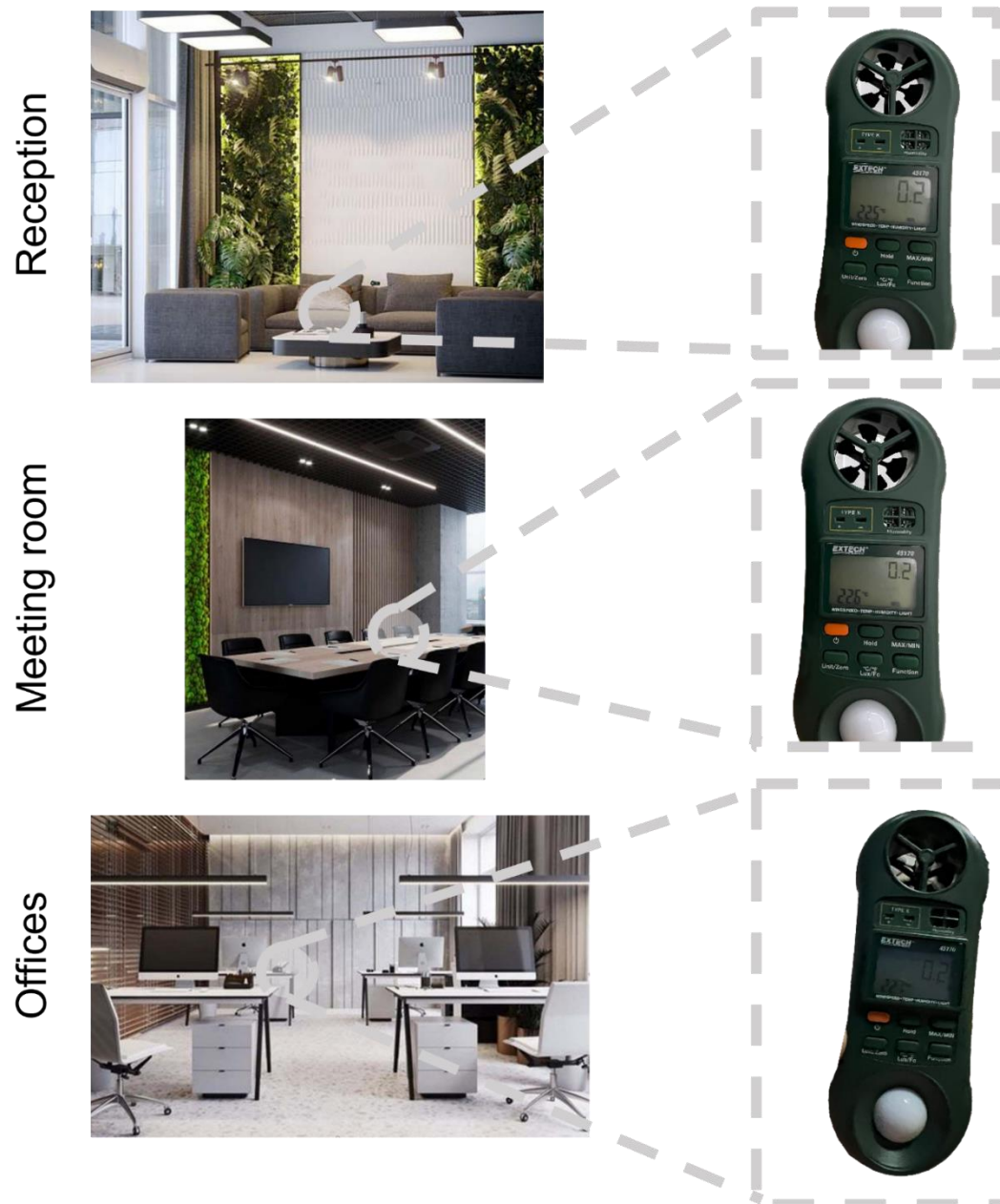


Figure 24: Results of air velocity in high-cost company 03.

(Source: Khaloud, 2023)

4.11 Temperature and Relative Humidity readings

4.11.1 Low-cost company 01



Figure 25: Results of temperature and relative humidity in low-cost company 01.

(Source: Khaloud, 2023)

4.11.2 Low-cost company 02



Figure 26: Results of temperature and relative humidity in low-cost company 02.

(Source: Khaloud, 2023)

4.11.3 Low-cost company 03



Figure 27: Results of temperature and relative humidity in low-cost company 03.

(Source: Khaloud, 2023)

4.11.4 High-cost company 01

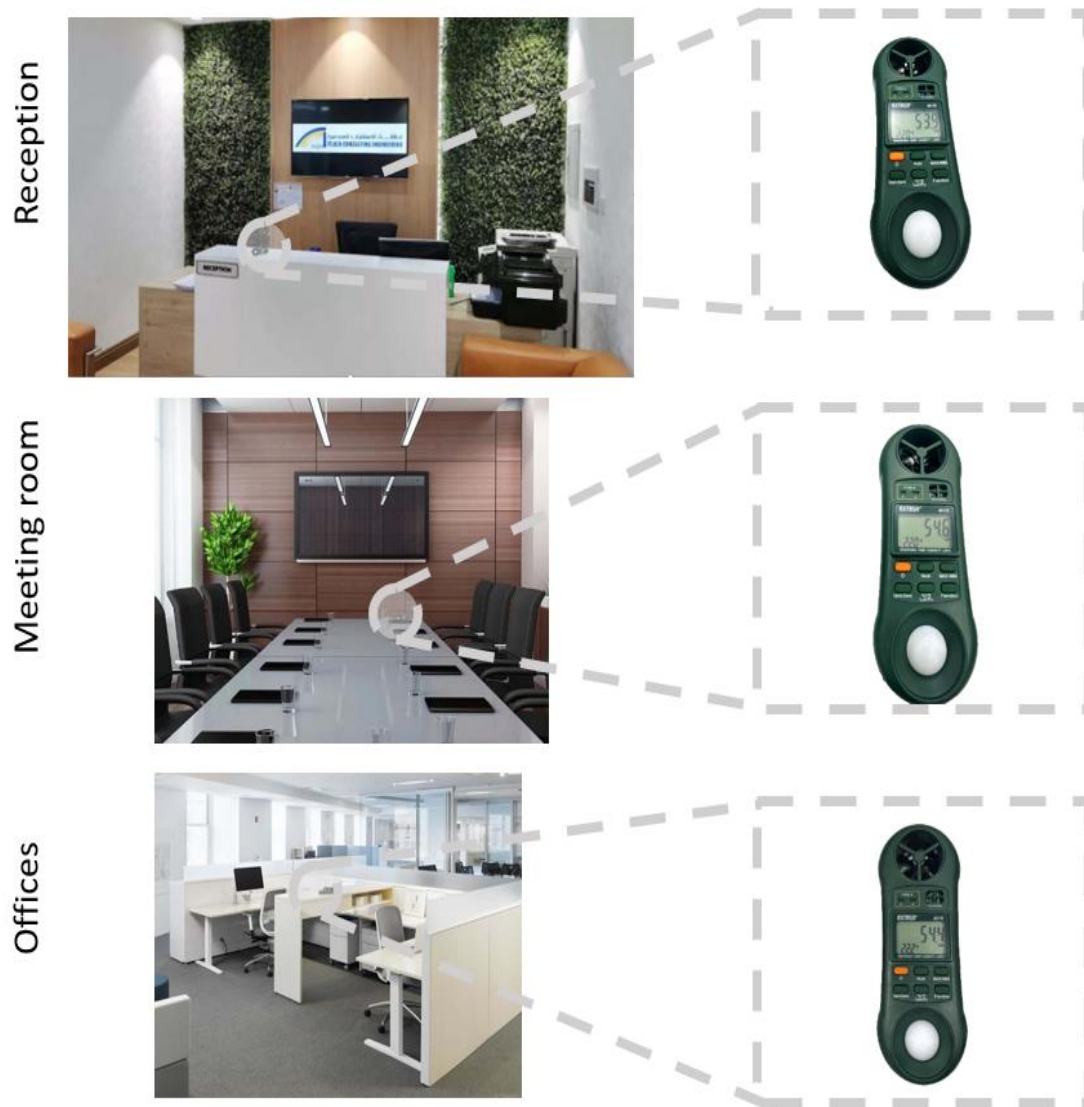


Figure 28: High-cost company 01 results of Temperature and relative humidity.
(Source: Khaloud, 2023)

4.11.5 High-cost company 02



Figure 29: High-cost company 02 results of Temperature and relative humidity.
(Source: Khaloud, 2023)

4.11.6 High-cost company 03



Figure 30: High-cost company 03 results of Temperature and relative humidity.

(Source: Khaloud, 2023)

4.12 Lighting level readings

4.12.1 Low-cost company 01

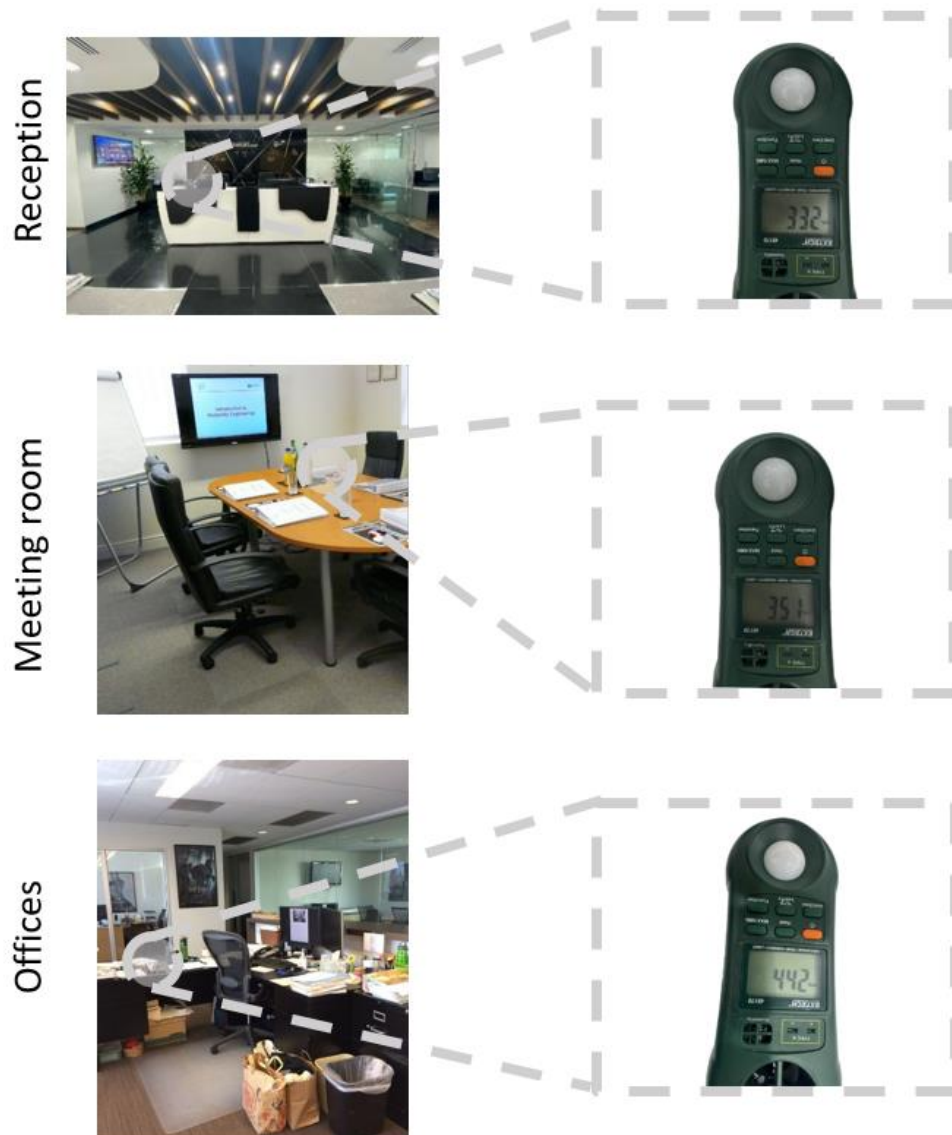


Figure 31: Results of lights in low-cost company 01.

(Source: Khaloud, 2023)

4.12.2 Low-cost company 02



Figure 32: Results of lights in low-cost company 02.

(Source: Khaloud, 2023)

4.12.3 Low-cost company 03

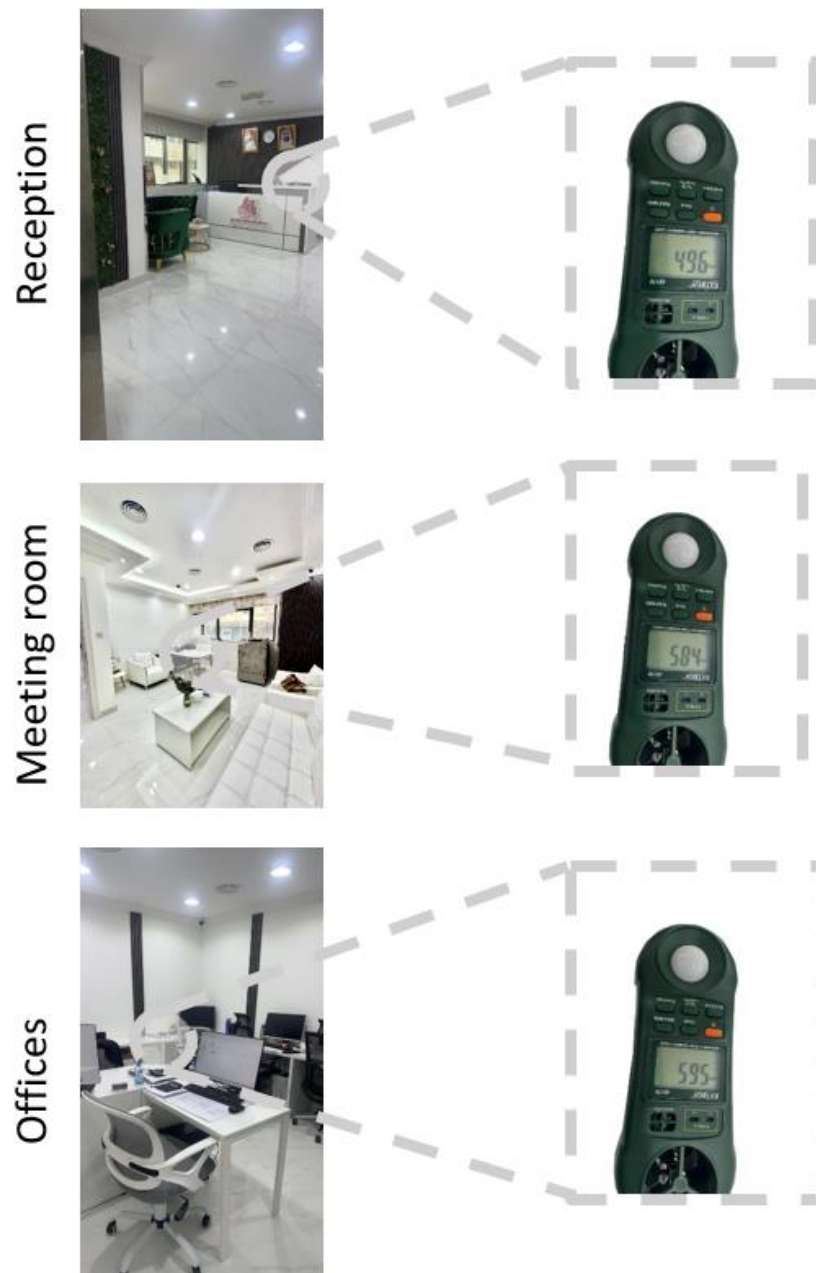


Figure 33: Results of lights in low-cost company 03.
(Source: Khaloud, 2023)

4.12.4 High-cost company 01



Figure 34: High-cost company 01 results of lights.
(Source: Khaloud, 2023)

4.12.5 High-cost company 02

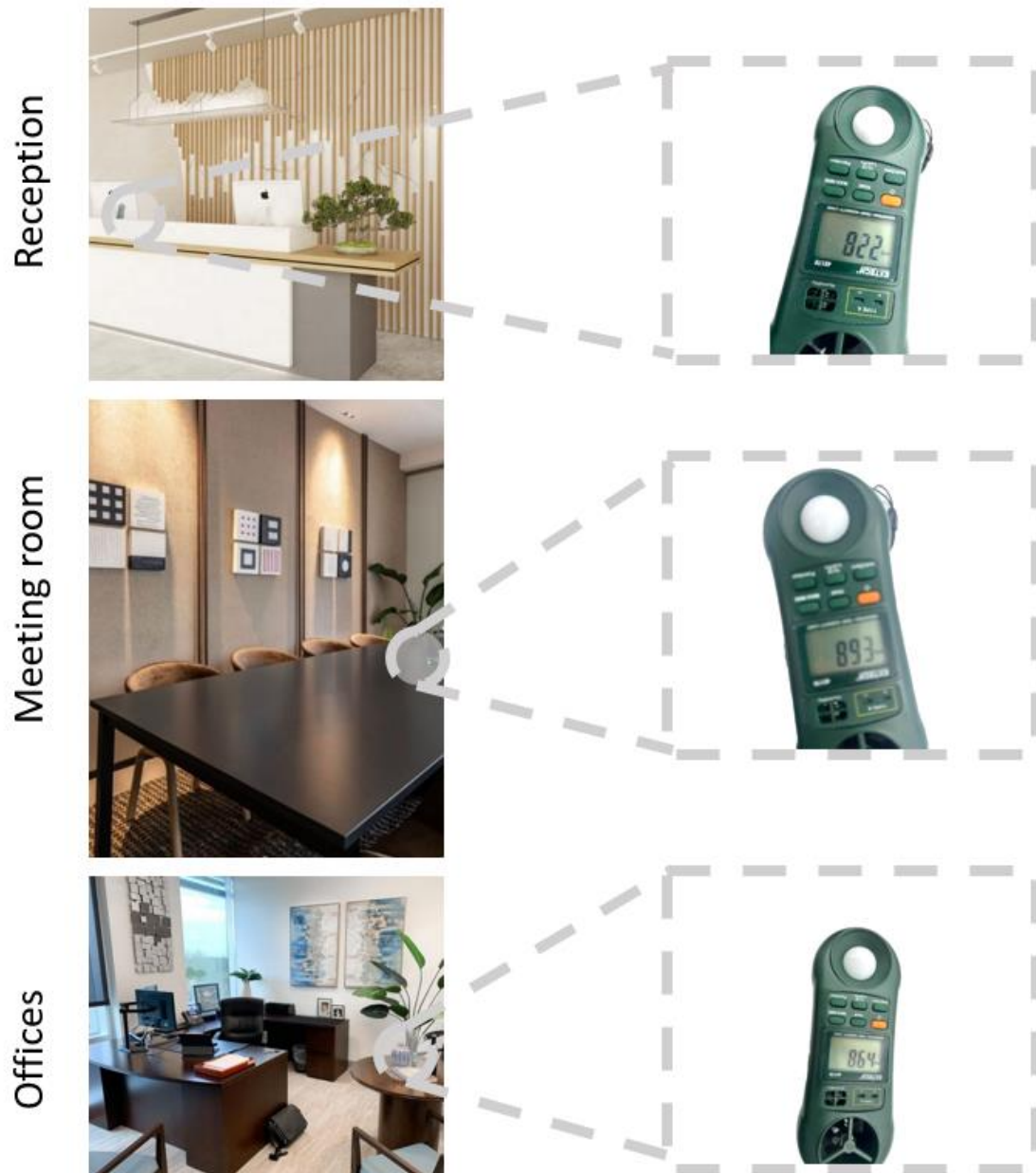


Figure 35: High-cost company 02 results of lights.
(Source: Khaloud, 2023)

4.12.6 High-cost company 03

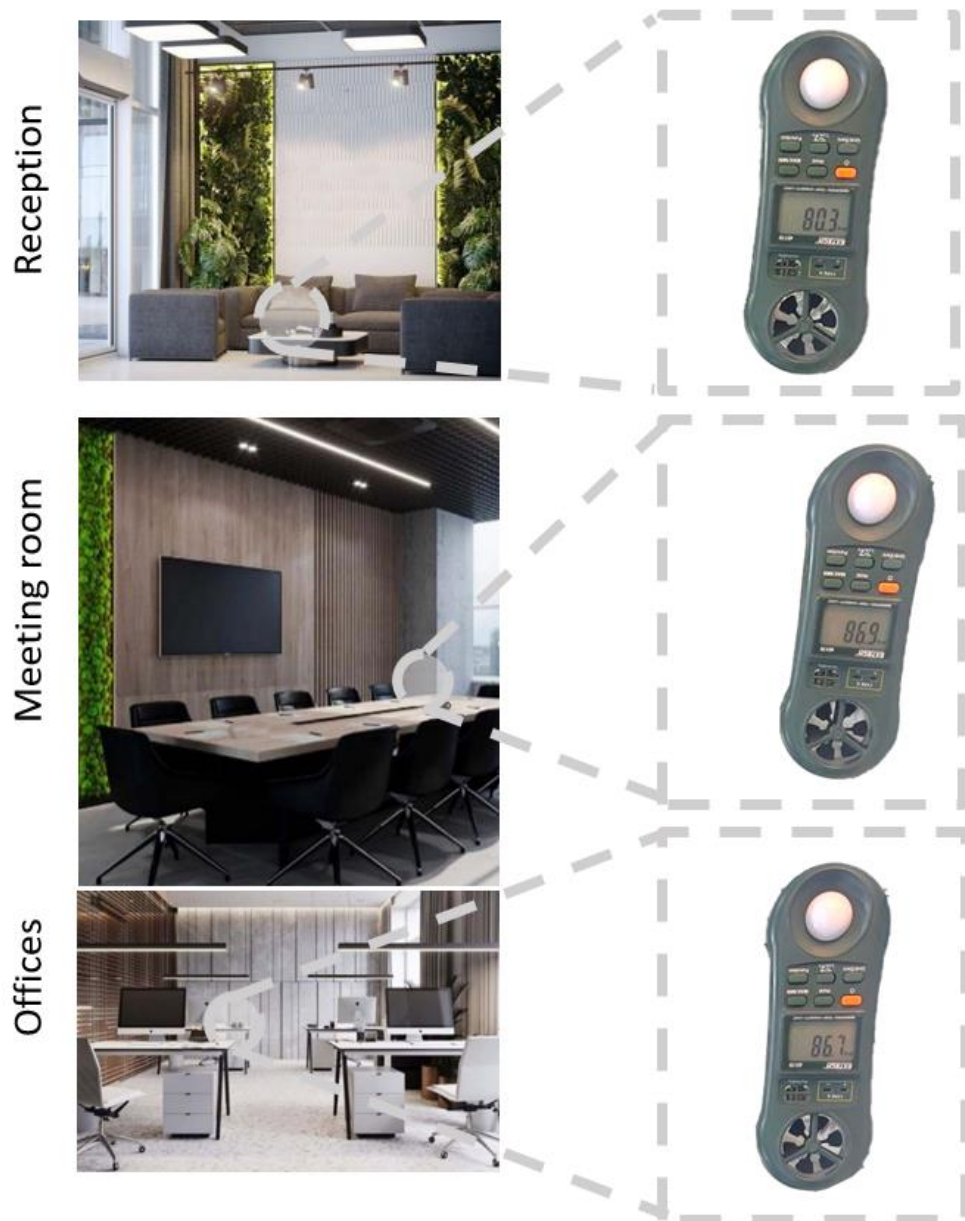


Figure 36: High-cost company 03 results of lights.
(Source: Khaloud, 2023)

4.13 Sound level alert meter readings

4.13.1 Low-cost company 01

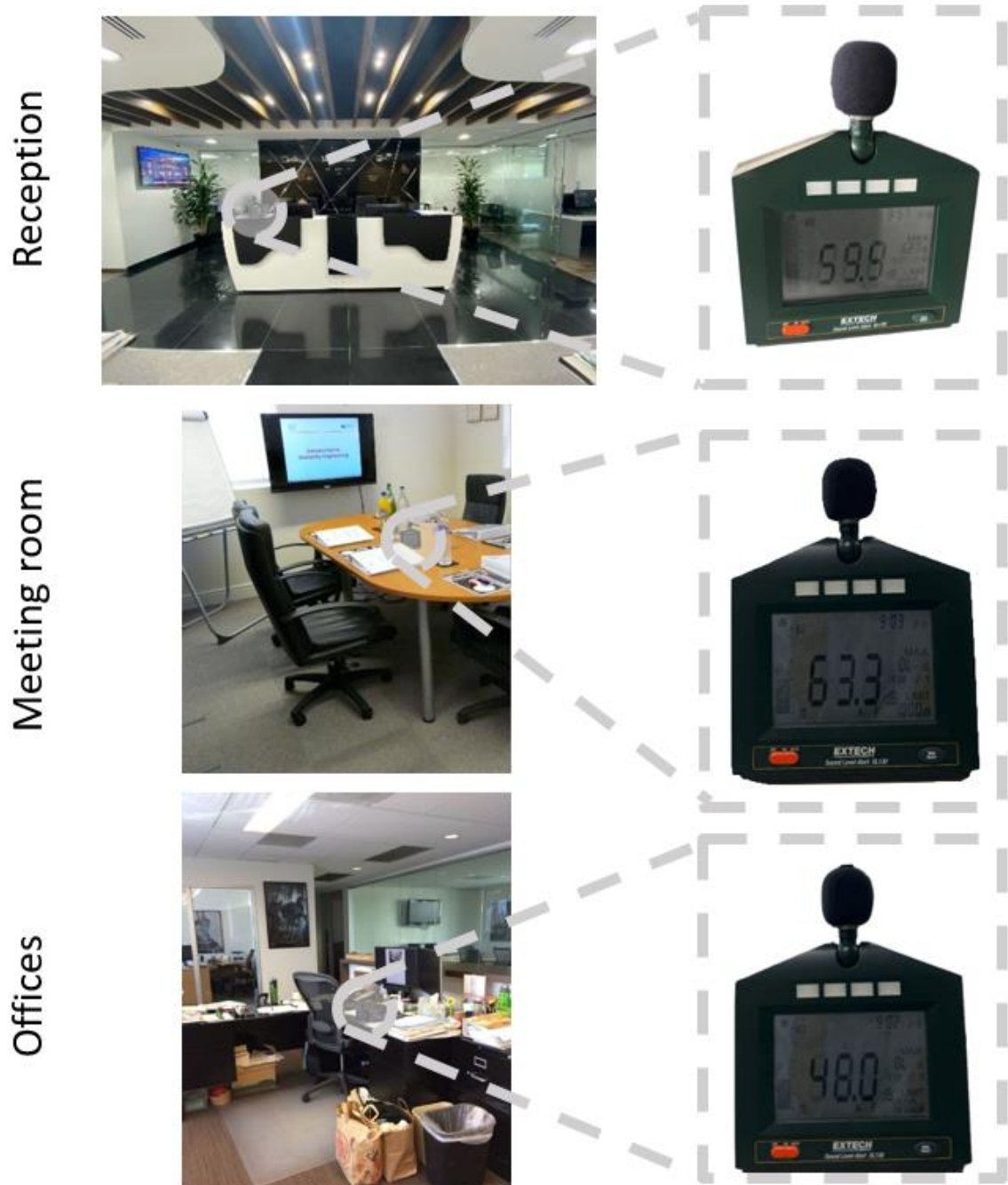


Figure 37: Results of sound level alert meter in low-cost company 0

(Source: Khaloud, 2023)

4.13.2 Low-cost company 02

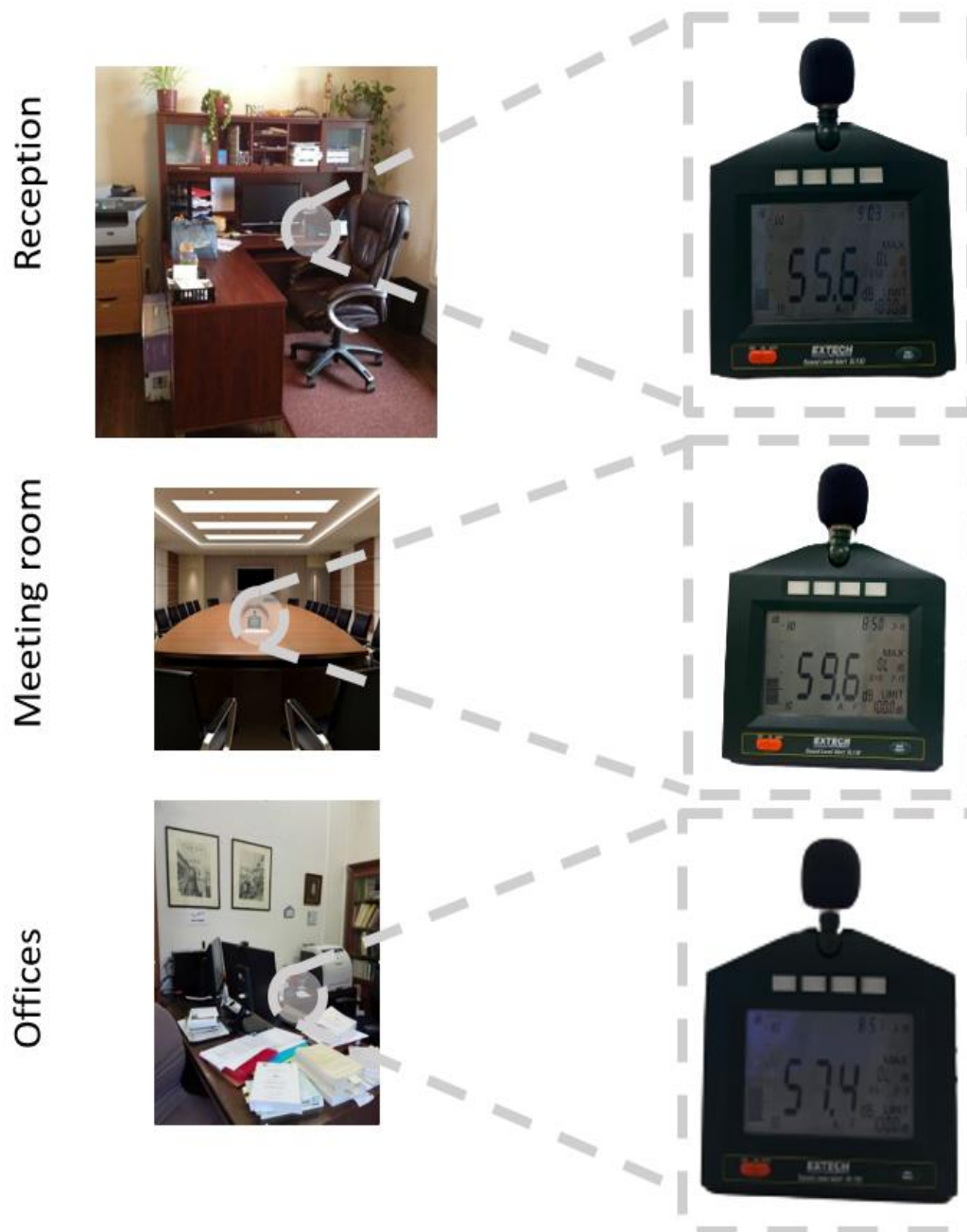


Figure 38: Results of sound level alert meter in low-cost company 02.

(Source: Khaloud, 2023)

4.13.3 Low-cost company 03



Figure 39: Results of sound level alert meter in low-cost company 03.
(Source: Khaloud, 2023)

4.13.4 High-cost company 01

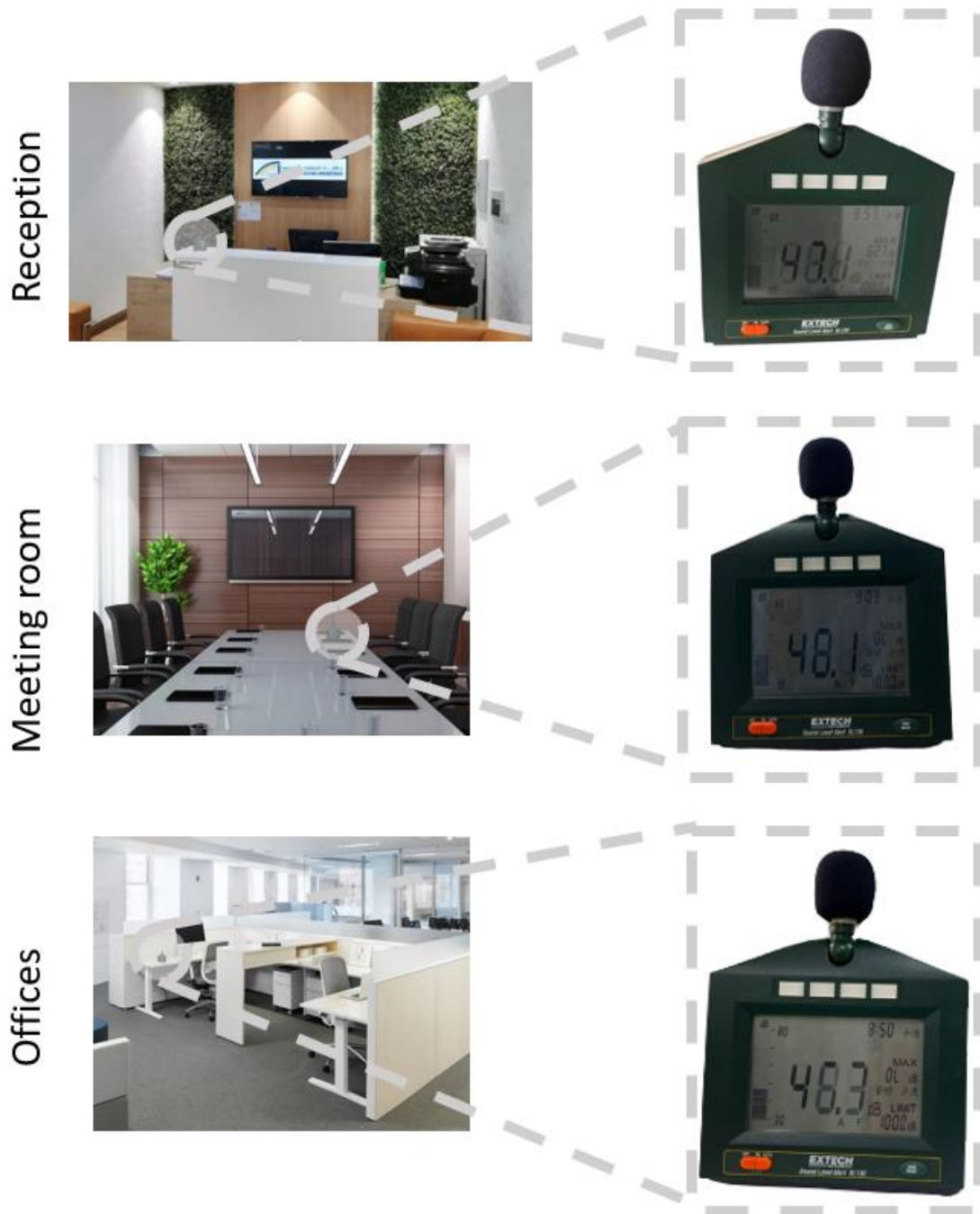


Figure 40: Results of sound level alert meter in high-cost company 01

(Source: Khaloud, 2023)

4.13.5 High-cost company 02



Figure 41: Results of sound level alert meter in high-cost company 02.

(Source: Khaloud, 2023)

4.13.6 High-cost company 03

Reception



Meeting room



Offices



Figure 42: Results of sound level alert meter in high-cost company 03.

(Source: Khaloud, 2023)

4.14 Indoor environment CO2 meter readings

4.14.1 Low-cost company 01

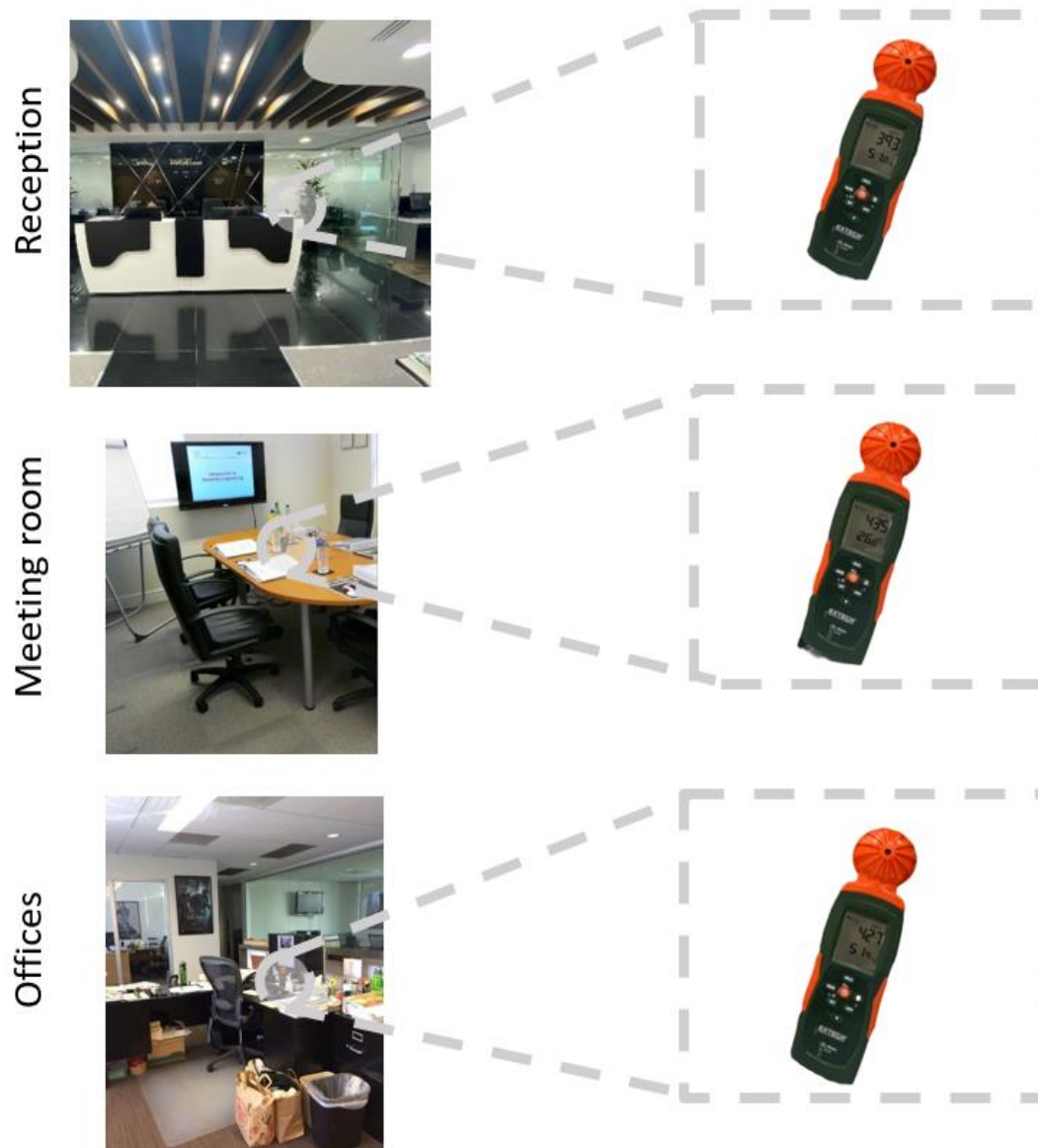


Figure 43: Low-cost company 01 indoor environment CO2 meter results.

(Source: Khaloud, 2023)

4.14.2 Low-cost company 02

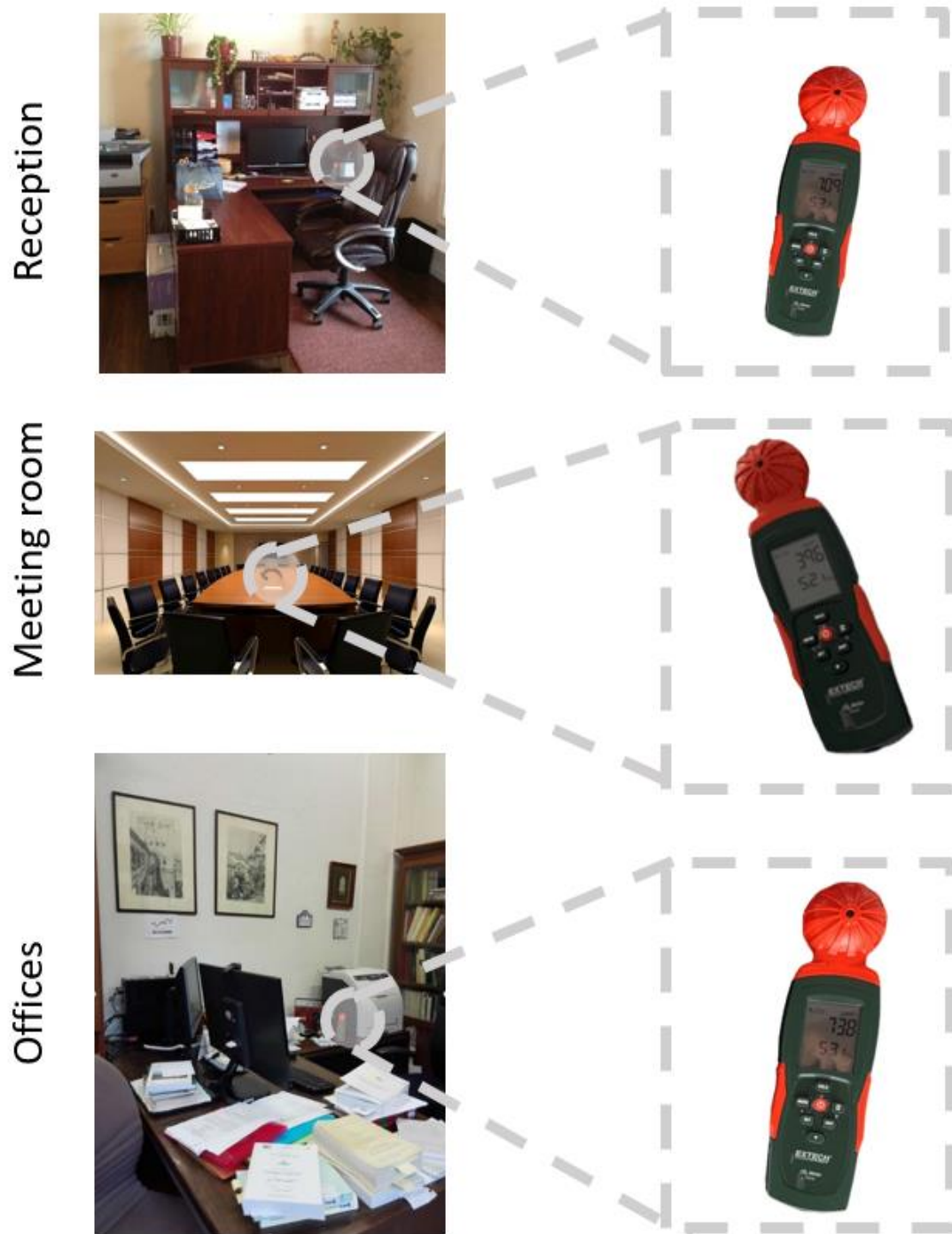


Figure 44: Low-cost company 02 indoor environment CO2 meter results.

(Source: Khaloud, 2023)

4.14.3 Low-cost company 03

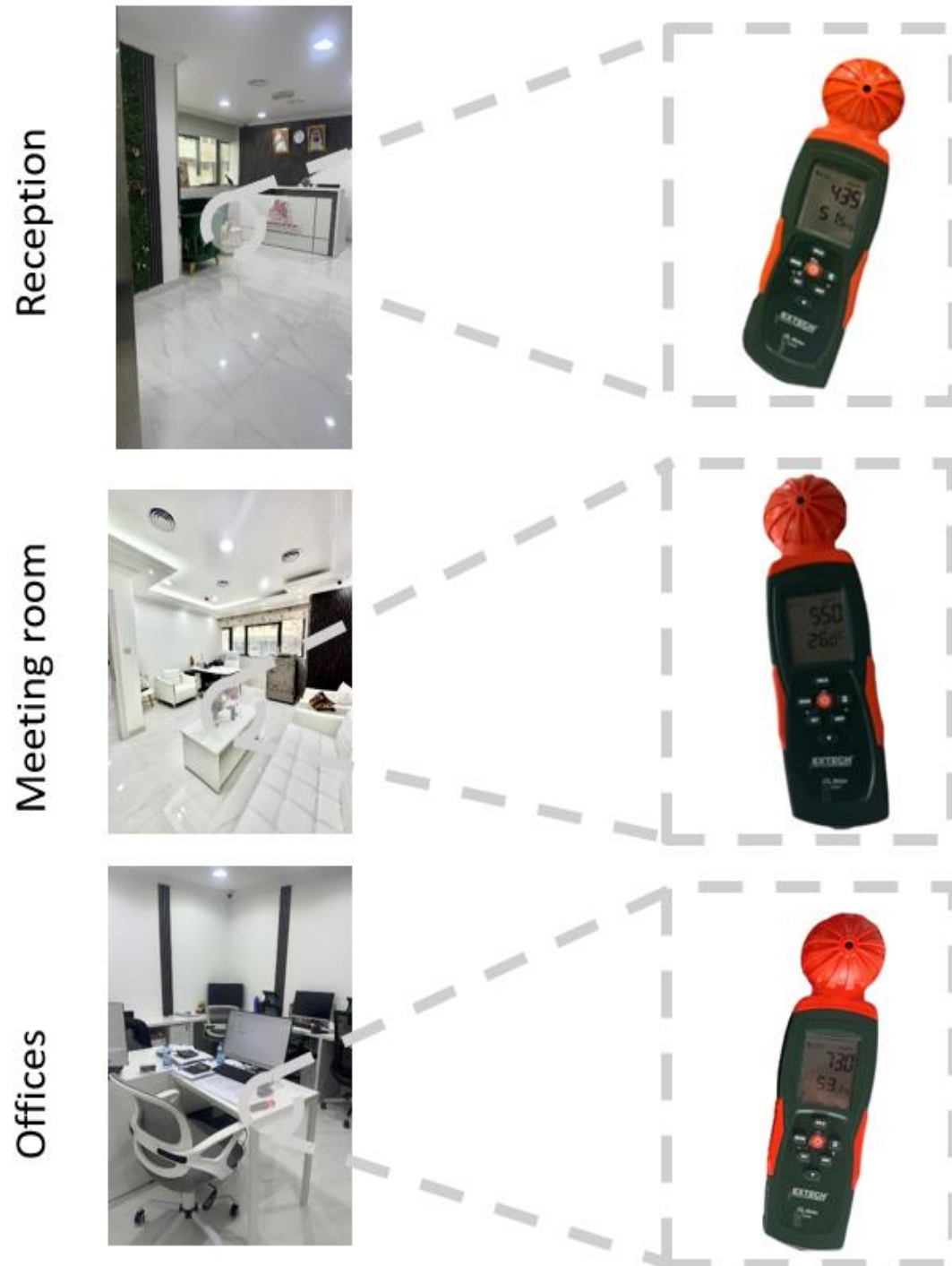


Figure 45: Low-cost company 03 indoor environment CO2 meter results.

(Source: Khaloud, 2023)

4.14.4 High-cost company 01

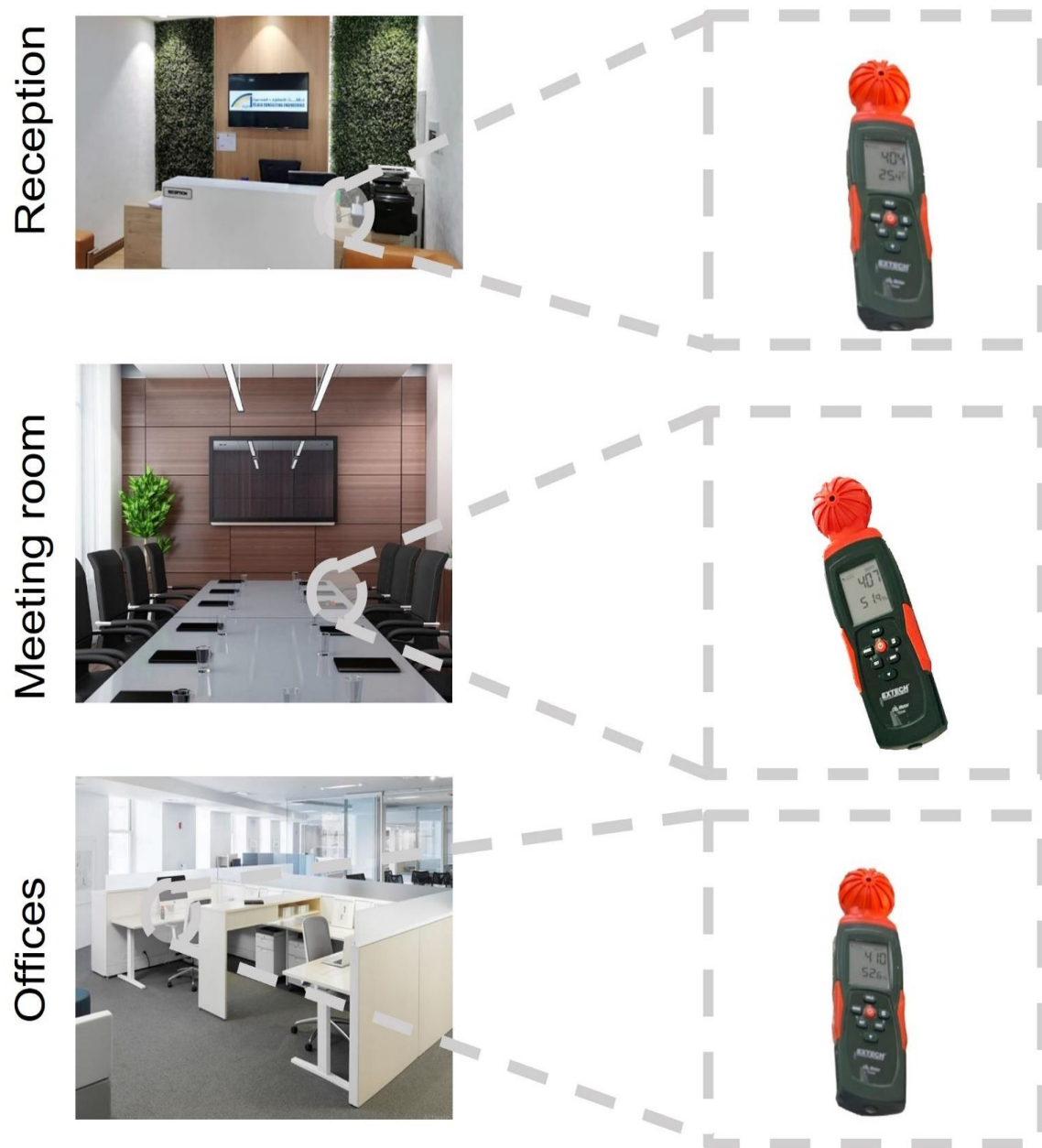


Figure 46: High-cost company 01 indoor environment CO2 meter results.

(Source: Khaloud, 2023)

4.14.5 High-cost company 02



Figure 47: High-cost company 02 indoor environment CO2 meter results.

(Source: Khaloud, 2023)

4.14.6 High-cost company 03



Figure 48: High-cost company 03 indoor environment CO2 meter results.
(Source: Khaloud, 2023)

Chapter 5 : Result and discussions

5.1 Background

This section will present a comprehensive analysis of the results and findings of the research. In this division, I will provide an objective interpretation of the results as well as a clear explanation of the implications of the findings. I will try to present the results in a clear and organized manner by using tables, figures, and graphs, if applicable. I will try to discuss the results in relation to the research questions or hypotheses. Furthermore, I will try to compare the results with others research and discuss any similarities or differences. In addition, I will highlight any limitations or constraints in my research and their impact on the results. Discuss any implications of the results for future research or practice.

5.2 Objectives and clear explanation of findings.

The objective of indoor air quality assessments is to evaluate the level of contaminants in the air inside a building and determine if it poses a risk to the health and comfort of the occupants. IAQ can be affected by a variety of factors, such as poor ventilation, moisture problems, and the presence of pollutants from indoor sources like cleaning products, carpets, and furniture (Norhidayah et al. 2013).

The findings of an IAQ assessment can vary widely depending on the specific building, but some common findings include:

- High levels of carbon dioxide (CO₂) indicate poor ventilation.
- Elevated levels of volatile organic compounds (VOCs) from sources such as cleaning products, paints, and furniture.
- Elevated levels of particulate matter such as dust, pollen, and mold spores.

- Elevated levels of moisture in the air, which can contribute to mold growth and other indoor air quality problems.
- Elevated levels of radon, a naturally occurring radioactive gas that can cause lung cancer (Norhidayah et al. 2013).

Based on these findings, the assessor can make recommendations to improve IAQ, such as increasing ventilation, improving moisture control, and reducing the use of indoor pollutants. It is important to address any IAQ problems promptly, as poor indoor air quality can have serious health consequences and impact the comfort and productivity of building occupants (Liang et al. 2022).

5.3 Finding and results

5.3.1 How I analyzed survey

I have filtered surveys that have all questions answered by employees. After that, I randomly selected 120 questionnaires after making sure that all the questions had been answered by the respondents. I chose 60 questionnaires for each type of company, and I analyzed each question so that I could reach the problems faced by employees related to the internal environment. I noticed that some employees suffer from breathing problems, headaches, coughing, allergies, indoor comfort problems, problems related to indoor air quality, and a lack of indoor ventilation in the company, I will discuss the survey in detail for each type of company separately.

5.3.2 Summary results of survey findings in low-cost companies

The main purpose of my resignation is to maintain a healthy work environment for any employee who spends most of their time in these environments. Three methods were utilized in this study (survey, field measurement, and interview) to enable us to collect the

appropriate data needed and to provide us with knowledge about employee satisfaction and how indoor IAQ affects their health and performance.

To start with the first method, which is a survey, the survey was divided into three main parts. The initial section was to gather general information about the responder. The second sector was to collect data about the company in terms of size, employees, equipment, cleaners, and the building. The last part was to assess employees' satisfaction with IAQ.

Around 70% of females' and 30% of males responded to the survey. As shown in figure 50, 30% of the respondents were between 20 and 30 years old, 50% were between 30 and 40 years old, and 20% were between 40 and 50 years old.

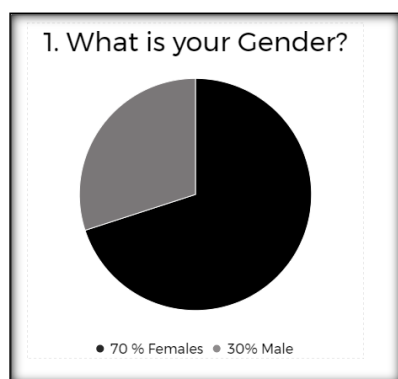


Figure 50: Present gender type.

(Source: Khaloud, 2023)

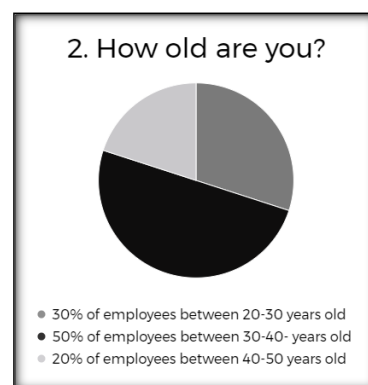


Figure 49: Present employees' age.

(Khaloud, 2023)

While in fig. 54, 30% of the respondents were working in the same company for 1-2 years, 40% were working for 2–5 years, and 30% were working for 5-8 years in the same company.

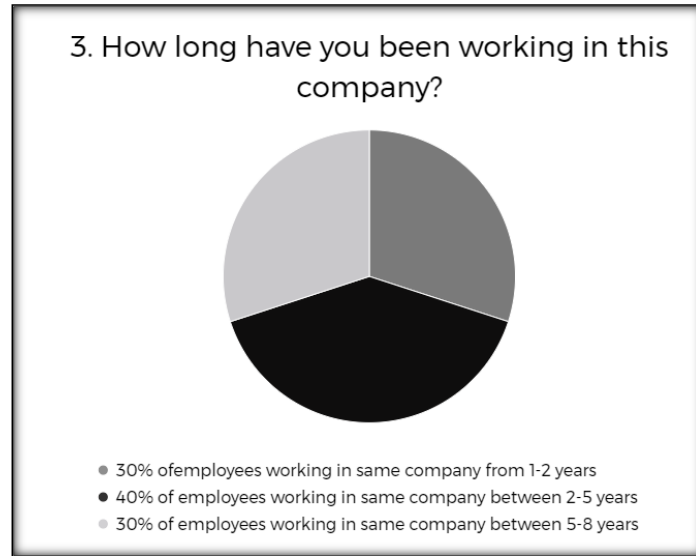


Figure 51: Specifying the period of working in this company.
(Source: Khaloud, 2023)

Regarding working hours, 90% of respondents said that they spend more than 48–55 hours per week, and only 10% spend less than 20 hours per week.



Figure 52: Present employee's time spending in the office.
(Source: Khaloud, 2023)

In terms of the reflection of sunlight and glare (reflection of light). Approximately 75% responded that there was no glare in the work area, and 25% responded that there was glare in the morning and evening in the workplace.

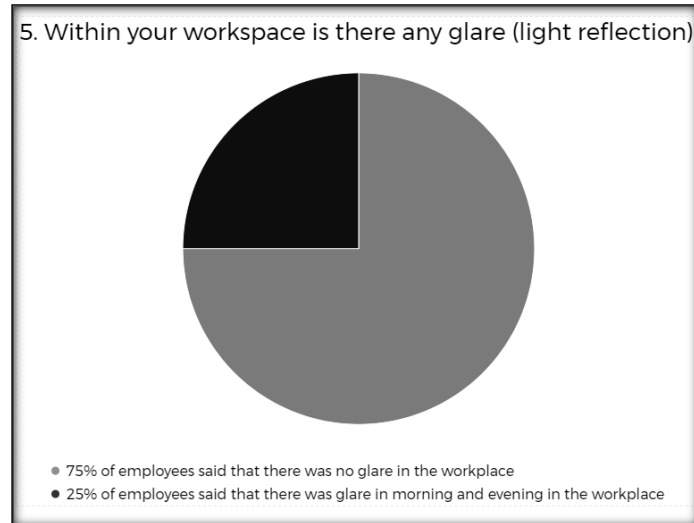


Figure 53: Present the percentage of the amount of glare.
(Source: Khaloud, 2023)

As for the number of windows available, 60% showed that there were three or more windows available in the office. Approximately 32% said that there were no windows, and only 8% said that there were 1-2 windows in the office.

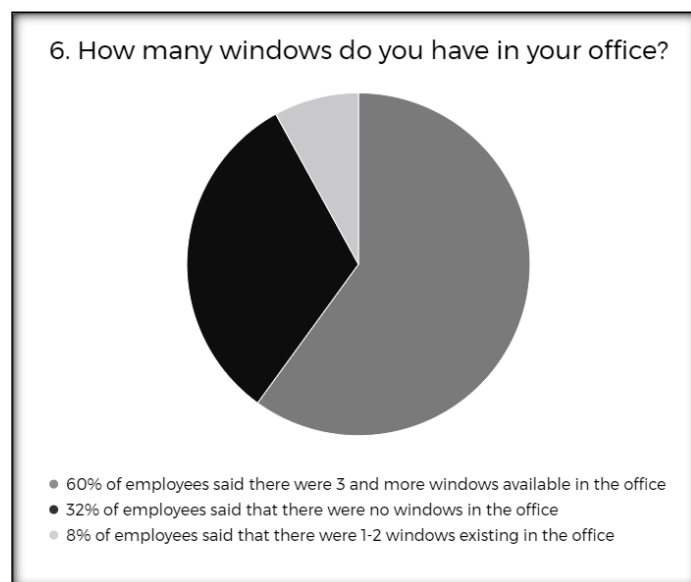


Figure 54: Present the number of windows.
(Source: Khaloud, 2023)

In terms of copiers, printers, and scanners' locations, 60% said that this equipment was available in their offices, while 40% said that it was available in the reception.

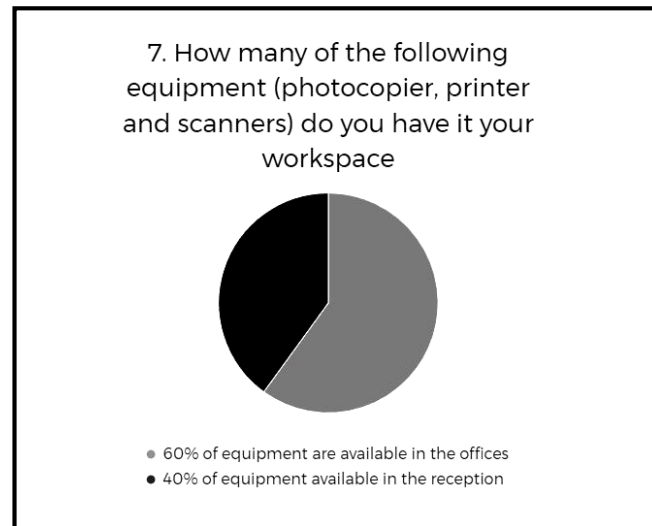


Figure 55: specifying the place of equipment.
(Source: Khaloud, 2023)

As for the wet ceilings due to water leakage or the walls, 30% of the ceilings are wet due to water leakage, and 70% do not have any leakage. In regards to the floors that were damaged due to leaks or high humidity, 13% answered that floors were damaged by leakage, and 87% mentioned that floors were not damaged by leaks.

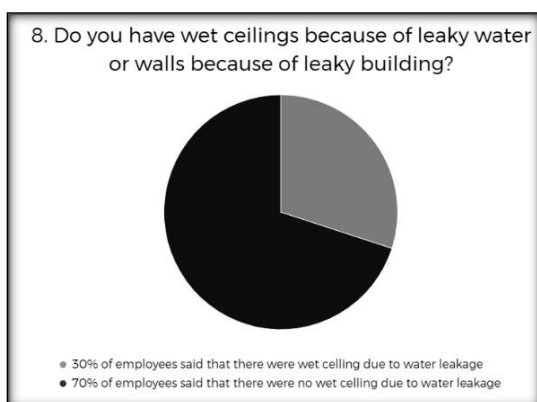


Figure 57: Present the percentage of wet ceilings because of leaked water.
(Source: Khaloud, 2023)



Figure 56: Present the damaged floor because of leaked water.
(Source: Khaloud, 2023)

There were 20% of them who have houseplants in their office and 80% who do not have any houseplants in their office. Around 87% mentioned that floors were cleansed daily, and only 13% said that once per week.



Figure 59: Present the availability of houseplant in the office.
(Source: Khaloud, 2023)

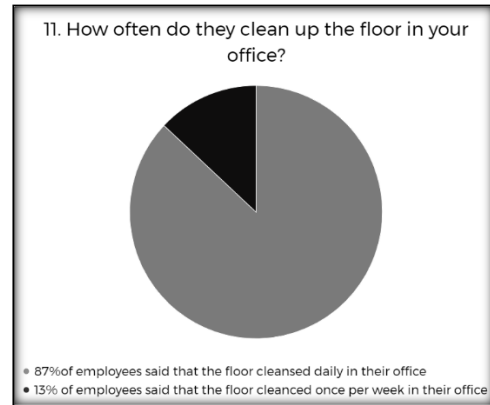


Figure 58: Present the amount of floor cleaning
(Source: Khaloud, 2023)

There were 42% of employees who kept windows open for less than two minutes a day, 17% kept windows open for two to five minutes a day, 28% kept windows open for 5 to 10 minutes a day, and only 13% kept windows open for 10 to 30 minutes a day.

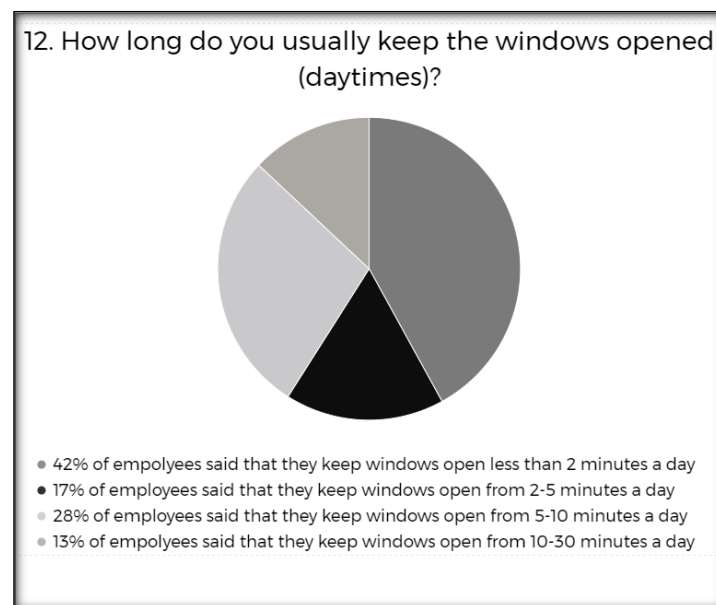


Figure 60: Specifying period of keeping windows open.
(Source: Khaloud, 2023)

59% of employees consider indoor air quality clean, and only 41% of employees consider indoor air quality moderate.



Figure 61: Describing indoor air quality.
(Source: Khaloud, 2023)

41% of employees think that indoor lighting is glare or high, only 35% think that indoor lighting is medium glare, and 42% think that indoor lighting is without glare in the office.



Figure 62: Specifying glare from light reflection.
(Source: Khaloud, 2023)

In terms of noise, 34% of employees think inner voices are fair, only 34% of employees think inner voices are good, and only 32% of employees consider them bad.

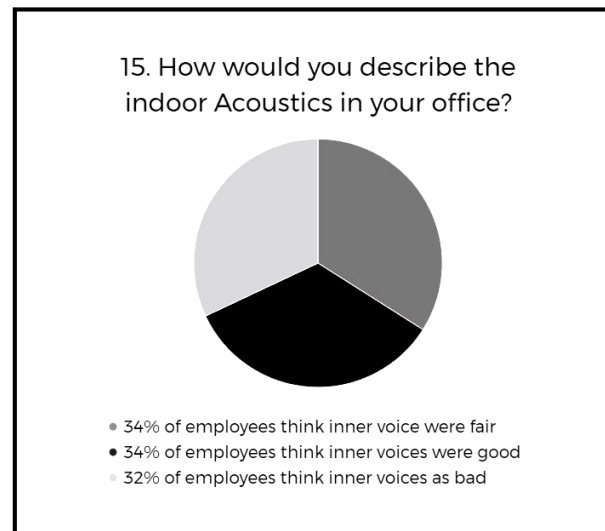


Figure 63: Present an acoustic and noisy in the office.
(Source: Khaloud, 2023)

Regarding fatigue and the employee's presence at work, workers' beliefs that the quality of the internal environment was the reason behind fatigue are around 63% of employees believe that IEQ makes them feel tired, 34% of employees never believe that IEQ leaves them suffering from fatigue, and 13% of employees think that there is no relationship between IEQ and fatigue.

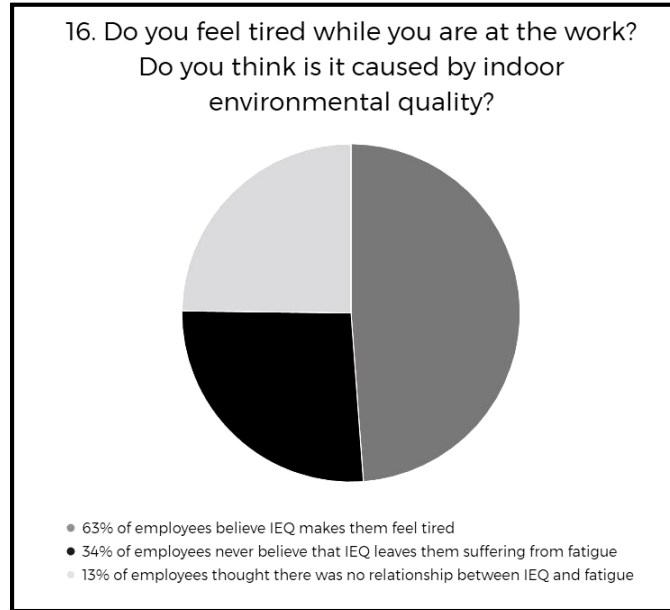


Figure 64: Present the relationship between tired and IEQ.
(Source: Khaloud, 2023)

Furthermore, around 76% of employees develop skin itchiness and eye burning, and they connect these symptoms to IEQ, while 24% of employees do not have any symptoms related to IEQ.

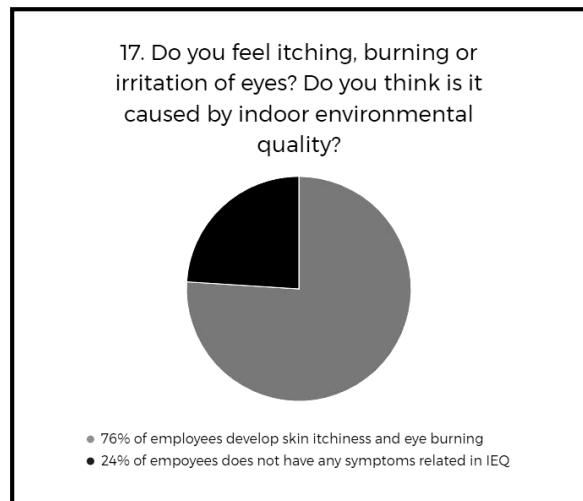


Figure 65: Present how IAQ can impact employees and have health symptoms.
(Source: Khaloud, 2023)

40% of employees believe that the furniture is somewhat comfortable in their workplaces, and only 60% of employees believe that the furniture is slightly uncomfortable in their office.

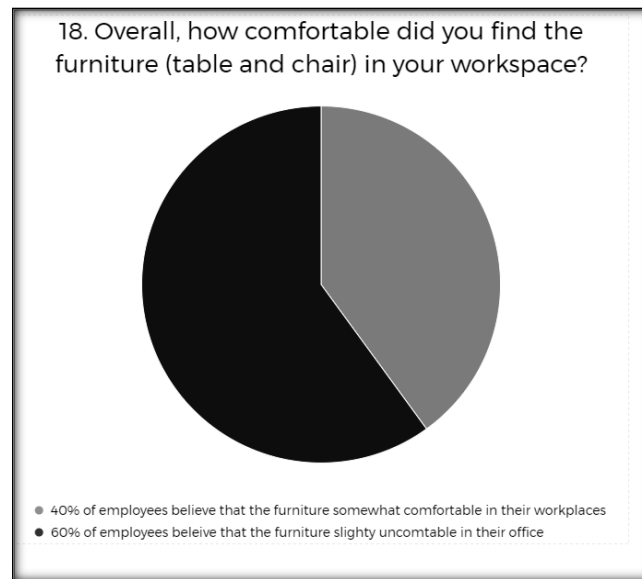


Figure 66: Specifying the employees comfortable with the furniture.
(Source: Khaloud, 2023)

As for general satisfaction with the ongoing environment, 59% of employees were strongly satisfied with the internal environment, 28% of employees were satisfied, and only 13% of employees were not satisfied with the internal environment.

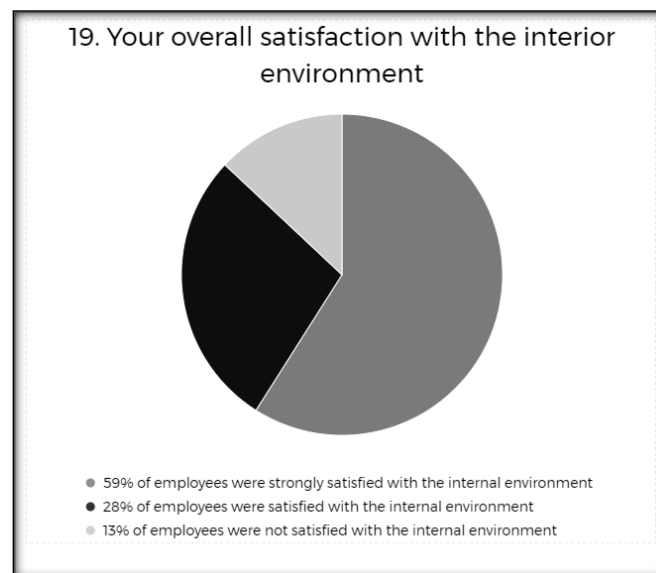


Figure 67: Present the employees satisfaction with the interior environment.
(Source: Khaloud, 2023)

Electrical lighting was an important part of the internal environment; accordingly, 52% of employees were very satisfied with the electrical lighting in their offices, 35% of employees were accustomed, and only 13% of employees were not satisfied with the electrical lighting in their offices.

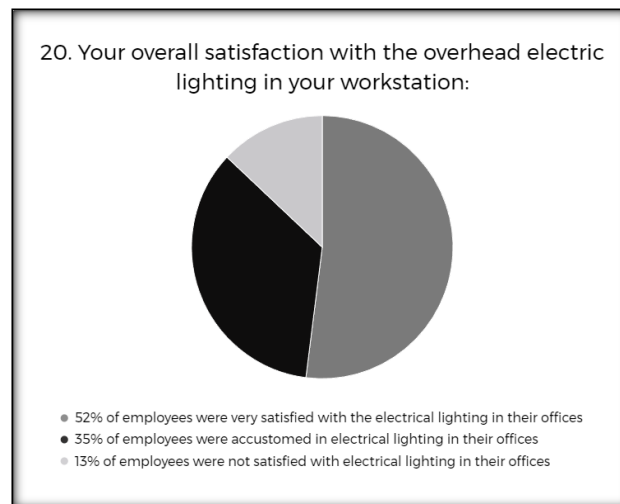


Figure 68: Present the satisfaction of employees' overhead electrical light.
(Source: Khaloud, 2023)

While talking about thermal comfort (temperature, air velocity, humidity) at their workstation, 48% of employees were very satisfied with the thermal comfort in their workplace office, while 39% of employees were normal, and only 13% of employees were not very satisfied with the heat in their offices.

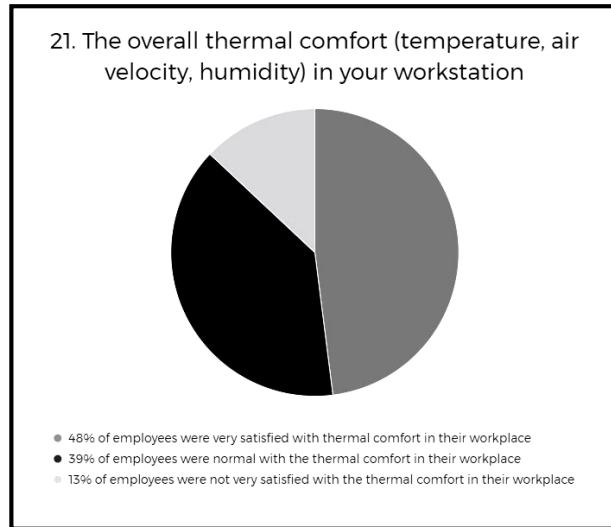


Figure 69: Present the satisfaction of employees about the thermal comfort.

(Source: Khaloud, 2023)

It was very important that employees could control or block the natural daylight at their workstation. 52% of employees were very satisfied with natural daylight, while 35% of employees were neutral with natural daylight, and only 13% of employees were very dissatisfied with natural daylight.



Figure 70: Present the ability to control or block daylight.

(Source: Khaloud, 2023)

While when we asked about the number of employees present in three meters, around 58% of employees said there were less than three employees in three meters, and 42% of employees said that there were more than four in three meters as you can see in fig.71.

Regarding flooring materials available in employees' office spaces, 50% of workers said that they used carpet. Similarity: 50% of employees said that they used ceramic floors.

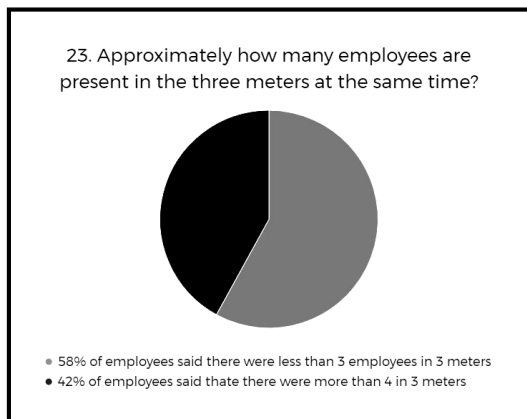


Figure 71: Present the employee's number in 3 meters.

(Source: Khaloud, 2023)

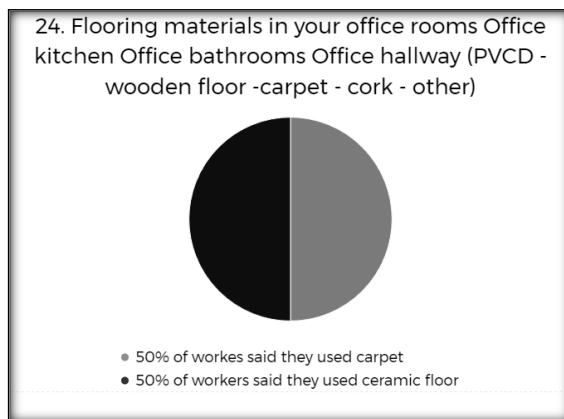


Figure 72: Specifying the flooring materials.

(Source: Khaloud, 2023)

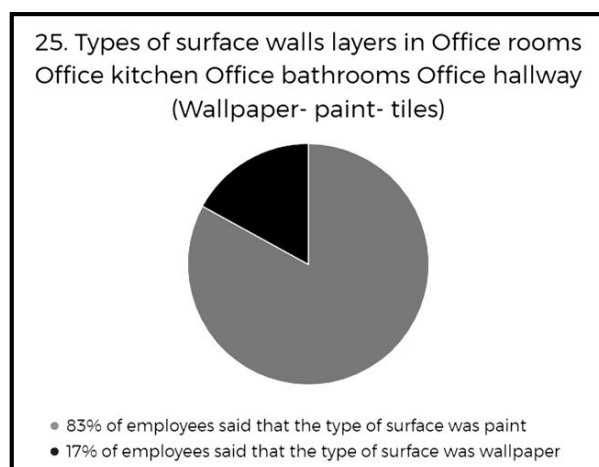


Figure 73: Specifying wall surface materials.

(Source: Khaloud, 2023)

While talking about types of surface wall layers, around 83% of employees confirmed that the type of surface was paint, and only 17% of employees stated that the type of surface was wallpaper.

While suffering from nausea, eye irritation, nose/throat pain, headache, breathing problems, coughing, blurred vision, difficulty concentrating, and sneezing. 44% of employees suffered from headaches, 78% suffered from coughs, and 13% suffered from sneezes. And 5% of workers do not have any symptoms as its present in fig.74.

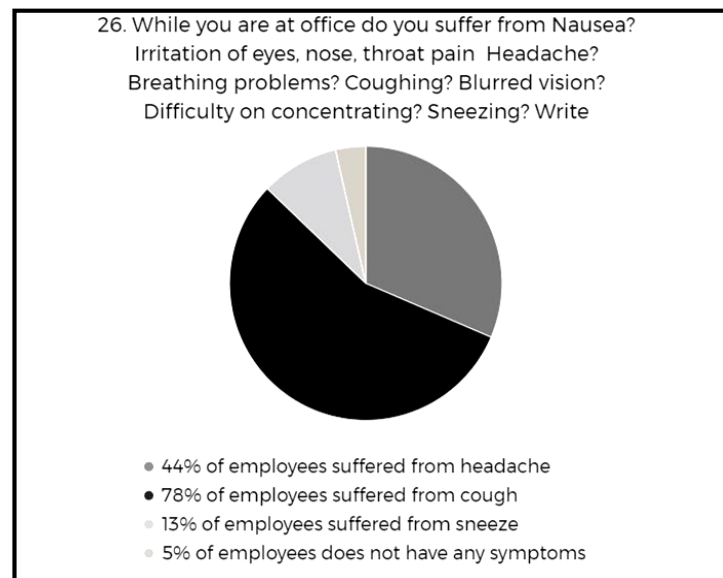


Figure 74: Present employee's health problems.

(Source: Khaloud, 2023)

Finally, 58% of employees think that their building was certified as a green building, and 42% of employees think that their building was decertified as a green building.



Figure 75: Present the building certified or not.
(Source: Khaloud, 2023)

5.3.3 Summary results of survey findings in high-cost companies

Around 75% of females' and 25% of males responded to the survey. 10% of the responders were between 20 and 30 years old, 30% were between 30 and 40 years old, and 60% were between 40 and 50 years old.

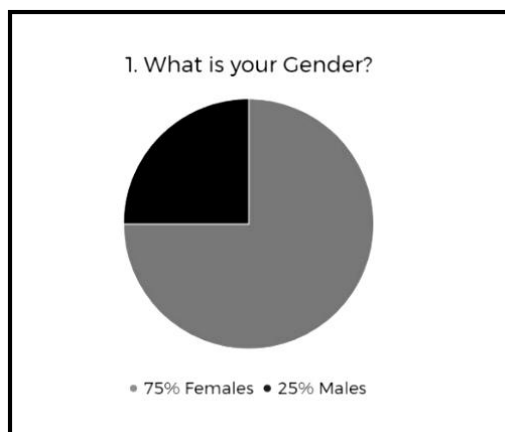


Figure 76.Present gender type.
(Source: Khaloud, 2023)

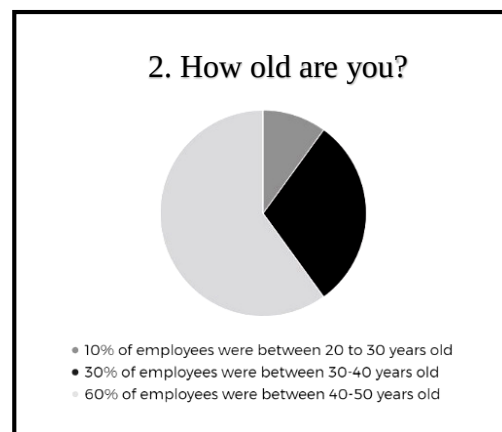


Figure 77. Present employees' age.
(Source: Khaloud, 2023)

As you can see in fig. 80 around 30% of the respondents were working in the same company for 1-2 years, around 30% were working between 2 and 5 years, and 40% were working for 5-8 years in the same company.

Regarding working hours, 80% of respondents said that they spend more than 48–55 hours per week, and only 20% spend less than 20 hours per week.



Figure 78. specifying the period of working in this company.

(Source: Khaloud, 2023)

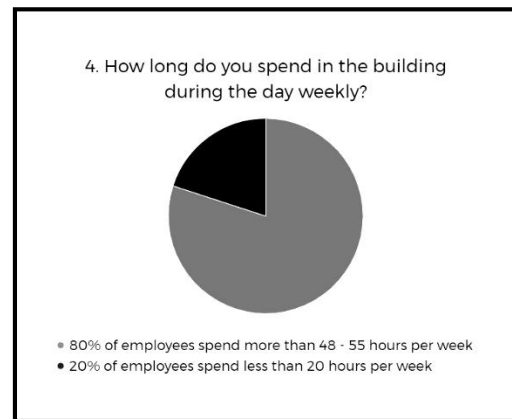


Figure 79. Present 'employees time spent in the office.

(Source: Khaloud, 2023)

In terms of the reflection of sunlight and glare (reflection of light). Approximately 60% respond that there was no glare in the work area, and equally, 40% respond that there was glare in the morning and evening in the workplace.

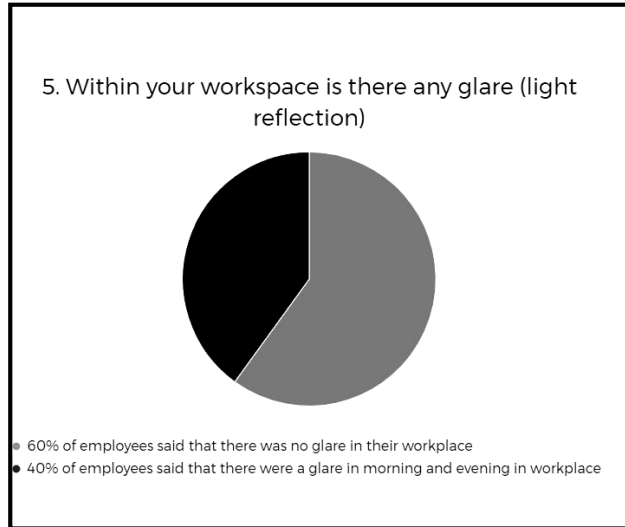


Figure 80: Present the amount of glare in the office.
(Source: Khaloud, 2023)

As for the number of windows available, 63% showed that there were three or more windows available in the office. Approximately 18% said that there were no windows, and only 17% said that there were 1-2 windows in the office.

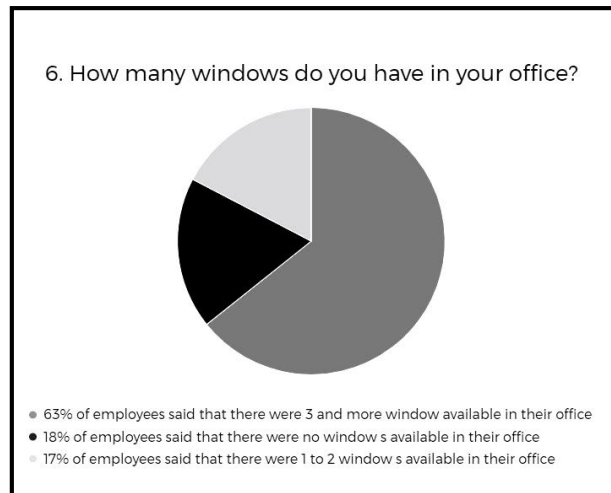


Figure 81: Specifying the number of windows in the office.
(Source: Khaloud, 2023)

In terms of copiers, printers, and scanners' locations, 35% said that these equipment was available in their offices, while 65% said that it was available in the reception.

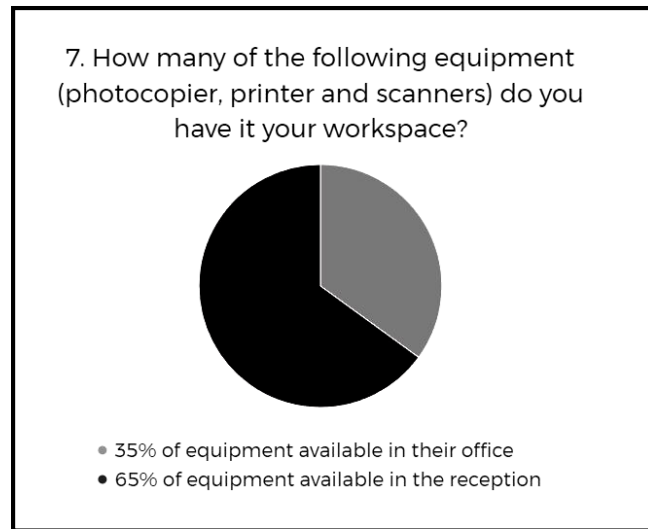


Figure 82: Specifying the place of equipment.
(Source: Khaloud, 2023)

As for the wet ceilings due to water leakage or the walls, 15% of the ceilings are wet due to water leakage, and 85% do not have any leakage. As for the floors that were damaged due to leaks or high humidity, 5% answered that floors were damaged by leakage, and 95% mentioned that floors were not damaged by leaks.

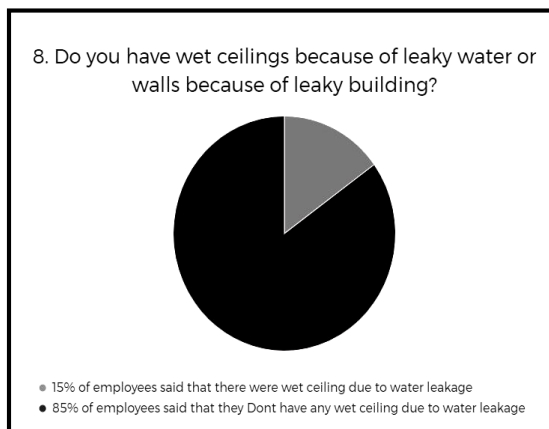


Figure 84: present the percentage of wet ceilings due to leaky water.
(Source: Khaloud, 2023)

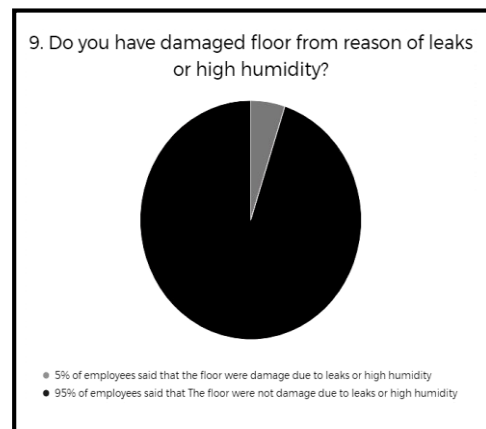


Figure 83: Present the percentage of damage floors due to leaky water.
(Source: Khaloud, 2023)

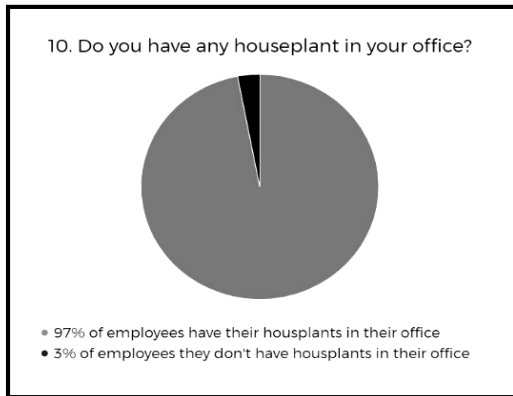


Figure 86: Present if the office contains a houseplant.
(Source: Khaloud, 2023)



Figure 85: Present the amount of floor cleaning.
(Source: Khaloud, 2023)

There were 97% of them who have houseplants in their office and 3% who do not have any houseplants in their office. While for the houseplants, 95% mentioned that floors were cleansed daily, only 5% said that once per week.

42% keep windows open less than two minutes a day, 59% keep windows open two to five minutes a day, 25% keep windows open 5 to 10 minutes a day, and only 16% keep windows open 10 to 30 minutes a day.

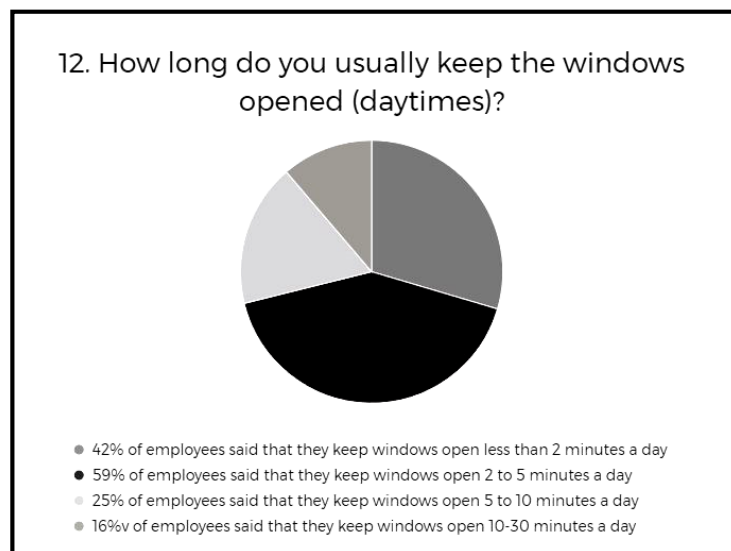


Figure 87: Present the period of keeping windows open.
(Source: Khaloud, 2023)

In terms of IAQ, around 70% of employees consider indoor air quality clean, and 30% of employees consider indoor air quality moderate.

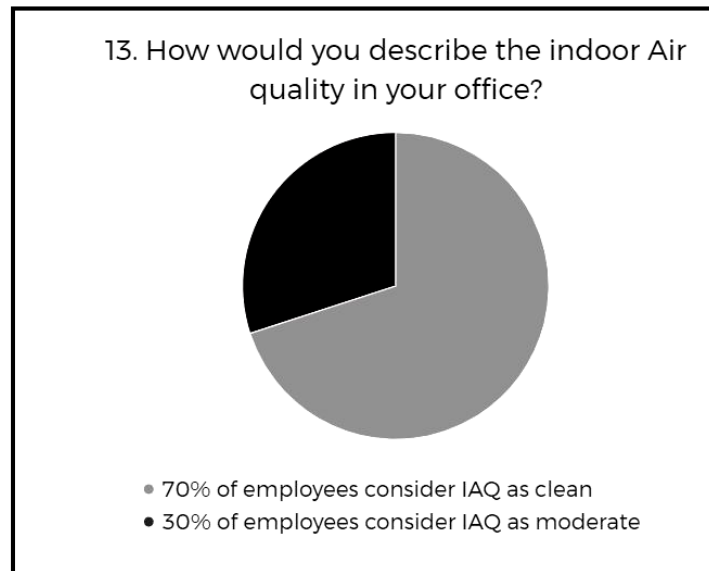


Figure 88: Describing the IAQ.
(Source: Khaloud, 2023)

10% of employees think that indoor lighting is glare-free or high, only 60% of employees think that indoor lighting is medium glare, and only 30% of employees think that indoor lighting is without glare in the office.

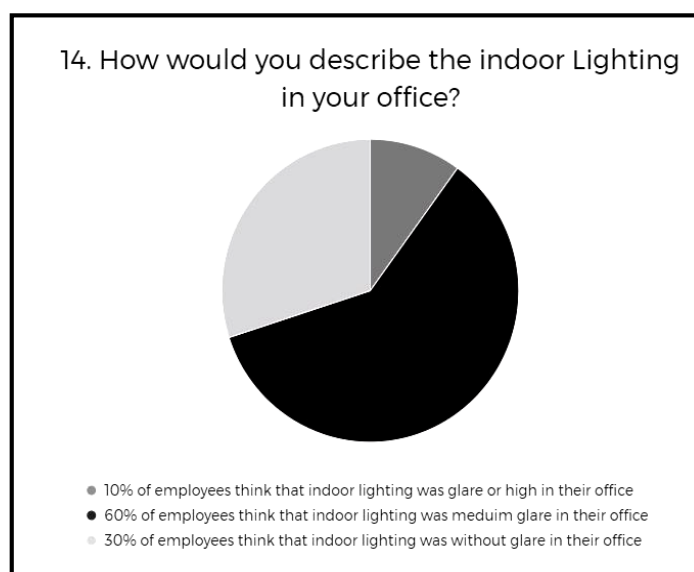


Figure 89: Describing the glare from light reflection.
(Source: Khaloud, 2023)

In terms of noise, 40% of employees think inner voices are fair, only 40% of employees think inner voices are good, and only 20% of employees consider it bad.

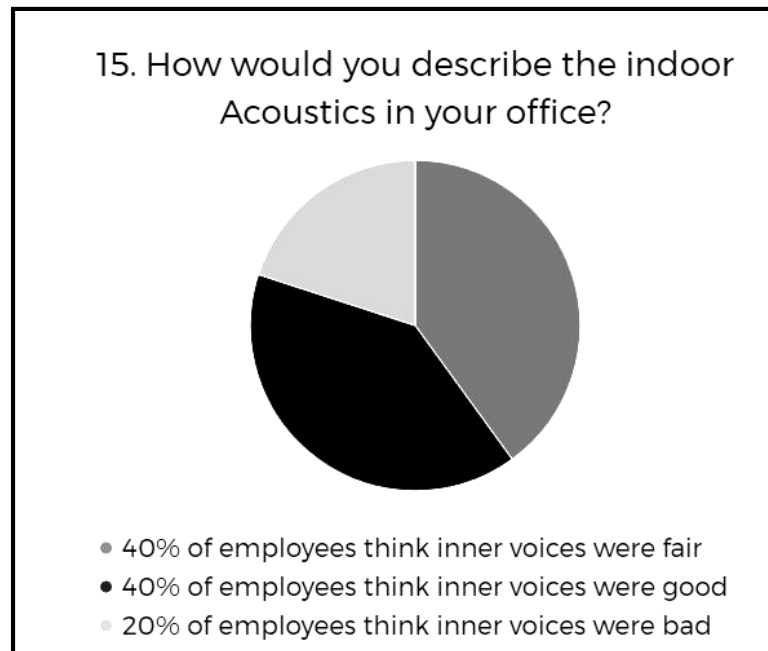


Figure 90: Specifying the acoustic in the office.

(Source: Khaloud, 2023)

Regarding fatigue and the employee's presence at work, workers' beliefs that the quality of the internal environment was the reason behind fatigue were around 24% of employees believing that IEQ makes them feel tired, 13% of employees never believing that IEQ leaves them suffering from fatigue, and 63% of employees thought that there was no relationship between IEQ and fatigue.

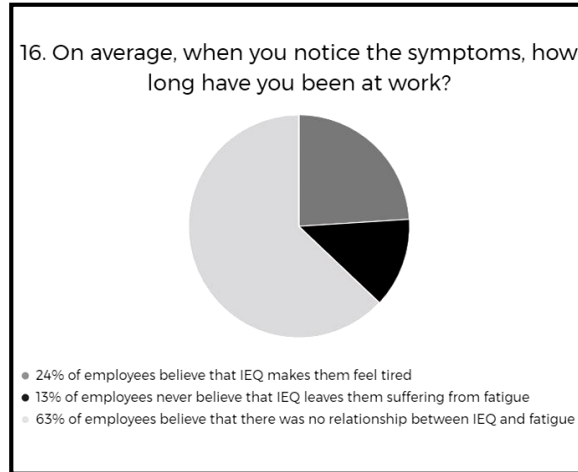


Figure 91: Present relationship between IAQ and employees tired.
(Source: Khaloud, 2023)

Furthermore, around 30% of employees develop skin itchiness and eye burning, and they connect these symptoms to IEQ, while 70% of employees do not have any symptoms related to IEQ.

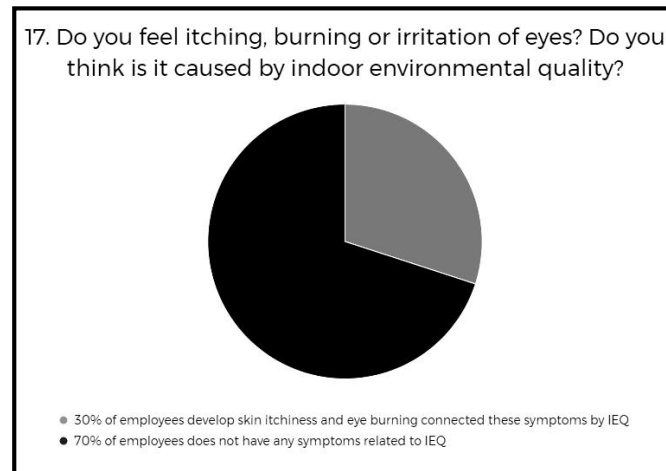


Figure 92: present how IAQ can impact employees and have health symptoms.
(Source: Khaloud, 2023)

85% of employees believe that the furniture is somewhat comfortable in their workplaces, and only 15% of employees believe that the furniture is slightly uncomfortable in their office.

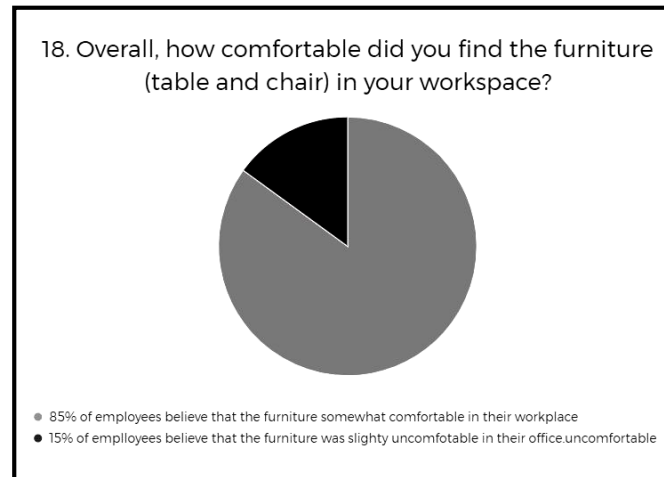


Figure 93: Specifying the employees comfortable with the furniture.
(Source: Khaloud, 2023)

As for general satisfaction with the ongoing environment, 80% of employees were strongly satisfied with the internal environment, 10% of employees were satisfied, and only 10% of employees were not satisfied with the internal environment.

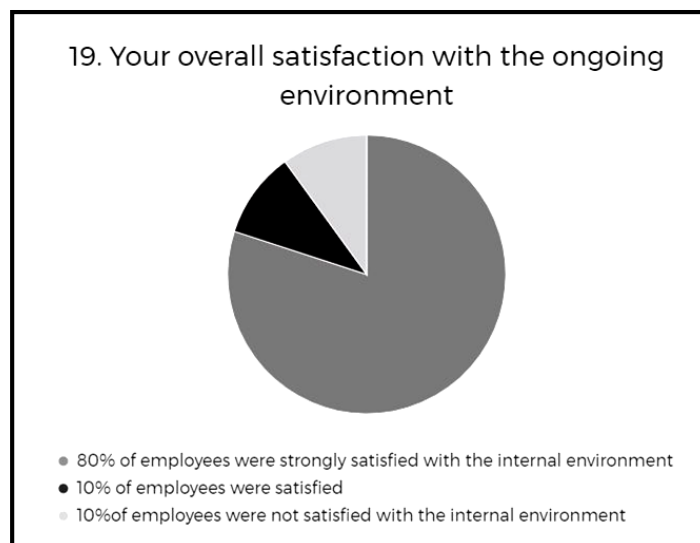


Figure 94: Employees' satisfaction with the interior environment.
(Source: Khaloud, 2023)

Electrical lighting was an important part of the internal environment; accordingly, 75%% of employees were very satisfied with the electrical lighting in their offices, 15% of employees were accustomed, and only 10% of employees were not satisfied with the electrical lighting in their offices.

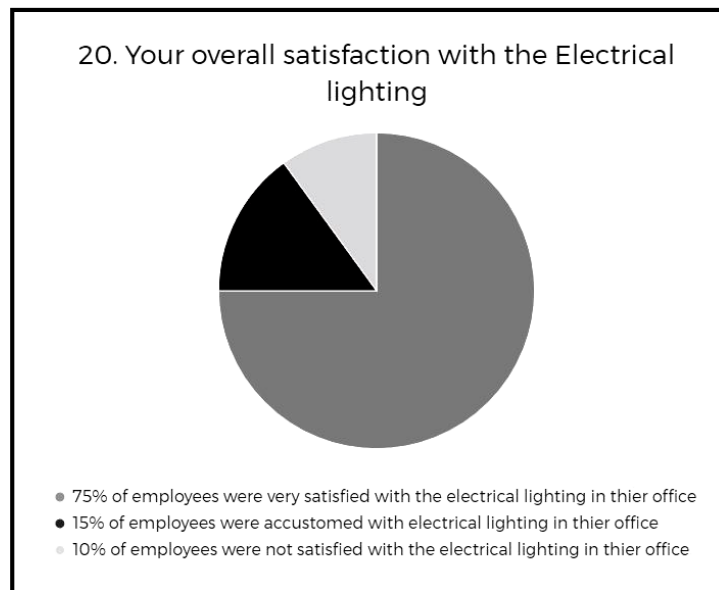


Figure 95: Employees' satisfaction with overhead electrical light.

(Source: Khaloud, 2023)

While about thermal comfort (temperature, air velocity, humidity) at their workstation, 70% of employees were very satisfied with the thermal comfort in their workplace office, while 20% of employees were normal, and only 10% of employees were not very satisfied with the heat in their offices.

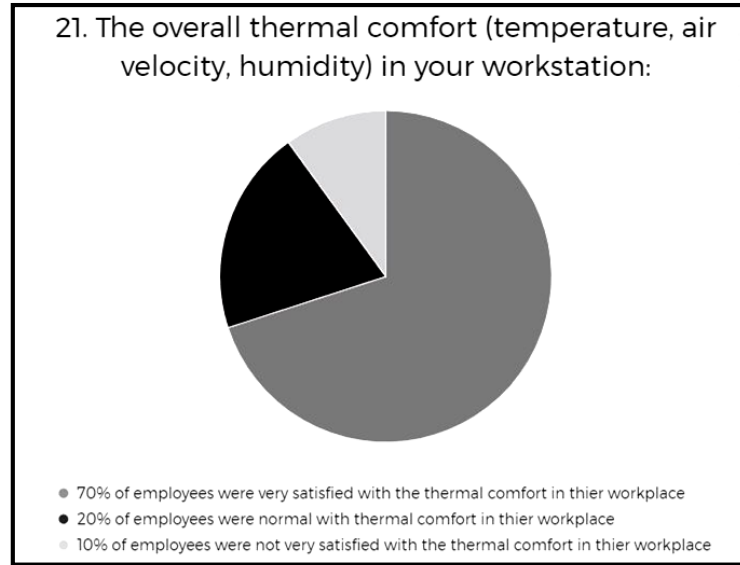


Figure 96: Employees' satisfaction with thermal comfort.
(Source: Khaloud, 2023)

It was very important that employees could control or block the natural daylight at their workstation. 75% of employees were very satisfied with natural daylight, 20% of employees were neutral with natural daylight, and only 5% of employees were very dissatisfied with natural daylight.

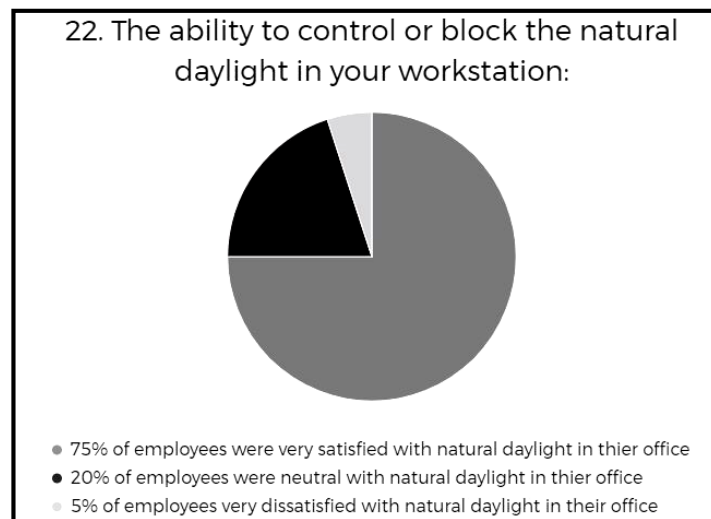


Figure 97: Employees' ability to control or block daylight.
(Source: Khaloud, 2023)

While when we asked about the number of employees present in three meters, around 70% of employees said there were less than three employees in three meters, and 30% of employees said that there were more than four in three meters.

Regarding flooring materials that are available in employees' office spaces: 30% of workers said that they used carpet. 70% of employees said that they used ceramic floors.

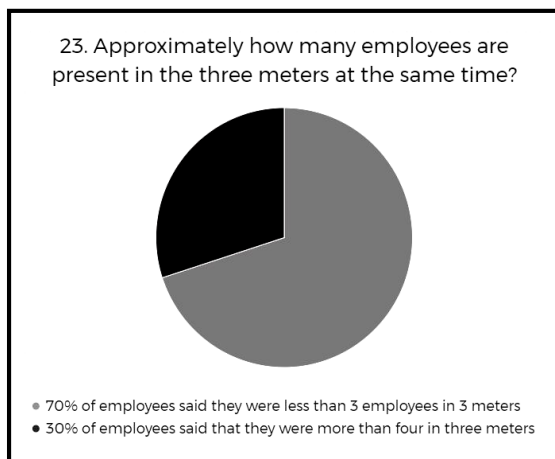


Figure 98: Present number of employees in 3 meters.
(Source: Khaloud, 2023)

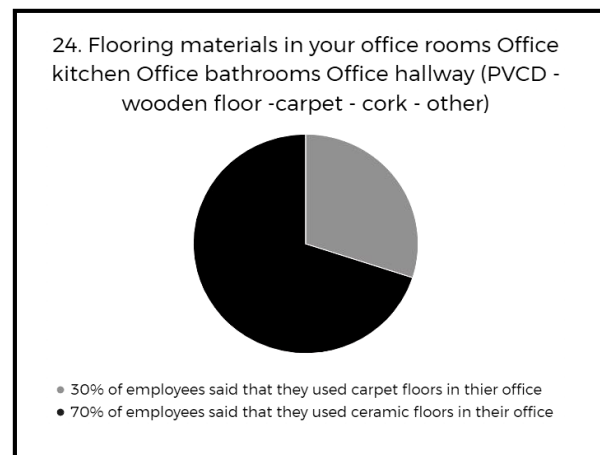


Figure 99: Specifying floor materials in the office.
(Source: Khaloud, 2023)

While talking about types of surface wall layers, around 50% of employees confirmed that the type of surface was paint, and equally 50% of employees stated that the type of surface was wallpaper.

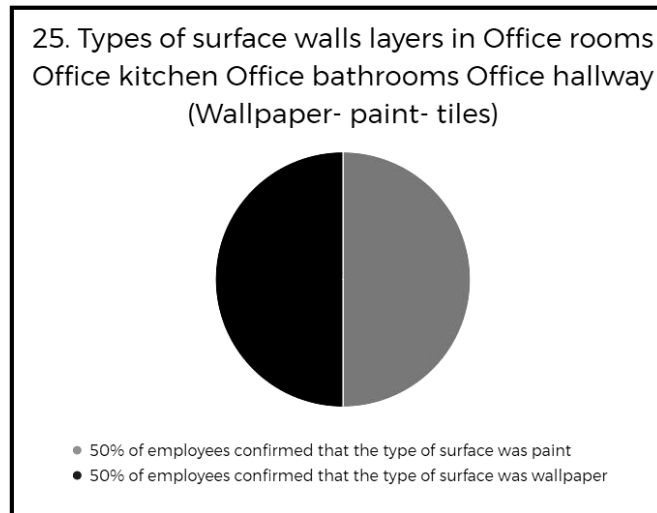


Figure 100: Specifying surface materials in the office.

(Source: Khaloud, 2023)

While suffering from nausea, eye irritation, nose/throat pain, headache, breathing problems, coughing, blurred vision, difficulty concentrating, and sneezing. As in fig.104 around 20% of employees suffered from headaches, 10% suffered from coughs, and 10% suffered from sneezes. And 60% of workers do not have any symptoms.

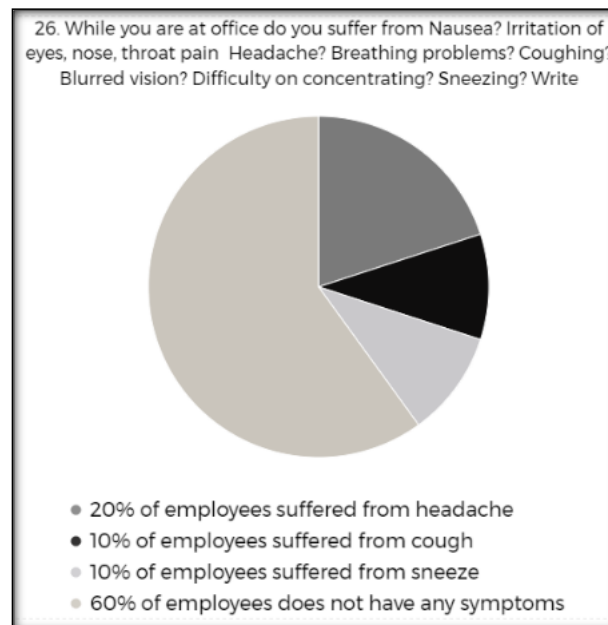


Figure 101: Present employee's health problems.

(Source: Khaloud, 2023)

Finally, 70% of employees think that their building was certified as a green building, and 30% of employees think that their building was decertified as a green building.

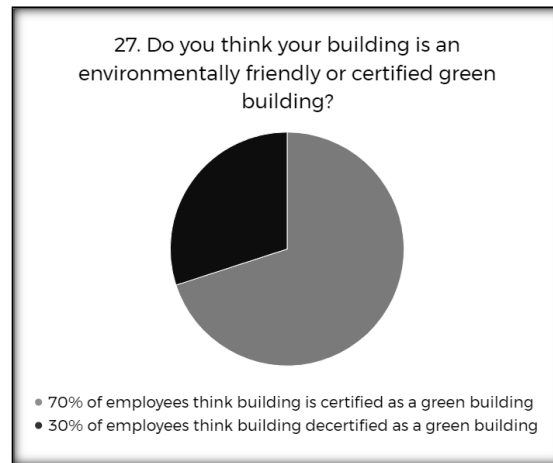


Figure 102: Present the building certified or not.
(Source: Khaloud, 2023)

5.3.4 Survey analysis and descriptive

The amount of time that employees spend in their workplace can have a significant impact on their physical and mental health. For example, long work hours and extended periods of sitting or standing can contribute to health problems such as back pain, neck pain, and musculoskeletal disorders. In addition, extended work hours can lead to increased stress levels, which can contribute to a range of negative health outcomes, including anxiety, depression, and cardiovascular disease.

Glare, or excessive brightness or contrast in the visual field, can have a number of negative effects on employees in the workplace. One of the most immediate effects of glare is eye strain and discomfort, which can lead to headaches, fatigue, and reduced productivity. This is because the eyes have to work harder to focus on objects in the presence of glare, which can lead to visual fatigue and discomfort.

Overall, reducing glare in the workplace is an important step in promoting employee health and well-being, improving productivity, and reducing the risk of accidents and injuries.

One of the most important ways that windows can affect employee health is by impacting exposure to natural light. Exposure to natural light has been shown to have a range of health benefits, including improved mood, increased productivity, and better sleep. In addition, natural light exposure can help regulate the body's circadian rhythms, which can help reduce the risk of health problems such as obesity, diabetes, and cardiovascular disease.

However, windows can also have negative effects on employee health if they are positioned in a way that creates glare or excessive heat, or if they are located near sources of noise or air pollution. Glare from windows can contribute to eye strain and discomfort, while excessive heat can lead to discomfort, dehydration, and reduced productivity.

Printers, photocopiers, and scanners can affect employees in several ways, both positively and negatively. Here are some examples: Positive impact: Printers, photocopiers, and scanners can increase productivity by providing quick and easy access to hard copies of documents. This can be especially useful when employees need to share information with colleagues or customers who prefer hard copies. Negative impact: Printers, photocopiers, and scanners can be a source of noise and distraction, especially if they are located near employees' workstations. This can be particularly problematic for employees who need to concentrate on complex tasks or who work in open-plan offices. Photocopiers and printers can emit harmful chemicals and particles that can affect indoor air quality and potentially cause health problems for employees. This is especially true if the equipment is not properly maintained or if it is located in poorly ventilated areas.

Wet ceilings caused by leaky water can have several negative effects on employees, both in terms of their health and their productivity. Here are some examples: Health risks: Wet ceilings can create an ideal environment for mold and mildew to grow, which can cause respiratory problems, allergic reactions, and other health issues for employees who are exposed to them. In addition, damp conditions can attract pests like insects and rodents, which can also pose health risks. Safety hazards: If water is leaking from a ceiling, there is a risk that it could cause damage to the electrical wiring or equipment in the area, which could create a fire hazard. In addition, wet floors can be slippery and increase the risk of slips and falls, which can cause injuries.

In regards to damaged floors caused by leaks or high humidity, this can have several negative effects on employees, both in terms of their health and their productivity. Here are some examples:

Health risks: If water penetrates the floor, it can create an ideal environment for mold and mildew to grow. This can cause respiratory problems, allergic reactions, and other health issues for employees who are exposed to it. Safety hazards: A damaged floor can be uneven or slippery, which can increase the risk of slips, trips, and falls. This can cause injuries ranging from minor cuts and bruises to more serious injuries like broken bones or head injuries. Reduced productivity: A damaged floor can be a major distraction for employees, especially if it is causing noise or if the area is cordoned off for safety reasons. This can make it difficult for employees to concentrate on their work and can lead to reduced productivity.

Having houseplants in the workplace can have several positive effects on employees. Here are some ways that houseplants can affect employees: Improved air quality: Houseplants can help improve the air quality in the workplace by removing pollutants and

increasing oxygen levels. This can lead to better health outcomes for employees, including reduced sick days and improved overall well-being. Reduced stress: Studies have shown that having plants in the workplace can help to reduce stress levels in employees. This can lead to increased productivity and job satisfaction. Increased creativity: Exposure to nature and natural elements, including plants, has been shown to increase creativity and problem-solving abilities. This can be especially beneficial for employees who work in creative fields. Improved mood: Houseplants can help improve the mood of employees by creating a more pleasant and relaxing atmosphere. This can lead to increased job satisfaction and overall happiness.

Cleaning up the floor at the workplace can have several positive effects on employees. Here are some ways that cleaning up the floor can affect employees: Improved safety: Cleaning up spills and debris on the floor can help prevent slips, trips, and falls, which can cause serious injuries. By ensuring a clean and safe working environment, employees are less likely to suffer accidents and injuries, leading to increased job satisfaction and lower healthcare costs for employers. Increased morale: A clean and organized workplace can help improve employee morale by creating a more pleasant and comfortable atmosphere. Employees are more likely to feel valued and respected when their workplace is clean and well-maintained, which can lead to increased job satisfaction and productivity. Improved productivity: A clean and organized workplace can help improve productivity by reducing distractions and creating a more efficient work environment. Employees who are not distracted by clutter or debris on the floor are better able to focus on their work and complete tasks more quickly.

Opening windows in the workplace can have several positive effects on employees. Here are some ways that opening windows can affect employees: Improved air quality: Opening windows can help improve air circulation and ventilation in the workplace, which can lead

to improved air quality. This can help reduce the buildup of indoor pollutants and allergens, leading to improved respiratory health and fewer sick days for employees. Increased natural light: Opening windows can allow for increased natural light in the workplace, which has been shown to improve mood, reduce stress, and increase productivity in employees. Exposure to natural light can also help regulate the body's natural sleep-wake cycle, leading to improved overall health and well-being. Improved temperature regulation: Opening windows can help regulate the temperature in the workplace, which can lead to improved comfort for employees. In the summer, opening windows can help to cool the environment, while in the winter, opening windows can help to bring in fresh air and prevent stuffiness and dryness.

Indoor air movement is an important factor in maintaining a healthy and comfortable workplace environment. Proper ventilation and air circulation can help remove pollutants and contaminants from the air, control temperature and humidity levels, and reduce the risk of airborne diseases and illnesses. There are several benefits to indoor air movement in the workplace:

- Improved air quality: Air movement helps to circulate fresh air through the workplace, which can help to remove pollutants and contaminants such as dust, pollen, and mold spores. This can help reduce the risk of respiratory problems and allergies among employees.
- Enhanced productivity: When the temperature and humidity levels are controlled, and the air quality is improved, employees are more likely to feel comfortable and focused. This can lead to increased productivity and reduced absenteeism.
- Improved health and safety: Indoor air movement can help reduce the risk of airborne diseases and illnesses by preventing the buildup of bacteria and viruses

in the air. This is especially important in workplaces where many people share the same space.

- Energy efficiency: Proper ventilation and air circulation can help reduce the need for heating and cooling systems, which can help save energy and reduce costs.

Overall, indoor air movement is an important factor in creating a healthy and comfortable workplace environment. It can help to improve air quality, enhance productivity, and promote the health and safety of employees.

Indoor acoustics can have a significant impact on employees in the workplace. Poor acoustics can lead to a variety of negative effects, including reduced productivity, increased stress levels, and decreased job satisfaction. Here are some ways in which indoor acoustics can affect employees in the workplace:

- Noise distractions: Excessive noise levels can be distracting and make it difficult for employees to concentrate on their work. This can lead to reduced productivity and increased stress levels.
- Speech intelligibility: Poor acoustics can make it difficult for employees to hear and understand each other during conversations. This can lead to misunderstandings and errors, which can be frustrating and time-consuming.
- Privacy concerns: In open office environments, poor acoustics can make it difficult for employees to have private conversations. This can lead to concerns about confidentiality and privacy.
- Health concerns: Exposure to excessive noise levels over a prolonged period of time can lead to hearing damage and other health issues.

To address these issues, workplaces can take steps to improve their indoor acoustics. This might include using sound-absorbing materials, such as acoustic ceiling tiles or wall panels,

or installing sound masking systems to reduce noise distractions. By improving indoor acoustics, workplaces can create a more comfortable and productive environment for their employees.

The comfort of furniture, specifically the table and chair, in the workplace can have a significant impact on employee comfort, health, and productivity. Here are some ways in which comfortable furniture can affect employees in the workplace: Reducing physical discomfort: Employees who sit for extended periods of time may experience a range of physical discomforts, such as neck, back, and shoulder pain. Providing comfortable chairs and tables that are ergonomically designed can help to reduce these discomforts and improve posture, which can lead to increased productivity and fewer absences due to health issues.

Promoting good circulation: Comfortable furniture can help promote good circulation, which can reduce fatigue and muscle tension and promote good health. This is especially important for employees who spend long hours sitting at a desk or workstation.

Improving mental health: Comfortable furniture can also help improve mental health by reducing stress and anxiety levels. Employees who are comfortable in their workspace are more likely to feel relaxed and focused, which can lead to increased productivity and job satisfaction.

Enhancing teamwork: Comfortable furniture can also promote teamwork by creating spaces that are conducive to collaboration and communication. This can help improve morale, promote creativity, and encourage innovation.

Thermal comfort in the workplace, which includes factors such as temperature, air velocity, and humidity, can have a significant impact on employee comfort, health, and productivity. Here are some ways in which thermal comfort can affect employees in the workplace:

- **Temperature:** If the temperature is too high or too low, employees may become uncomfortable, leading to reduced productivity and increased health issues. For example, if the temperature is too high, employees may become dehydrated, fatigued, and more prone to heat exhaustion. On the other hand, if the temperature is too low, employees may experience discomfort, decreased dexterity, and an increased risk of cold-related illnesses.
- **Air velocity:** Air movement can affect how comfortable employees feel in a space. If air velocity is too low, employees may feel stagnant and stuffy. If air velocity is too high, employees may feel cold, drafty, and uncomfortable.
- **Humidity:** High humidity levels can lead to an uncomfortable and stuffy feeling, while low humidity levels can cause dry skin, eyes, and respiratory issues.

Overall, it is important for workplaces to maintain a comfortable thermal environment for their employees to promote productivity, health, and well-being. This can be achieved by maintaining proper temperature and humidity levels as well as providing adequate air circulation to ensure proper air velocity. Additionally, providing employees with control over their immediate environment, such as through adjustable temperature and air flow, can help ensure that they are comfortable and productive throughout the workday.

It may not always be possible or advisable to have employees work in close proximity to each other due to various reasons, such as:

Social distancing requirements: In response to the COVID-19 pandemic, many workplaces have implemented social distancing measures to reduce the spread of the virus. This may involve spacing out workstations or implementing remote work policies.

Health and safety concerns: Depending on the nature of the work being performed, it may be necessary to maintain physical distance between employees to ensure their safety. For

example, in industries such as construction or manufacturing, employees may need to operate heavy machinery or equipment that requires a certain amount of space to operate safely.

Noise levels: Some workplaces may be noisy, which can make it difficult for employees to communicate effectively with each other. In these situations, it may be necessary to separate workstations or implement sound-absorbing materials to reduce noise levels.

Privacy concerns: In certain industries, such as healthcare or finance, employees may need to handle sensitive or confidential information. In these cases, it may be necessary to separate workstations to ensure privacy and confidentiality.

Flooring materials can have an impact on employee health in several ways. Here are some examples:

Indoor air quality: Many flooring materials, such as carpeting, can release volatile organic compounds (VOCs) into the air, which can cause respiratory irritation, headaches, and other health problems. Some flooring materials, such as vinyl, can also contain phthalates, which have been linked to a variety of health issues.

Slip and fall injuries: Slip and fall injuries can be a common workplace hazard, especially in areas with wet or slippery floors. Choosing flooring materials that provide good traction and slip resistance can help reduce the risk of these types of injuries.

Noise levels: Certain flooring materials, such as hard surfaces like tile or concrete, can create a lot of noise in a workplace. This can be a problem in areas where employees need to concentrate or communicate with each other. Choosing flooring materials that absorb sound can help reduce noise levels and improve the overall acoustics of a space.

Choosing flooring materials that are low in VOCs, slip-resistant, and easy to maintain can help create a healthier and safer workplace environment for employees. It is important to

consider these factors when selecting flooring materials for a workplace and to consult with professionals who are knowledgeable about the health and safety implications of different flooring types.

The nearness of employees, or the physical proximity of individuals in a workplace setting, can have both positive and negative effects on health.

On the other hand, physical proximity can also increase the risk of exposure to infectious diseases, particularly in situations where employees work in close quarters or share equipment and facilities. This can lead to increased rates of illness and absenteeism, which can negatively impact both individual and organizational health.

In addition, prolonged exposure to poor indoor air quality, noise, and other environmental factors can also have negative health effects on employees in close proximity. This can lead to increased rates of respiratory illness, hearing loss, and other health problems.

The type of wall surface in a workplace can affect employee health in a number of ways.

Firstly, the materials used on wall surfaces can release volatile organic compounds (VOCs) into the air, which can contribute to poor indoor air quality and negatively affect the health of employees. For example, some types of paint, wallpaper, and other wall coverings can emit VOCs such as formaldehyde, which can cause respiratory symptoms, headaches, and other health problems.

In addition, the texture and color of wall surfaces can impact employee mood and well-being. For example, research has shown that natural materials such as wood and stone can have a calming effect and contribute to a sense of well-being, while bright or bold colors can increase energy levels and creativity.

The design and layout of wall surfaces can also impact employee health. For example, walls can be used to create private spaces for employees to work or take breaks, which can

help reduce stress levels and promote mental health. Conversely, overly open workspaces with few walls or partitions can lead to a lack of privacy and increased distraction, which can negatively impact employee productivity and well-being.

Overall, the type of wall surface in a workplace can have a significant impact on employee health, and it is important to consider factors such as materials, texture, color, and layout when designing and outfitting workspaces. By prioritizing the health and well-being of employees, organizations can create a more productive and positive work environment.

There can be several reasons why an employee may suffer from coughing. Some common causes include:

Respiratory infections: Coughing can be a symptom of respiratory infections such as colds, flu, or pneumonia. These infections can spread easily in the workplace.

Allergies: Allergies to substances such as pollen, dust, or pet dander can cause coughing and other respiratory symptoms.

Air pollution: Poor indoor air quality can cause coughing and other respiratory problems. This can be due to factors such as inadequate ventilation, the presence of mold or other contaminants, or exposure to chemicals or pollutants.

Smoking: Employees who smoke or are exposed to second hand smoke may experience coughing as a result of the irritation to their respiratory system.

If an employee is experiencing persistent coughing or other respiratory symptoms, it is important for them to seek medical advice to determine the underlying cause and appropriate treatment. Employers can also take steps to promote a healthy workplace environment by implementing policies and practices that support good indoor air quality and reduce exposure to respiratory irritants.

Sustainable building, also known as green building or eco-building, is the practice of designing, constructing, operating, maintaining, and demolishing buildings in an environmentally responsible and resource-efficient manner. Sustainable building aims to reduce the negative environmental impact of buildings by utilizing sustainable materials, improving energy efficiency, conserving water, reducing waste, and enhancing indoor environmental quality. It also considers the social and economic impact of the building on the surrounding community. Some examples of sustainable building practices include using renewable energy sources such as solar panels, incorporating natural ventilation and daylighting, using sustainable building materials such as recycled steel, and implementing water conservation measures such as rainwater harvesting and greywater recycling.

Sustainable building is becoming increasingly popular as people recognize the importance of reducing our ecological footprint and mitigating the effects of climate change. Many countries and organizations have developed standards and certifications for sustainable building, such as LEED (Leadership in Energy and Environmental Design) and BREEAM (Building Research Establishment Environmental Assessment Method).

5.4 Filed measurement 4 in 1 environmental meters

5.4.1 Filed measurement 4 in 1 environmental meter in low-cost company

As you can see in table 5 the result of filed measurement 4 in 1 environmental meter in low-cost company for the three selected companies in each reception, meetings room, and offices.

Furthermore, each of these companies has four readings such as: air velocity, temperature, humidity, and lights.

Start with the first device, which is a field measurement device. 4 in 1 environmental meter according to ASHRAE's recommended standard for Air velocity 0.15 and 0.25 m/s. Temperature: 20–24 °C. Relative humidity: 30–60%. Lights: 300 and 500 lux. The lowest air velocity reading is in low-cost 01 on reception, while in low-cost 02 it is above the standard level due to small space and high AC, and in low-cost 03 it is acceptable. All air velocity levels in high-cost companies are acceptable. Regarding the temperature and relative humidity, both low-cost and high-cost companies are at standard levels; additionally, the lighting in a low-cost company 01 has the lowest reading, while 02 and 03 are at standard levels. Finally, in all high-cost companies, the lighting readings are much higher than the standard level.

Start with the first device, which is a field measurement device. 4 in 1 environmental meter according to ASHRAE's recommended standard for Air velocity 0.15 and 0.25 m/s. Temperature: 20–24 °C. Relative humidity: 30–60%. Lights: 300 and 500 lux. The lowest air velocity reading is in low-cost 01 on reception, while in low-cost 02 it is above the standard level due to small space and high AC, and in low-cost 03 it is acceptable. All air velocity levels in high-cost companies are acceptable. Regarding the temperature and relative humidity, both low-cost and high-cost companies are at standard levels; additionally, the lighting in a low-cost company 01 has the lowest reading, while 02 and 03 are at standard levels. Finally, in all high-cost companies, the lighting readings are much higher than the standard level.

5.4.2 Filed measurement 4 in 1 environmental meter in high-cost company

Table 5: Filed measurement 4 in 1 environmental meter in low-cost company result.

(Source: Khaloud, 2023)

4 in 1 environmental meter	Low-cost company 01				Low-cost company 02				Low-cost company 03			
	Air velocity	Temperature	Humidity	Light	Air velocity	Temperature	Humidity	Light	Air velocity	Temperature	Humidity	Light
Reception	0.08m/s	23.0 °C	58.2 % RH	332 Lux	0.08 m/s	23.0 °C	58.3 % RH	497 Lux	0.2m/s	22.7 °C	59.1% RH	496 Lux
Meeting room	0.14m/s	23.2 °C	57.7 % RH	351 Lux	0.4m/s	23.7 °C	57.3 % RH	567 Lux	0.2 m/s	22.8 °C	58.8% RH	584 Lux
Office	0.14m/s	23.5 °C	57.0 % RH	442 Lux	0.1m/s	23.4 °C	57.6 % RH	583 Lux	0.2 m/s	22.7 °C	59.0% RH	595 Lux

Table 6: Filed measurement 4 in 1 environmental meter in high-cost company result.

(Source: Khaloud, 2023)

4 in 1 environmental meter	High-cost company 01				High-cost company 02				High-cost company 03			
	Air velocity	Temperature	Humidity	Lights	Air velocity	Temperature	Humidity	Lights	Air velocity	Temperature	Humidity	Lights
Reception	0.1 2 m/s	22.0 °C	53.9%RH	681Lux	0.1 6 m/s	22.3 °C	55.2%RH	822Lux	0.2 m/s	22.5 °C	58.9 %RH	803Lux
Meeting room	0.1 2 m/s	22.0 °C	54.6%RH	774Lux	0.1 2 m/s	22.0 °C	54.4%RH	893Lux	0.2 m/s	22.6 °C	59.0 %RH	869Lux
Office	0.0 8 m/s	22.2 °C	54.4%RH	797Lux	0.1 2 m/s	22.0 °C	53.9%RH	846Lux	0.2 m/s	22.7 °C	58.8 %RH	867Lux

5.4.3 Sound level alert meter in low and high-cost companies.

As you can see in the below table 7 the result of sound level alert meter in low and high-cost company for the six selected companies in each reception, meetings room, and offices. Furthermore, each of these companies has three readings in the three selected spaces. The second device used was a sound level alert meter. The acceptable noise level standard in the office is typically between 40 and 60 dP. The yellow color shows the reading is within the standard level, while the red color shows the reading is high but still within the acceptable level. Due to different sources of noise, meeting rooms in low-cost 01 and 03 have high readings.

Table 7: Sound level alert meter in low and high-cost companies.

(Source: Khaloud, 2023)

Sound level alert meter	Low-cost company	Low-cost company	Low-cost company	High-cost company	High-cost company	High-cost company
Reception	59.9 dB	55.6 dB	55.7 dB	47.1 dB	42.3 dB	42.3 dB
Meeting room	63.3 dB	59.6 dB	60.0 dB	48.1 dB	49.9 dB	39.6 dB
Office	48.0 dB	57.4 dB	56.4 dB	46.3 dB	48.0 dB	49.9 dB

5.4.4 Indoor environment CO2 meter in low and high-cost companies.

As you can see in the below table 8 the result of CO2 meter in low and high-cost company for the six selected companies in each reception, meetings room, and offices. Furthermore, each of these companies has three readings in the three selected spaces. The last device used was a CO2 indoor environment meter. The recommended CO2 level is typically between 350 and 1000 ppm due to low indoor quality. The red color is below the acceptable level; the reading highlighted with yellow is at the standard level; and the reading highlighted with blue is high but still at the acceptable level.

Table 8: Result of indoor environment CO2 meter in low and high-cost companies.

(Khaloud, 2023)

Indoor environment CO2 meter	Low-cost company	Low-cost company	Low-cost company	High-cost company	High-cost company	High-cost company
Reception	393 ppm 51.8%	709 ppm 53.2 %	435 ppm 51.5 %	404 ppm 25.4 %	407 ppm 51.9 %	409 ppm 51.6 %
Meeting room	435 ppm 26.8 %	396 ppm 52.1 %	550 ppm 26.0 %	407 ppm 51.9 %	558 ppm 26.0 %	404 ppm 51.8 %
Office	427 ppm 51.9 %	738 ppm 53.1 %	730 ppm 53.1 %	410 ppm 52.6 %	724 ppm 53.2 %	523 ppm 52.2 %

5.5 Explanations of results

5.5.1 Air velocity

The relationship between air velocity and temperature it's depending on the area of the spaces and the number of AC diffusers that space contains. As you can see in fig. 103 according to ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers), and NEA (The National Environment Agency) When the temperature between 22.5 °C. to 26.0 °C the range of air velocity will be less than 0.25 m/s at the diffuser itself.

Diffuser	Temperature (°C)		Velocity (m/s)	
	At diffuser	1 m below diffuser	At diffuser	1 m below diffuser
1	16.8	22.5	0.48	0.08
2	14.5	22	1.33	0.12
3	15.2	22.4	0.56	0.12
4	15.7	21.9	0.84	0.18
5	14.9	21.2	1.24	0.23
6	17.2	23.6	0.68	0.47
7	16.5	23.4	0.78	0.10
8	16.1	23.3	1.06	0.14
9	15.5	21.9	1.07	0.08
10	18.3	21.6	0.65	0.11
Overall	16.07	22.38	0.87	0.16
ASHRAE Standard	22.5–26.0		<0.25	
Singapore NEA Standard	22.5–25.5		<0.25	

Figure 103: standards of temperature and air velocity.

(Yau, Chew Saifullah 2012)

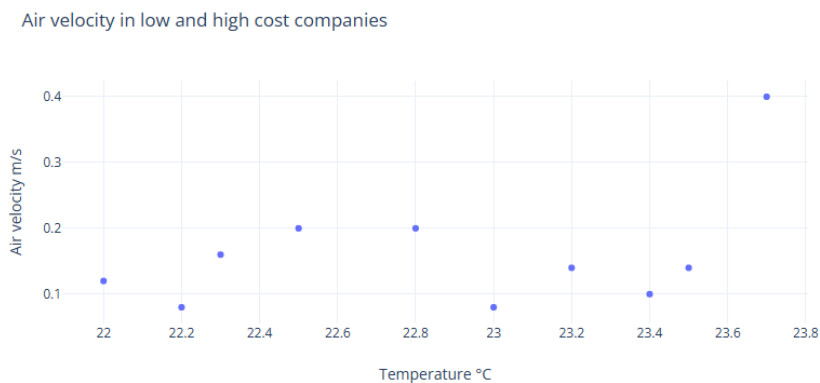


Figure 104: Relationship between temperature and air velocity in high-cost company

(Source: Khaloud, 2023)

According to the measurements that I did when the temperature 22.0 °C the air velocity was 0.12 m/s, while when the temperature 22.3 °C the air velocity was 0.16 m/s, and while when temperature 22.7 °C the air velocity was 0.2 m/s. so, it means the relationship between the air velocity and temperature is positive correlation.

5.5.2 Temperature and humidity

As you can see in fig.105, and 106 the relationship between humidity and temperature clearly notices as inverse from the reading in both level low and high companies. When the humidity increases the temperature decrease and vice versa. For instance, I will present three readings from high-cost company 03 when:

Reading01: humidity 58.9 % RH, the temperature is 22.5 °C.

Reading02: humidity 59.0 % RH, the temperature is 22.6 °C

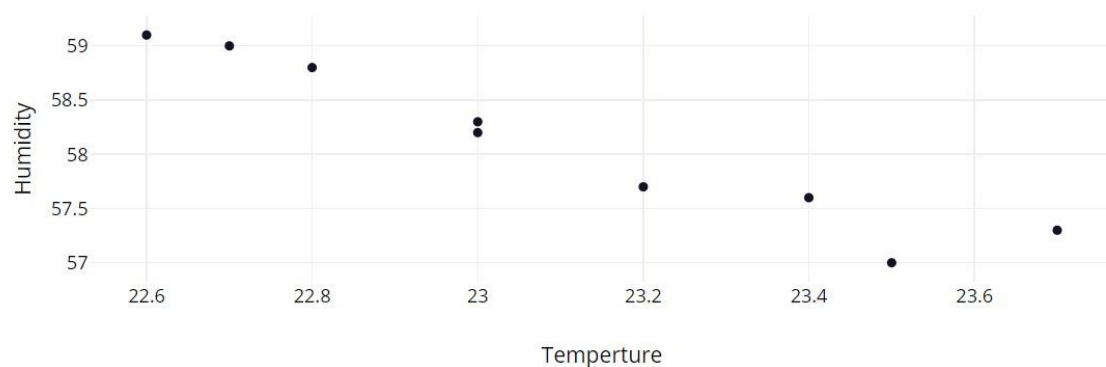


Figure 105: Relationship between humidity and temperature in low-cost company
(Source: Khaloud, 2023)

Reading03: humidity 58.8 % RH, the temperature is 22.7 °C

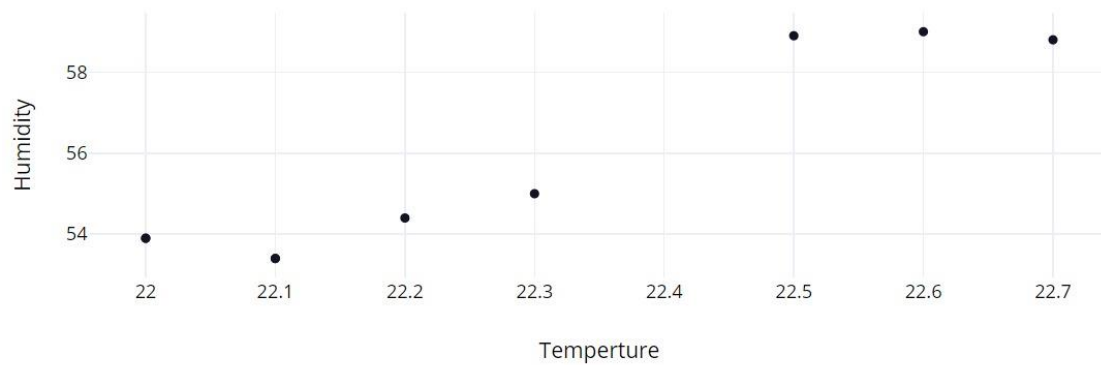


Figure 106: Relationship between temperature and humidity in high-cost company.
(Source: Khaloud, 2023)

5.5.3 Lights

As you can see in fig.107 deeply comparison between high and low-cost companies in term of lights in each space. the number of lights in high-cost company is much higher than in the low-cost company. In same figure you can clearly notice that the meetings room and offices in high-cost companies exceeds the amount of acceptable level. Also, you can notice from fig.108 a general comparison between high and low-cost companies in term of lights in each space.

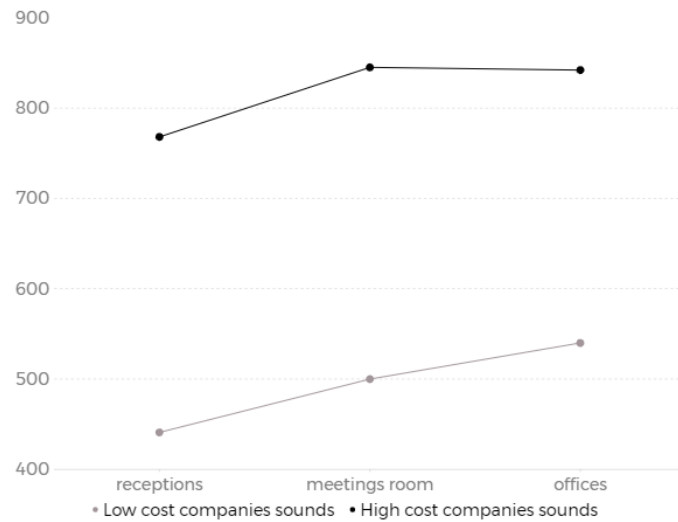


Figure 107: deeply comparison between high and low-cost companies in term of lights in each space.

(Source: Khaloud, 2023)

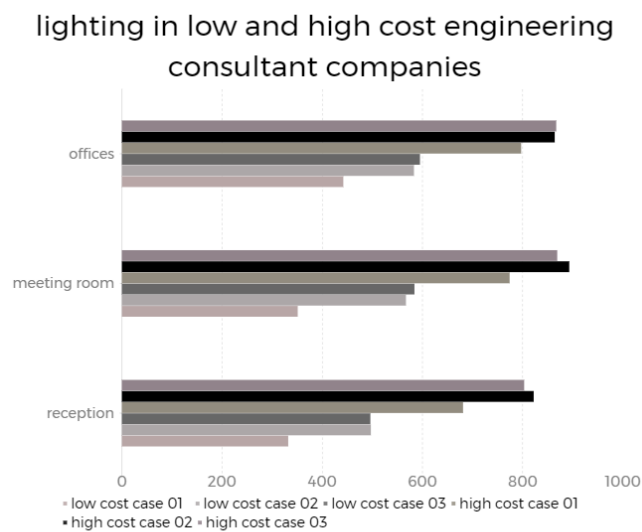


Figure 108: General comparison between high and low-cost companies in term of lights.

(Source: Khaloud, 2023)

5.5.4 Sound levels alert meters

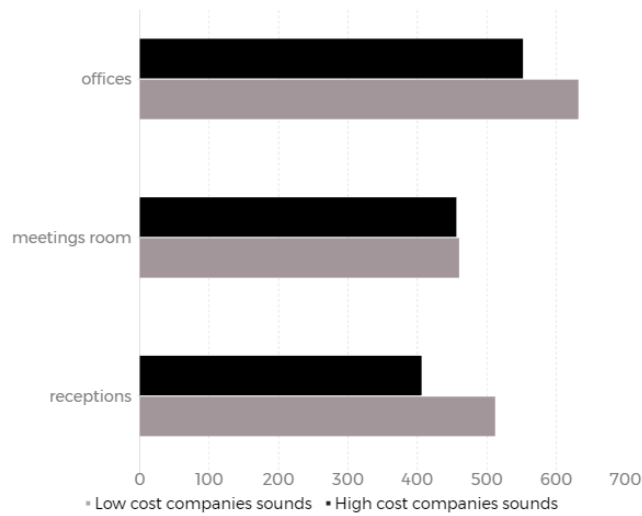


Figure 109: Deeply sound level comparison between low and high-cost companies
(Source: Khaloud, 2023)

As you can see in fig.109 deeply comparison between high and low-cost companies in each selected space in term of sound level. Readings in low-cost company is much higher than in the high-cost company. Generally, low-cost companies have a lot of noise due to amount of people, lack of isolation, might be due to the conversations, telephones, and equipment's not to ignore the outdoor traffics. According to our case studies when the space area is high the sound will be less.

In the fig.110 below you can notice that the noise in reception is decrease and it's within the limit of acceptable limits. While in the meeting due to Ac fans, using computers, talking, and narrow spaces, the second case study in low-cost company the sound level exceed the limits.

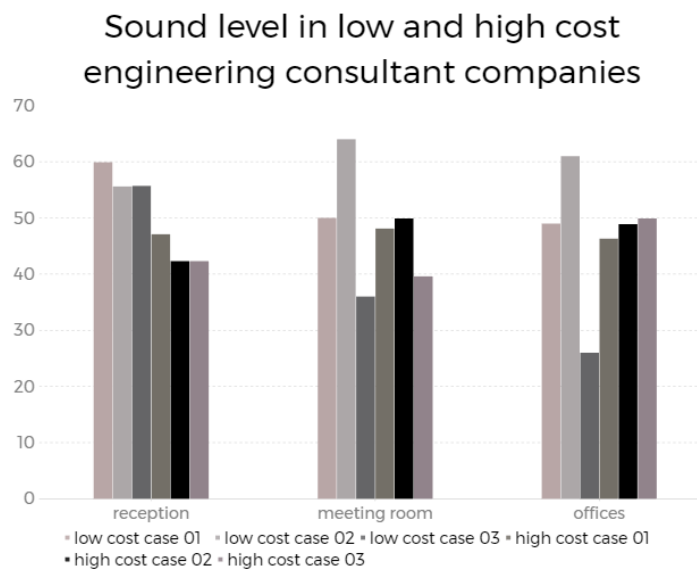


Figure 110: Sound level comparison between low and high-cost engineering consultant companies.

(Source: Khaloud, 2023)

5.5.5 CO2

As you can see in fig.111 deeply comparison between high and low-cost companies in each selected space in term of CO2 level. Readings in low-cost companies is much higher than the high-cost companies. Generally, low-cost companies have a lot of CO2 due to amount of people, low materials used, smokers, and equipment's that has a bad emissions and it can affect human health and productivity, not to ignore the outdoor traffics and emissions.

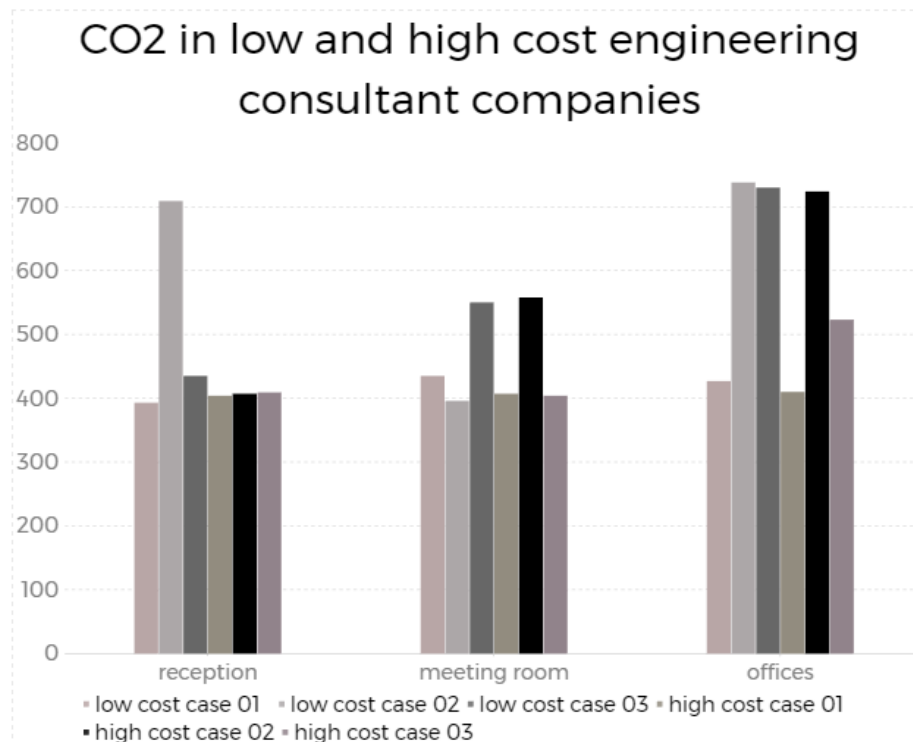


Figure 111: High and Low-quality company indoor environment CO2 meter results.

(Source: Khaloud, 2023)

5.6 General Comparison between low and high-cost company in term of 4 in 1 and the CO2 and sound level

High-quality companies prioritize the comfort and well-being of their employees, including the indoor environmental factors mentioned earlier. In contrast, low quality companies may not invest as much in creating a comfortable and healthy indoor environment. When comparing these two types of companies in terms of indoor environmental factors, several differences arise.

Firstly, high-quality companies typically monitor CO2 levels in the office to ensure they remain within acceptable limits for human health and comfort. Conversely, low quality companies may neglect CO2 monitoring or fail to take action when high levels are detected.

Secondly, high-quality companies often invest in HVAC systems that effectively maintain a consistent and comfortable temperature throughout the office. In contrast, low

quality companies may lack efficient HVAC systems, leading to temperature fluctuations and discomfort for employees.

Next, high-quality companies pay attention to air velocity and ensure proper airflow without causing discomfort for employees. They may use fans or other devices to facilitate effective air circulation. Conversely, low-quality companies may overlook air velocity, resulting in stagnant air or uncomfortable drafts.

In terms of humidity, high-quality companies utilize humidifiers or dehumidifiers to maintain a comfortable humidity level in the office. They actively monitor and control humidity to prevent employee discomfort. On the other hand, low-quality companies may not prioritize humidity levels, leading to discomfort among employees.

Furthermore, high-quality companies invest in measures to reduce noise levels in the office, such as soundproofing. By doing so, they create a more comfortable and productive work environment. In contrast, low-quality companies may neglect noise reduction, resulting in distractions and decreased productivity for employees.

Lastly, high-quality companies use lighting systems that offer adjustable brightness and color temperature, allowing employees to customize their workspace according to their preferences. Conversely, low-quality companies may have poor lighting systems that contribute to eye strain or headaches.

Overall, high-quality companies prioritize the comfort and well-being of their employees, investing in the necessary measures to create a healthy and comfortable indoor environment. In contrast, low-quality companies may not allocate sufficient resources to ensure such an environment, potentially compromising employee well-being and productivity.

5.6.1 Create a comfortable office environment in terms of CO2, air velocity, humidity, temperature, and sound level for employees in order to increase their health and productivity

Creating a comfortable office environment is crucial for promoting employee health and productivity. There are several strategies that can be implemented to achieve this goal. First, providing ergonomic furniture such as chairs, desks, and keyboards can help reduce the risk of musculoskeletal disorders and improve posture, ultimately increasing productivity.

Second, ensuring proper lighting is essential. Natural lighting is ideal, but if that is not feasible, providing adequate artificial lighting that is neither too harsh nor too dim can enhance the overall comfort of the workspace.

Third, maintaining a comfortable temperature in the office is important. Keeping the temperature between 68- and 77-degrees Fahrenheit ensures that employees are neither too hot nor too cold, contributing to their well-being and ability to focus on tasks.

Encouraging movement throughout the workday is another effective approach. This can be achieved by offering options such as standing desks, walking meetings, or designated exercise breaks. Movement helps prevent sedentary behavior and promotes physical and mental well-being.

Additionally, providing healthy snacks and drinks like fresh fruit, nuts, and water can keep employees energized and nourished throughout the day, supporting their overall health and productivity.

Fostering a positive workplace culture is also crucial. A culture that emphasizes teamwork, effective communication, and recognition for a job well done can reduce stress and enhance employee morale, ultimately boosting productivity.

Furthermore, offering mental health resources is vital to creating a comfortable environment. Employee assistance programs, mental health days, and access to counseling services are valuable resources that support employees' mental well-being, leading to improved productivity and job satisfaction.

By implementing these strategies, employers can create a comfortable office environment that prioritizes employee health and enhances productivity.

Creating a good office indoor environment requires careful attention to several factors: CO2 levels, air velocity, humidity, temperature, and sound level. Here are some tips for optimizing each of these factors.

Firstly, maintaining adequate ventilation is crucial to ensuring that indoor CO2 levels do not exceed 1000 ppm. This can be achieved through proper ventilation methods, such as opening windows or using air purification systems.

Secondly, it's important to avoid drafts and excessive air movement, as they can cause discomfort and distractions for employees. Using fans or HVAC systems that provide consistent airflow without creating drafts is recommended.

Thirdly, maintaining a relative humidity level between 30% and 60% promotes indoor comfort and reduces the risk of mold growth. Humidifiers or dehumidifiers can be used as needed to maintain the optimal humidity level.

Fourthly, maintaining a comfortable temperature between 68- and 77-degrees Fahrenheit is essential. HVAC systems that provide consistent temperature control or allow employees to adjust their workspace temperature as needed can help achieve this.

Lastly, minimizing noise levels is important for a good office environment. Using sound-absorbing materials like acoustic panels or carpets, avoiding loud equipment or noisy

appliances, and considering the implementation of a white noise system can help reduce distractions.

In summary, creating a good office indoor environment involves optimizing ventilation, temperature, humidity, air velocity, and sound level. By paying attention to these factors, employers can enhance employee comfort, productivity, and overall well-being.

5.6.2 Paying attention to the office's indoor environment quality?

High-quality companies understand the importance of creating a healthy and comfortable indoor environment for their employees. They invest in high-quality HVAC systems that provide consistent temperature control and air filtration, ensuring that indoor air quality is healthy and comfortable. Many high-quality companies use eco-friendly materials for their office interiors, such as low-VOC paint and sustainable carpeting, which reduces the amount of indoor air pollution and creates a healthier work environment. High-quality companies prioritize access to natural light in their office spaces, which improves employee mood, productivity, and overall health. Ergonomic design is also implemented, which can help reduce the risk of musculoskeletal disorders and improve posture, increasing productivity. High-quality companies invest in ergonomic furniture, such as standing desks and adjustable chairs, and provide training on proper ergonomics. They also prioritize indoor air quality testing, regularly testing indoor air quality to ensure healthy ranges of pollutants like CO₂, humidity, and particulate matter. Overall, high-quality companies understand that a healthy and comfortable indoor environment is essential for employee well-being and productivity. They prioritize indoor environmental quality to create a better work environment.

Unfortunately, low-quality companies may not prioritize office indoor environment quality as much as they should, which can have negative impacts on employee health, comfort, and productivity. They may neglect proper ventilation systems, leading to poor

indoor air quality and an increased risk of respiratory problems, headaches, and fatigue among employees. Inadequate temperature control, often due to a lack of investment in HVAC systems, can result in uncomfortable working conditions, reducing productivity, and increasing employee absenteeism. Low-quality companies may also fail to prioritize access to natural light in their office spaces, which can adversely affect employee mood, productivity, and overall health. Insufficient investment in ergonomic furniture and a lack of training on proper ergonomics can contribute to an increased risk of musculoskeletal disorders and decreased productivity. Additionally, noise pollution may be disregarded, causing distractions and reduced productivity in the office environment. While low-quality companies may neglect office indoor environment quality due to budget constraints, a lack of awareness, or other factors, it is crucial for all companies to prioritize it in order to ensure a healthy and comfortable working environment for employees.

5.7 Comparison between 4 in 1 environmental meter and other devices

5.7.1 4 in 1 and the CO2 environmental meter device

A 4-in-1 environmental meter typically measures temperature, relative humidity, air velocity, and light intensity, while a CO2 environmental meter specifically measures carbon dioxide levels in the air.

The 4-in-1 environmental meter is a versatile device that can provide a range of environmental data, making it useful in a variety of settings such as HVAC, building maintenance, and indoor air quality assessment. It can help identify issues such as poor ventilation, inadequate lighting, and temperature or humidity imbalances that can affect occupant comfort and health.

On the other hand, a CO2 environment meter is specifically designed to measure carbon dioxide levels in the air. High levels of CO2 can indicate poor ventilation, which can lead to a buildup of other harmful pollutants and affect occupant health and productivity. CO2 meters are often used in indoor environments such as offices, classrooms, and homes to monitor and maintain healthy levels of CO2.

In summary, a 4-in-1 environmental meter is a more general-purpose tool for assessing indoor environmental conditions, while a CO2 environmental meter is a specialized tool for monitoring a specific pollutant. Both types of devices can be useful in different situations, depending on the specific needs and goals of the user.

5.7.2 4 in 1 environmental meter device and the sound level alert meter device

A 4-in-1 environmental meter typically measures temperature, relative humidity, air velocity, and light intensity, while a sound level alert meter specifically measures the sound pressure levels in the air.

The 4-in-1 environmental meter is designed to provide environmental data that can help identify issues such as poor ventilation, inadequate lighting, and temperature or humidity imbalances that can affect occupant comfort and health. It is useful in a variety of settings, such as HVAC, building maintenance, and indoor air quality assessment.

A sound level alert meter, on the other hand, is designed to measure and alert users to potentially harmful levels of noise in a given environment. High levels of noise exposure can lead to hearing damage, stress, and other negative health effects. Sound level alert meters are often used in occupational settings such as manufacturing, construction, and transportation to monitor and control noise exposure levels.

In summary, while a 4-in-1 environmental meter is a general-purpose tool for assessing indoor environmental conditions, a sound level alert meter is a specialized tool for monitoring sound pressure levels and preventing potential health hazards associated with excessive noise exposure. Both types of devices can be useful in different situations, depending on the specific needs and goals of the user.

5.8 Comparison CO2 environmental meter device to the other devices

5.8.1 CO2 indoor environments meter device and sound levels device

Office indoor environments can be affected by carbon dioxide (CO₂) levels and sound levels, which can have significant impacts on the health, comfort, and productivity of occupants.

High levels of CO₂ in office indoor environments can indicate poor ventilation, which can lead to a buildup of other harmful pollutants and affect occupant health and productivity. CO₂ meters are often used in indoor environments, such as offices, to monitor and maintain healthy levels of CO₂. Recommended CO₂ levels in office indoor environments typically range between 350 and 1000 parts per million (ppm).

Sound levels in office indoor environments can also have a significant impact on occupant comfort and productivity. High levels of noise exposure can lead to hearing damage, stress, and other negative health effects. Sound level meters are often used in offices to monitor and control noise exposure levels. Recommended sound levels in office indoor environments typically range between 40 and 60 decibels (dB).

In summary, monitoring CO₂ levels and sound levels in office indoor environments is important to ensure that occupants are provided with a safe, healthy, and comfortable work

environment. Maintaining healthy CO₂ levels and low sound levels can help improve occupant comfort, reduce stress, and enhance productivity.

5.8.2 CO₂ indoor environment meter device and 4 in 1 environments meter device

The comparison between office indoor environments, CO₂, and 4 in 1 is not entirely clear. CO₂ refers to carbon dioxide, a gas that is naturally present in the Earth's atmosphere and is produced by human respiration and other natural processes. In indoor environments, CO₂ can accumulate due to poor ventilation and cause health problems such as headaches, dizziness, and fatigue.

On the other hand, 4 in 1 refers to air quality monitors that measure multiple parameters, including CO₂, temperature, humidity, and volatile organic compounds (VOCs). These monitors are designed to help people understand and improve the air quality in their indoor environments.

Therefore, it is not accurate to compare office indoor environments to CO₂ and 4 in 1, as they measure different things. However, it is important to monitor CO₂ levels in indoor environments to ensure good air quality and prevent health problems, and using a 4-in-1 air quality monitor can help achieve this goal.

CO₂ and humidity are both important factors to consider when it comes to indoor air quality in an office environment, but they measure different things.

CO₂ levels in an office can rise due to insufficient ventilation and the presence of many people in a small space. High levels of CO₂ can cause headaches, dizziness, and fatigue, and in extreme cases, it can lead to unconsciousness and even death. Therefore, it's important to monitor CO₂ levels in an office and ensure adequate ventilation to maintain healthy levels.

Humidity, on the other hand, refers to the amount of moisture in the air. High humidity levels can make an office feel stuffy and uncomfortable, and they can also promote the growth of mold and mildew. Low humidity levels can cause dry skin, respiratory problems, and discomfort.

Both CO₂ and humidity levels are important to consider when it comes to indoor air quality in an office environment. Ideally, the CO₂ level should be below 1000 parts per million (ppm), and the humidity level should be between 30% and 60%. Regular monitoring and maintenance of these levels can help promote a healthy and comfortable work environment.

CO₂ and lighting levels are both important factors to consider when it comes to indoor air quality and the overall comfort of an office environment, but they measure different things.

CO₂ levels in an office can rise due to insufficient ventilation and the presence of many people in a small space. High levels of CO₂ can cause headaches, dizziness, and fatigue, and in extreme cases, it can lead to unconsciousness and even death. Therefore, it's important to monitor CO₂ levels in an office and ensure adequate ventilation to maintain healthy levels.

Lighting levels, on the other hand, refer to the amount of light in an indoor space. Adequate lighting is important for promoting productivity, reducing eye strain, and creating a comfortable work environment. However, excessive lighting can cause discomfort and even headaches, while too little lighting can strain the eyes and cause fatigue.

Both CO₂ and lighting levels are important to consider when it comes to indoor air quality and the overall comfort of an office environment. Ideally, the CO₂ level should be below 1000 parts per million (ppm), and the lighting level should be adequate for the tasks being performed in the space. It's important to strike a balance between comfortable lighting levels

and maintaining healthy CO₂ levels, and regular monitoring and maintenance of these factors can help promote a healthy and comfortable work environment.

CO₂ and temperature are both important factors to consider when it comes to indoor air quality and the overall comfort of an office environment, but they measure different things.

CO₂ levels in an office can rise due to insufficient ventilation and the presence of many people in a small space. High levels of CO₂ can cause headaches, dizziness, and fatigue, and in extreme cases, it can lead to unconsciousness and even death. Therefore, it's important to monitor CO₂ levels in an office and ensure adequate ventilation to maintain healthy levels.

Temperature, on the other hand, refers to the level of heat in an indoor space. An office that is too cold or too hot can be uncomfortable and lead to decreased productivity. Research has shown that the optimal temperature for an office environment is between 20°C and 24°C (68°F and 75°F).

Both CO₂ and temperature levels are important to consider when it comes to indoor air quality and the overall comfort of an office environment. Ideally, the CO₂ level should be below 1000 parts per million (ppm), and the temperature should be within the optimal range for an office environment. Regular monitoring and maintenance of these factors can help promote a healthy and comfortable work environment, and adjustments may need to be made to heating, ventilation, and air conditioning (HVAC) systems to achieve the desired levels.

CO₂ and air velocity are both important factors to consider when it comes to indoor air quality and the overall comfort of an office environment, but they measure different things.

CO₂ levels in an office can rise due to insufficient ventilation and the presence of many people in a small space. High levels of CO₂ can cause headaches, dizziness, and fatigue, and in extreme cases, it can lead to unconsciousness and even death. Therefore, it's important to monitor CO₂ levels in an office and ensure adequate ventilation to maintain healthy levels.

Air velocity, on the other hand, refers to the speed and direction of the air in an indoor space. Air velocity can affect the comfort of people in an office, with high air velocity causing discomfort and low air velocity leading to a stuffy and stagnant environment. The optimal air velocity for an office environment is generally between 0.15 and 0.25 meters per second.

Both CO₂ and air velocity are important to consider when it comes to indoor air quality and the overall comfort of an office environment. Ideally, the CO₂ level should be below 1000 parts per million (ppm), and the air velocity should be within the optimal range for an office environment. Regular monitoring and maintenance of these factors can help promote a healthy and comfortable work environment, and adjustments may need to be made to HVAC systems to achieve the desired levels.

5.9 Why is the sound level too high in offices, and how to solve this problem?

There could be several reasons why the sound level increases in a reception area. If there are more people coming and going in the reception area, this can naturally lead to an increase in noise levels. People talking, walking, and opening and closing doors can create a lot of sound. Additionally, if the reception area is designed in a way that doesn't absorb sound well, such as with hard surfaces like tile or marble or with high ceilings, this can contribute to an increase in noise levels. Nearby noise sources, such as a busy street outside or construction happening nearby, can also contribute to an increase in overall noise levels in the reception area. Finally, if there is a sound system in the reception area, such as music playing or a speaker system for announcements, this can obviously contribute to an increase in sound levels. To address high noise levels in a reception area, it's a good idea to identify the cause and take steps to mitigate it. This could involve adding sound-absorbing materials,

rearranging furniture to better absorb sound, or simply asking people to keep their voices down.

There are several reasons why sound levels can increase in an open-plan office area. Firstly, the lack of sound barriers in open-plan offices, with fewer walls and partitions, allows sound to travel more easily throughout the space. This absence of barriers means that sound can bounce around the office and create a noisy environment. Secondly, the high density of people in open-plan offices contributes to increased noise levels. With more individuals working in a smaller area, there are more conversations, ringing phones, and movements, all of which add to the overall noise. Additionally, the acoustics of an open-plan office can exacerbate the noise issue. Hard surfaces like concrete or glass reflect sound, making it harder to hear others or concentrate on work. The design with high ceilings and many hard surfaces can create a "reverberant" effect, where sound lingers longer than it should. Lastly, the presence of technology in modern offices, such as computers, printers, and phones, also contributes to noise levels. The humming of printers and the ringing of phones can be distracting and hinder concentration. To address high sound levels in an open plan office, companies can implement measures such as incorporating sound-absorbing materials like acoustical ceiling tiles or carpets, introducing partitions or panels to create more private workspaces, or employing sound masking technology to foster a more comfortable and productive environment.

There are several strategies that can be used to solve sound level issues in a meeting room. Utilizing sound-absorbing elements like acoustic panels, carpets, or drapes is one strategy. These materials help reduce sound reflections and make the room quieter. Another strategy involves arranging the seating in a way that optimizes sound transmission. Placing seats in a semi-circle arrangement or around a central table can help reduce the distance between speakers and listeners, making it easier for people to hear each other.

The use of white noise machines or other sound masking devices is another effective technique. These devices create a consistent background noise level that helps mask distracting sounds. Additionally, utilizing microphones and a sound system can amplify speakers' voices, ensuring that everyone in the room can hear what is being said.

Controlling background noise is crucial to improving sound quality in a meeting room. This can be achieved by turning off fans or air conditioning units, closing windows or doors, or scheduling meetings during quieter times of the day. Furthermore, the design of the room itself plays a role in sound levels. A room with a low ceiling and soft furnishings can help absorb sound, while a room with hard surfaces and high ceilings can create an echo effect.

By implementing one or more of these strategies, it is possible to reduce sound levels in a meeting room and create a more comfortable and productive environment for all participants.

Sound levels can become excessively high in close offices due to various factors. Poor acoustics, characterized by hard surfaces and a lack of soft furnishings like carpets, curtains, or acoustic panels, can cause echoes and reflections, resulting in elevated sound levels. Open-plan layouts, with fewer barriers between individuals, can facilitate easy sound transmission, leading to increased overall noise levels and hindering concentration and effective communication. High occupancy in close proximity can also contribute to noise generation, particularly through conversations and the use of equipment such as printers and phones.

Mechanical noise from air conditioning units, fans, and computers further adds to the overall sound level in an office. Moreover, inadequate sound insulation between rooms or floors can enable sound to easily travel through walls and ceilings, amplifying noise levels. To address the issue of high sound levels in close offices, it is crucial to consider factors like

office layout, the use of acoustic treatments, and potential sources of noise. Implementing solutions such as incorporating sound-absorbing materials, rearranging office furniture, establishing private spaces for meetings or phone calls, and regulating the use of noisy equipment can be effective.

Additionally, educating employees about noise reduction techniques, such as speaking softly, using headphones, and minimizing unnecessary conversations, can contribute to creating a more conducive and peaceful office environment. By implementing these measures, the sound levels in close offices can be effectively managed, promoting better concentration, communication, and overall well-being for the occupants.

5.10 How to solve the CO2 problems?

To solve CO2 problems in receptions, several steps can be taken. One approach is to increase ventilation by bringing in more fresh air into the reception area. This can be achieved by opening windows, using fans to increase airflow, or installing a mechanical ventilation system. Additionally, using air purifiers equipped with HEPA filters can help remove CO2 from the air by effectively capturing airborne particles.

Reducing the sources of CO2 in the reception area is another important step. While it may not be possible to eliminate these sources entirely, measures can be taken to minimize their impact. This includes reducing the number of people in the room, turning off electronics when not in use, or limiting the number of indoor plants.

Regular monitoring of CO2 levels in the reception area is essential to identifying when levels are becoming too high. This can be done using portable CO2 monitors or by installing a permanent CO2 monitor as part of the building's HVAC system.

Educating employees about the importance of good indoor air quality and providing guidance on reducing CO2 levels can also be effective. Encouraging employees to take

breaks outside or in well-ventilated areas can help reduce the number of people in the reception area and improve overall air quality.

By implementing these steps, it is possible to reduce CO₂ levels in reception areas and create a healthier and more comfortable environment for both employees and visitors.

To address the issue of high CO₂ levels in meeting rooms, there are several possible solutions. One approach is to increase ventilation by introducing more fresh air into the room. This can be achieved through methods such as opening windows, adjusting the HVAC system to increase airflow, or using air purifiers to filter the air.

Controlling occupancy in the meeting room can also help reduce CO₂ levels. Since CO₂ is produced when people exhale, limiting the number of occupants can lower the amount of CO₂ being released into the air.

Incorporating plants into the meeting room is another effective solution. Plants naturally absorb CO₂ and release oxygen, which can help to reduce CO₂ levels and improve the overall air quality.

Regularly monitoring CO₂ levels in the meeting room is important to ensure that they remain within acceptable limits. Using a CO₂ monitor provides real-time feedback on the concentration of CO₂, allowing for adjustments in ventilation and occupancy as needed.

Educating meeting room occupants about the significance of proper ventilation and the impact of high CO₂ levels on health and productivity is crucial. This can involve reminding individuals to open windows for fresh air, encouraging breaks outside the meeting room, and emphasizing the importance of limiting the number of occupants.

By implementing these measures, it is possible to mitigate high CO₂ levels in meeting rooms and create a healthier and more comfortable environment for participants.

High CO₂ levels can be a concern in offices, particularly in areas with inadequate ventilation. To address this issue, several approaches can be taken. Firstly, improving ventilation is crucial. This can involve increasing the intake of fresh air into the building, utilizing air purifiers, and ensuring the proper functioning of HVAC systems. Monitoring CO₂ levels is also important, and employing a CO₂ monitor can provide real-time feedback on the CO₂ concentration in the air, enabling adjustments to ventilation and occupancy as necessary.

Controlling occupancy levels in offices can help reduce CO₂ levels. Since CO₂ is released when people exhale, limiting the number of individuals in a given area can minimize CO₂ production. Additionally, incorporating plants into the office space can be beneficial, as they naturally absorb CO₂ and enhance air quality.

Educating office occupants about the significance of proper ventilation and the impact of high CO₂ levels on health and productivity is essential. This can involve promoting behaviors such as opening windows for fresh air, taking breaks outside, and reducing occupancy in specific areas. Encouraging environmentally friendly commuting options, such as public transportation, carpooling, or working from home, can also contribute to reducing the overall CO₂ emissions associated with commuting.

By implementing these measures, it is possible to address high CO₂ levels in offices, creating a healthier and more comfortable work environment for employees.

5.11 How to reduce the humidity levels?

High humidity levels in a reception area can cause discomfort to visitors and employees while also increasing the risk of problems like mold growth and respiratory illnesses. To address this issue, several measures can be taken. Firstly, increasing ventilation is essential

for reducing humidity. This can be achieved by opening windows, utilizing fans, or adjusting the HVAC system to allow for more fresh air circulation.

Another effective approach is to use a dehumidifier, either in the form of a portable device or a whole-house system. Dehumidifiers work to extract moisture from the air, thereby lowering humidity levels in the reception area. It is also important to promptly fix any leaks present in the area, whether from the roof or plumbing, as leaks can contribute to high humidity and foster mold growth.

Air conditioning not only provides cooling but also aids in humidity reduction. Ensuring that the air conditioning system is well maintained, and properly adjusted helps maintain optimal humidity levels. Additionally, the use of moisture-absorbing materials like charcoal, silica gel, or activated carbon can be beneficial. Placing these materials strategically throughout the reception area aids in absorbing excess moisture from the air.

By implementing these strategies, it is possible to effectively lower humidity levels in the reception area, fostering a more comfortable and healthier environment for both visitors and employees.

Reducing humidity levels in a meeting room can be achieved through various approaches. One effective method is using a dehumidifier, which removes excess moisture from the air and helps lower humidity levels. It is important to select a dehumidifier that is suitable for the size of the room and follow the manufacturer's instructions for optimal results.

Another approach is to increase ventilation in the meeting room. This can be accomplished by opening windows or utilizing air conditioning to allow fresh air to circulate and decrease moisture in the air. Additionally, using a fan in the room can improve air circulation and aid in reducing humidity levels. Placing the fan near a window or door helps facilitate the movement of air throughout the room.

To further control humidity, it is advisable to limit moisture sources within the meeting room. This includes minimizing the presence of plants and aquariums and managing the moisture generated by individuals through respiration. By mitigating these sources, the overall humidity levels can be reduced.

Regularly monitoring the humidity levels in the meeting room using a hygrometer is crucial. Maintaining a humidity range of 30–60% promotes comfort and prevents the growth of mold or mildew.

By implementing these strategies, it is possible to effectively reduce humidity levels in a meeting room, creating a more comfortable and conducive environment for productive discussions and interactions. Top of Form

Reducing humidity levels in an office is essential for creating a comfortable and productive work environment. There are several effective ways to achieve this. One approach is to use a dehumidifier specifically designed for office spaces. This device helps eliminate excess moisture from the air, thereby reducing humidity levels. It is important to select a dehumidifier that matches the size of the office and follow the manufacturer's instructions for optimal performance.

Increasing ventilation is another effective strategy. Opening windows or utilizing air conditioning systems promotes the circulation of fresh air, which helps to decrease moisture in the air and lower humidity levels. Placing fans strategically in the office enhances air movement and improves overall ventilation. Positioning fans near windows or doors can facilitate the flow of air throughout the space.

Limiting moisture sources within the office is crucial to managing humidity levels. This involves minimizing the presence of moisture contributors such as plants, aquariums and

being mindful of the moisture produced by individuals through respiration. By controlling these sources, excessive moisture in the office can be reduced.

Addressing any leaks promptly is vital to preventing the accumulation of moisture in the office. Leaks from pipes or roofs should be fixed in a timely manner to avoid contributing to elevated humidity levels.

Regular monitoring of humidity levels is essential. Employing a hygrometer allows for continuous tracking of humidity levels in the office. It is recommended to maintain a humidity range between 30 and 60% for optimal comfort and to prevent the growth of mold or mildew.

By implementing these strategies, it is possible to effectively reduce humidity levels in an office, resulting in a more comfortable and healthy work environment conducive to productivity and well-being.

5.12 How to increase the air velocity in spaces?

Increasing air velocity in a space is an effective way to enhance air circulation and create a comfortable and healthy environment. There are several methods to achieve this. One approach is to utilize fans, such as ceiling fans or standing fans, which can significantly increase air velocity and promote better air movement throughout the space. It is important to select a fan that is appropriate in size and speed for the specific area.

Another way to increase air velocity is by opening windows. This allows fresh air to enter the space, facilitating natural ventilation and enhancing air circulation. Opening windows not only promotes air movement but also helps improve indoor air quality by reducing the concentration of pollutants.

Air conditioning systems can also contribute to increased air velocity. By circulating cool air, air conditioning promotes airflow and enhances overall ventilation. It is crucial to choose an air conditioning system that is properly sized for the space and follow the manufacturer's instructions for optimal performance.

Using air purifiers is another effective strategy. Air purifiers filter out pollutants and allergens, improving air quality and increasing air velocity in the process. It is important to select an air purifier that matches the size of the space and consider the type of filter being used.

Rearranging furniture can also improve air circulation and increase air velocity. By ensuring sufficient space for air to circulate and avoiding the blocking of air vents or windows, furniture arrangements can promote better airflow throughout the space.

By implementing these strategies, it is possible to increase air velocity in a space, resulting in improved air circulation, comfort, and a healthier environment.

5.13 How does the moderate lightning level that affect employees?

Moderating the temperature in reception areas is essential to creating a comfortable and welcoming environment for visitors. There are several ways to achieve this. First, using a thermostat allows for precise temperature control in the reception area. Setting the temperature to a comfortable range, typically between 68 and 72°F (20 and 22°C), ensures a pleasant atmosphere.

Incorporating fans into the reception area helps to circulate the air and create a more comfortable environment. Ceiling fans or standing fans can be utilized based on the layout and specific needs of the space.

Air conditioning is another effective method to moderate the temperature, particularly during hot weather. It is crucial to select an appropriately sized air conditioning system for the reception area and follow the manufacturer's instructions for optimal performance.

To prevent excessive heat from entering the reception area, window treatments such as blinds or curtains can be employed to block out direct sunlight. This helps to maintain a cooler temperature and avert discomfort caused by excessive heat.

Proper insulation is important for maintaining a consistent temperature in the reception area. Ensuring that the walls, ceiling, and floor are adequately insulated helps to prevent heat loss or gain, thus promoting a stable and comfortable environment.

During mild weather conditions, natural ventilation can be utilized to moderate the temperature in the reception area. Opening windows or doors allows fresh air to circulate, aiding in temperature regulation and creating a refreshing atmosphere.

Moderating the lighting level in reception areas, offices, and meeting rooms can be achieved through several methods. One approach is to adjust the lighting fixtures themselves. This can involve replacing bulbs with lower-wattage options or installing dimmer switches that allow for customizable brightness control. Another way to moderate the lighting level is by utilizing natural light, if available. Opening blinds or curtains during the day allows natural light to enter the room. Alternatively, installing light-filtering shades provides the ability to manage the amount of light entering the space. Task lighting can be employed to provide focused illumination in specific areas where it is needed. Desk lamps or floor lamps can be utilized to supplement lighting in work areas, enhancing visibility and reducing strain. Indirect lighting offers a softer, more diffused lighting option that promotes a relaxed and comfortable atmosphere. This can be accomplished using wall sconces, uplights, or other fixtures designed to direct light towards the ceiling or walls. Smart lighting

systems provide advanced control over the lighting level. These systems can be programmed to adjust the lighting based on factors such as time of day, occupancy, or other parameters. Control can be achieved through a smartphone app or a central control panel, offering flexibility and convenience. By implementing one or more of these methods, it becomes possible to effectively moderate the lighting level in reception areas, offices, and meeting rooms, creating a comfortable and productive environment.

Moderating the lighting level in reception areas, offices, and meeting rooms can have a significant impact on employees in several ways. Firstly, it can lead to improved productivity. Excessive brightness or dimness in lighting can cause eye strain, headaches, and fatigue, ultimately reducing employees' ability to focus and perform tasks efficiently. By moderating the lighting level, employees are more likely to feel comfortable and alert, thereby enhancing their productivity. Secondly, moderating the lighting level can contribute to reduced stress levels. Harsh lighting conditions can create a stressful environment, particularly in meeting rooms where employees may already feel anxious or tense. By adjusting the lighting level to a more moderate and comfortable setting, a more relaxed atmosphere can be created, promoting a sense of calm and reducing stress among employees. Furthermore, lighting has a significant impact on mood. Different lighting levels and qualities can evoke various emotional responses. Dim lighting can create a cozy and relaxed atmosphere, while bright lighting can create a more energetic and focused environment. By carefully moderating the lighting level, it becomes possible to create the desired mood and atmosphere for specific tasks or activities, fostering a positive and engaging environment. Lastly, moderating the lighting level can contribute to improved employee health. Exposure to bright light for extended periods, especially in spaces where employees spend significant time, can disrupt the body's natural circadian rhythm and lead to sleep disturbances. By moderating the lighting level and opting for warmer, more soothing light, it becomes

possible to support employees in maintaining a healthy sleep-wake cycle, thus promoting their overall well-being.

5.14 How does field measurements readings support surveys

Field measurements are an essential component of many surveys, as they provide accurate and reliable data that can be used to verify or supplement information gathered through other methods. Field measurements can support survey efforts in several ways:

Firstly, field measurements can be used to verify or validate existing data, such as maps, plans, or aerial imagery. By comparing the field measurements with the existing data, surveyors can identify any inconsistencies or errors and correct them.

Secondly, it was used to collect new data that may not be available through other methods. For example, surveyors may use equipment such as GPS receivers, total stations, or laser scanners to collect data on the location, elevation, or dimensions of features such as buildings, roads, or natural features. It can improve the accuracy of survey data by providing precise and detailed information that may not be available through other methods.

Thirdly, field measurements can provide site-specific information that may not be available through other methods. For example, information collected during a field survey can provide information about the composition and properties of the place that can be used to inform construction or engineering projects.

Finally, field measurements are an important tool for surveyors, as they provide accurate and reliable data that can improve the quality of survey results.

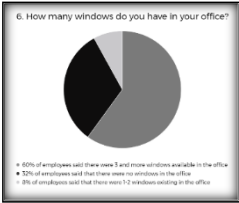
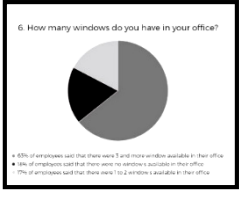
When we compare the findings from the survey and the findings from the field measurement, as clearly shown in the below discussion, each type of measurement suffers

from many issues, and we find that the results from the field measurement support the results from the survey.

As you can see from Table 9, the survey answers from the low-cost company regarding the number of windows available showed that 60% showed that there were three or more windows available in the office. Approximately 32% said that there were no windows, and only 8% said that there were 1-2 windows in the offices, while from a high-cost company, 63% showed that there were three or more windows available in the office. Approximately 18% said that there were no windows, and only 17% said that there were 1-2 windows in the office. Where the low-cost company 02 filed measurement readings show an air velocity 0.08 m/s and the high-cost company 02 filed measurement shows an air velocity 0.12 m/s. That means the amount of fresh air and good ventilation in the high-cost company is much higher than in the low-cost company. The presence of windows in companies helps with natural lighting and helps in communication with the outside world. It also contributes to improving the mood of the employee. Opening windows helps to ventilate the space and change the internal atmosphere. It also makes employees closed internally because they are unable to communicate with the outside world

Table 9: Comparison between survey answers and field measurements.

(Source: Khaloud, 2023)

Company	low-cost company survey	low-cost company 02 filed measurement	High-cost company survey	High-cost company 02 filed measurement
Survey answers and device readings	 6. How many windows do you have in your office? 60% of employees said that there were 3 and more windows available in the office 32% of employees said that there were no windows in the office 8% of employees said that there were 1-2 windows available in the office		 6. How many windows do you have in your office? 63% of employees said that there were 3 and more windows available in the office 18% of employees said that there were no windows available in the office 17% of employees said that there were 1-2 windows available in the office	

As for Table 10, the survey answers from the low-cost company regarding the photocopiers, printers, and scanners' locations show that 60% said that this equipment was available in their offices, while 40% said that it was available in the reception. In a high-cost company, 35% said that this equipment was available in their offices, while 65% said that it was available in the reception. Where the CO2 low-cost company-filed measurement readings show 730 ppm and the high-cost company-filed measurement reading is 523 ppm. That means the amount of fresh air and good ventilation in high-cost companies is much higher than in low-cost companies. Emissions from printing devices have a direct impact on employee breathing

Table 10: Between survey answers and field measurements.

(Source: Khaloud, 2023)

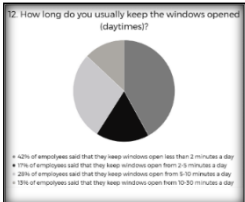
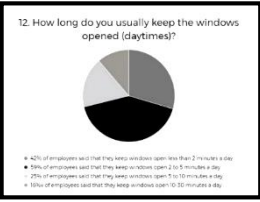
Company	low-cost company survey	low-cost company 03 filed measurement	High-cost company survey	High-cost company 03 filed measurement
Survey answers and device readings	7. How many of the following equipment (photocopier, printer and scanners) do you have it your workspace  • 60% of equipment are available in the offices • 40% of equipment available in the reception		7. How many of the following equipment (photocopier, printer and scanners) do you have it your workspace?  • 35% of equipment available in their office • 65% of equipment available in the reception	

As clearly shown in Table 11, the survey answers for the low-cost company regarding keeping windows open during working days show that 42% of employees kept windows open for less than two minutes a day, 17% kept windows open for two to five minutes a day, 28% kept windows open for 5 to 10 minutes a day, and only 13% kept windows open for 10

to 30 minutes a day. In high-cost companies, 42% keep windows open for less than two minutes a day, 59% keep windows open for two to five minutes a day, 25% keep windows open for 5 to 10 minutes a day, and only 16% keep windows open for 10 to 30 minutes a day. Where the relative humidity on low-cost company-filed measurement readings shows 58.3% and for the high-cost company-filed measurement reading 54.6%. means the amount of humidity, fresh air, and good ventilation in high-cost companies is much higher than in low-cost companies, and due to that, it is clearly shown from different readings that the amount of humidity is higher in low-cost companies than in high-cost companies.

Table 11: Between survey answers and field measurements.

(Source: Khaloud, 2023)

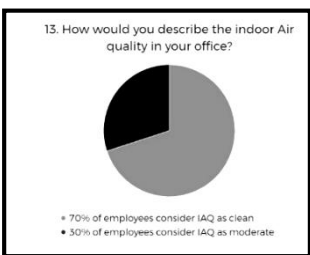
Company	low-cost company survey	low-cost company 02filed measurement	High-cost company survey	High-cost company 02filed measurement
Survey answers and device readings				

As clearly shown from the below table 12, the survey answers from the low-cost company regarding the quality of the indoor environment, 59% of employees consider indoor air quality clean, and only 41% of employees consider indoor air quality moderate. While in a high-cost company, 70% of employees considered indoor air quality clean, and 30% of employees consider indoor air quality moderate. Where the relative humidity on low-cost company filed measurement readings shows 59.1% and for high-cost company relative humidity filed measurement reading 54.4%. means the amount of fresh air and good

ventilation in high-cost companies is much higher than the low-cost companies, and due to that, it is clearly shown from different readings that the amount of humidity is higher in low-cost companies than in high-cost companies. That means can lead to mold and mildew growth in spaces. This can deteriorate the air quality in the building and increase the risk of health problems for residents.

Table 12: Between survey answers and field measurements.

(Source: Khaloud, 2023)

Company	low-cost company survey	low-cost company 03 filed measurement	High-cost company survey	High-cost company 02 filed measurement
Survey answers and device readings				

As clearly shown from Table 13 of the survey answers from the low-cost company regarding the indoor environment noise, 34% of employees think inner voices are fair, only 34% of employees think inner voices are good, and only 32% of employees consider them bad. While in a high-cost company, 40% of employees think inner voices are fair, only 40% of employees think inner voices are good, and only 20% of employees consider them bad. Where the sound level alert meter on low-cost companies' filed measurement readings shows 57.4% and the high-cost companies' filed measurement readings show 42.3%, the amount of sound level in low-cost companies is much higher than in high-cost companies. Due to the presence of a large number of employees, the presence of many passers, as well as many of

the devices used, the sounds of air conditioners, the tightness of the place, the lack of use of isolated materials, and the external traffic noise all of these contribute to high level of sound.

Table 13: Between survey answers and field measurements.

(Source: Khaloud, 2023)

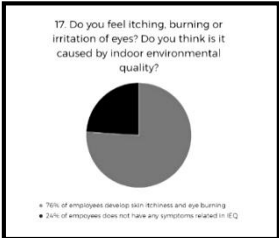
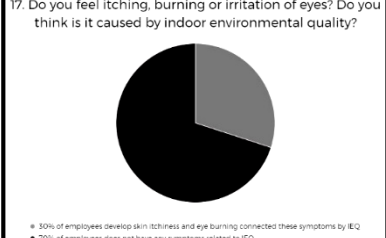
Company	low-cost company survey	low-cost company 01 filed measurement	High-cost company survey	High-cost company 02 filed measurement
Survey answers and device readings	15. How would you describe the indoor Acoustics in your office?  • 34% of employees think inner voices were fair • 34% of employees think inner voices were good • 32% of employees think inner voices as bad		15. How would you describe the indoor Acoustics in your office?  • 40% of employees think inner voices were fair • 40% of employees think inner voices were good • 20% of employees think inner voices were bad	

As clearly shown from table 14, the survey answers from the low-cost company regarding the symptoms related to IEQ show that around 76% of employees develop skin itchiness and eye burning, and they connect these symptoms to IEQ, while 24% of employees do not have any symptoms related to IEQ. In high-cost companies, around 30% of employees develop skin itchiness and eye burning, and they connect these symptoms to IEQ, while 70% of employees do not have any symptoms related to IEQ. Where the relative humidity on low-cost company-filed measurement readings shows 59.1% and for high-cost companies, the relative humidity on company-filed measurement readings shows 54.4%. means the amount of fresh air and good ventilation in high-cost companies is much higher than in low-cost companies, and due to that, it is clearly shown from different readings that the amount of humidity is higher in low-cost companies than in high-cost companies. It can help to mold

and mildew growth in floors, walls, and ceilings. This can decline the quality of air in the buildings and increase the health problems for employees.

Table 14: Between survey answers and field measurements.

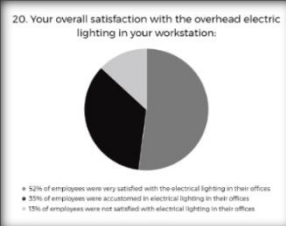
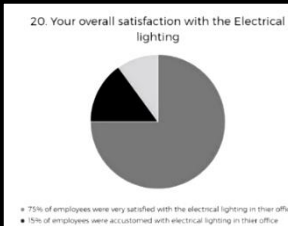
(Source: Khaloud, 2023)

Company	low-cost company survey	low-cost company 02 filed measurement	High-cost company survey	High-cost company 02 filed measurement
Survey answers and device readings	 17. Do you feel itching, burning or irritation of eyes? Do you think it is caused by indoor environmental quality? • 70% of employees develop skin-itchiness and eye burning • 24% of employees does not have any symptoms related to IEQ		 17. Do you feel itching, burning or irritation of eyes? Do you think it is caused by indoor environmental quality? • 50% of employees develop skin-itchiness and eye burning connected these symptoms by IEQ • 70% of employees does not have any symptoms related to IEQ	

As clearly shown in Table 15, an important part of the internal environment is electrical lighting. Accordingly, the survey answers from the low-cost company indicated that 52% of employees were very satisfied with the electrical lighting in their offices, 35% of employees were accustomed, and only 13% of employees were not satisfied with the electrical lighting in their offices. While for a high-cost company, 75% of employees were very satisfied with the electrical lighting in their offices, 15% of employees were accustomed, and only 10% of employees were not satisfied with the electrical lighting in their offices. The presence of lighting is a source that constitutes many health problems for employees, including vision problems and headache problems due to the strength of the lighting, or problems that make the employee unable to focus on his work in a way, and all of it is considered a source of heat if employee is close to it, which contributes to the lack of feeling of comfort.

Table 15: Between survey answers and field measurements.

(Source: Khaloud, 2023)

Company	low-cost company survey	low-cost company 03 filed measurement	High-cost company survey	High-cost company 02 filed measurement
Survey answers and device readings	 20. Your overall satisfaction with the overhead electric lighting in your workstation: 52% of employees were very satisfied with the electrical lighting in their offices 39% of employees were accustomed with electrical lighting in their offices 13% of employees were not satisfied with electrical lighting in their offices		 20. Your overall satisfaction with the Electrical lighting 75% of employees were very satisfied with the electrical lighting in their office 15% of employees were accustomed with electrical lighting in their office 10% of employees were not satisfied with the electrical lighting in their office	

As clearly shown from the below table 16, the survey answers from the low-cost company regarding the thermal comfort (temperature, air velocity, and humidity) at their workstation show that 48% of employees were very satisfied with the thermal comfort in their workplace office, while 39% of employees were normal, and only 13% of employees were not very satisfied with the heat in their offices. While about thermal comfort (temperature, air velocity, humidity) at their workstation, 70% of employees were very satisfied with the thermal comfort in their workplace office, while 20% of employees were normal, and only 10% of employees were not very satisfied with the heat in their offices. Where the relative humidity on low-cost company filed measurement readings shows 58.3% and for high-cost company filed measurement readings 54.6%. means the amount of humidity, fresh air, and good ventilation in high-cost companies is much higher than in low-cost companies, and due to that, it is clearly shown from different readings that the amount of humidity is higher in low-cost companies than in high-cost companies. High humidity and the presence of salts in

water can corrode metals such as iron and steel. Corrosion weakens metallic materials and may eventually lead to the failure of building structures.

Table 16: Between survey answers and field measurements.

(Source: Khaloud, 2023)

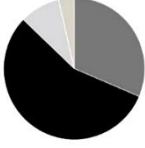
Company	low-cost company survey	low-cost company 02 filed measurement	High-cost company survey	High-cost company 02 filed measurement
Survey answers and device readings	21. The overall thermal comfort (temperature, air velocity, humidity) in your workstation  40% of employees were very satisfied with the thermal comfort in their workplace 30% of employees were normal with the thermal comfort in their workplace 30% of employees were not very satisfied with the thermal comfort in their workplace		21. The overall thermal comfort (temperature, air velocity, humidity) in your workstation:  70% of employees were very satisfied with the thermal comfort in their workplace 20% of employees were normal with the thermal comfort in their workplace 10% of employees were not very satisfied with the thermal comfort in their workplace	

Clearly shown from the below table 17, the survey answers from the low-cost company regarding suffering from nausea, eye irritation, nose/throat pain, headache, breathing problems, coughing, blurred vision, difficulty concentrating, and sneezing 44% of employees suffered from headaches, 78% suffered from coughs, and 13% suffered from sneezes. And 5% of workers do not have any symptoms at all. In a high-cost company, 20% of employees suffered from headaches, 10% suffered from coughs, and 10% suffered from sneezes. And 60% of workers do not have any symptoms. Where the relative humidity on low-cost company filed measurement readings shows 58.3% and for high-cost company relative humidity filed measurement readings 54.6%. means the amount of humidity, fresh air, and good ventilation in high-cost companies is much higher than in low-cost companies, and due to that, it is clearly shown from different readings that the amount of humidity is higher in low-cost companies than in high-cost companies. The presence of high humidity

is a source of many health problems, such as headaches, difficulty breathing, dizziness, malaise, and coughing, and to get rid of them, sufficient ventilation must be provided for the space.

Table 17: Between survey answers and field measurements.

(Source: Khaloud, 2023)

Company	low-cost company survey	low-cost company 02 filed measurement	High-cost company survey	High-cost company 01 filed measurement
Survey answers and device readings	26. While you are at office do you suffer from Nausea? Irritation of eyes, nose, throat pain, Headache? Breathing problems? Coughing? Blurred vision? Difficulty on concentrating? Sneezing? Write  • 44% of employees suffered from headache • 78% of employees suffered from cough • 13% of employees suffered from sneeze • 5% of employees does not have any symptoms		26. While you are at office do you suffer from Nausea? Irritation of eyes, nose, throat pain, Headache? Breathing problems? Coughing? Blurred vision? Difficulty on concentrating? Sneezing? Write  • 20% of employees suffered from headache • 10% of employees suffered from cough • 10% of employees suffered from sneeze • 60% of employees does not have any symptoms	

As clearly shown in the below table 18, the survey answers from the low-cost company regarding the building's status as a green building show that 58% of employees think that their building was certified as a green building, and 42% of employees think that their building was decertified as a green building. In high-cost companies, 70% of employees thought that their building was certified as a green building, and 30% of employees thought that their building was decertified as a green building. The aim of green buildings is to create sustainable and clean environments for users and provide employees with a comfortable, healthy indoor and outdoor environment. And it does not mean small companies do not follow sustainability.

Table 18: Between survey answers from different level companies.

(Source: Khaloud, 2023)

Company	low-cost company survey	High-cost company survey
Survey answers and device readings	 27. Do you think your building is an environmentally friendly or certified green building? • 58% of employees think building is certified as a green building • 42% of employees think building decertified as a green building	 27. Do you think your building is an environmentally friendly or certified green building? • 70% of employees think building is certified as a green building • 30% of employees think building decertified as a green building

5.15 Why to do interviews

The reason of conduct interviews it considers a valuable tool for gathering information and insights from employees. Interviews are often used to gathering information from individual employee. This information's can be used to inform researcher how to gain insights into the needs and opinions of a particular group of employees. It provides an opportunity to understand the perspectives and experiences of individual's employee.

Moreover, it can be a valuable tool for building relationships with employee individuals or groups. By engaging in a conversation with employees, you can establish rapport and trust, which can be beneficial for future interactions or collaborations.

Interviews can be used to collect stories and personal narratives from individuals. These stories can be used to inform research, to create content.

5.16 Misplaced device in filed measurements

If any device is placed in the wrong location during field measurements, it can result in inaccurate data and potentially compromise the integrity of the entire survey. However, there are steps that can be taken to mitigate the impact of a misplaced device: The first step is to identify that a device has been placed in the wrong location. This can be done by comparing

the device's location to a reference point or by using other devices to cross-check the measurements. Once the error has been identified, it is important to determine the extent of the error. This can be done by assessing how far off the device is from the correct location and how many measurements have been affected. If the error is minor and only affects a small number of measurements, it may be possible to correct the error by repositioning the device and retaking the measurements. However, if the error is more significant and has affected many measurements, it may be necessary to redo the entire field measurement. It is important to document the error and any corrective actions taken. This information can be used to assess the impact of the error on the survey results and to inform future surveys.

In general, it is important to take steps to prevent errors during field measurements. This can be done by ensuring that devices are properly calibrated and that surveyors are properly trained and following established procedures. Additionally, using multiple devices to cross-check measurements can help to identify errors before they become a significant issue.

As we can see in figure 112, when placing the sound measuring device near the window, we will get a high reading, and that is because the device picks up sounds from the external environment, such as cars and construction buildings, and the sounds of the internal environment, such as communication, conversations, and the sounds of appliances and air conditioners.

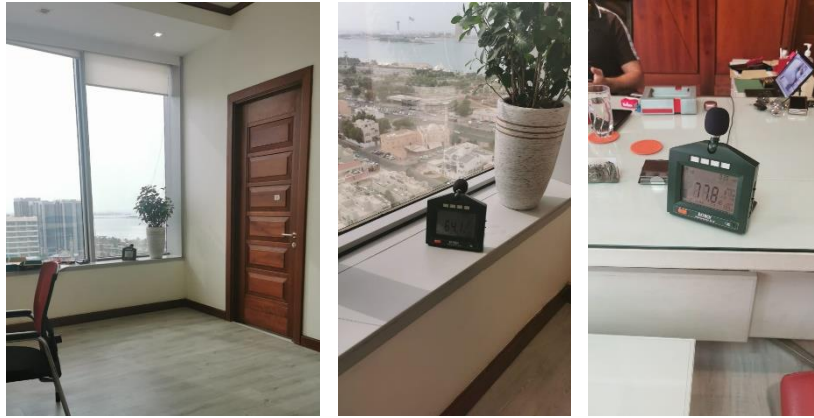


Figure 112: Misplaced sound alert meter device in filed measurement.
(Source: Khaloud, 2023)

5.17 Final remarks

In conclusion, by considering and adjusting the lighting level in reception areas, offices, and meeting rooms, employers can positively impact employees' health, well-being, and productivity.

We usually test the quality of the indoor environment to ensure that it is safe, healthy, and comfortable for the occupants. Poor indoor environmental quality can have negative effects on the health, well-being, and productivity of people who spend time in the space.

Indoor environmental quality testing can help identify potential issues such as poor ventilation, excessive humidity, high levels of pollutants, inadequate lighting, or uncomfortable temperatures that can cause discomfort, health problems, or reduced productivity.

Indoor environmental quality testing is particularly important in settings such as offices, schools, healthcare facilities, and homes where occupants spend a significant amount of time indoors. Testing helps to ensure that these spaces are providing a safe and healthy environment for occupants to live, work, and learn in.

In addition, testing the indoor environment can also help identify potential sources of environmental hazards such as mold, asbestos, and lead, which can be dangerous to human health if not properly managed. Regular testing and monitoring of indoor environmental quality can help identify and address these issues before they become health hazards for occupants.

I use devices for internal measurements that evidence the survey's results of people's opinions about the air quality of the indoor environment, then there are many problems that can be looked at in the indoor environment, as well as the materials and furniture used, and the owners of these companies must take into account the employees' comfort and their health to get more production and benefit as much as they can.

Please note that the questionnaire was distributed to a number of employees who were working in the same internal environment, and the field measurements are the best ones that give me the most accurate results.

Finally, to conclude this section, I will summarize the key findings and their significance.

In conclusion, we must take care and caution, and the health of the employees is above everything, so that they can work and produce well. Good ventilation enables employees to deal with each other with a kind and generous spirit. Also, good ventilation works to change the employee's psyche, makes him feel happy, and reduces the negative impact on their health.

Chapter 6 : Conclusions

6.1 Conclusions and recommendations

A healthy work environment can have a positive impact on employee health in several ways. It can reduce stress and workplace-related injuries, improve mental and physical well-being, increase job satisfaction, and enhance productivity. This can result in lower rates of absenteeism, turnover, and healthcare costs while promoting a culture of well-being and employee engagement. A healthy environment can have a significant positive impact on employee productivity. When employees work in a healthy environment, they are more likely to be engaged, motivated, and focused. A healthy environment can improve employee morale and job satisfaction, leading to increased motivation and productivity. Also, it can support cognitive function, which can improve concentration, memory, and problem-solving ability. Moreover, a healthy environment can promote healthy habits such as exercise and good nutrition, which can increase energy levels and reduce fatigue. In addition, it can help reduce stress and anxiety, leading to better mental health and improved productivity.

6.2 Recommendations and further research

Building change towards a healthy work environment does not depend on a single process; instead, new technology and continually more effective solutions are being released nowadays. As a result, many processes will be followed since the research is a continuation of the enhancement methods carried out earlier, so it is advisable to highlight some points that can be extensively studied in future studies. To ensure the financial benefits that should support any future retrofit or enhancement plan, start by thinking more about sophisticated alternative techniques for promoting and enhancing employee turnover.

The research concentrated on investigating the potential barriers and factors that can affect employees' health and performance. The remarkable findings from the study on the effect of poor indoor air quality might serve as the foundation for a specialized company or perhaps a government agency to adapt this project and put-up feasibility plans for introducing a healthy work environment; the same will be governed by contracts with the stakeholders.

Although UAE authorities are insistent on maintaining their control over promoting a healthy work environment, involving the local authorities in the transformation process may be the best way to avoid hurdles in the future.

In the end, all parties should work together to ensure the success of any change process, including the stakeholders, policymakers, energy producers, and final consumers, with people's awareness of a rational, healthy environment playing the most important role in advancing the community to the desired sustainable level.

6.3 Limitations or constraints in my research

I faced some limitations that let me reconsider the results of the measurements more than once. I took and redistributed the questionnaire more than once because some employees skipped some questions, and some didn't have enough time to answer the questionnaire. Below are some barriers:

6.3.1 Access

Because of the limited access, we need to reorganize or rearrange the research. Access permissions were asked in some scenarios so that I could enter the office and take the measurements that I needed.

6.3.2 Samples size:

The research question being examined will affect how many units of analysis we utilize in the study. Hence, finding meaningful links in the data will be very difficult when the sample size is too small, as statistical tests often call for a larger sample size to assure a fair representation, which can be constricting.

6.3.3 Lack of prior study on the topic

The literature review was based on citing prior research papers, which will help readers understand the topic. However, there may not have been much or any prior research on your topic.

6.3.4 Bias

The respondent may have biased opinions because of their cultural backgrounds or beliefs about the events they observe, which can affect the validity of the study.

6.4 Ethical consideration

All research studies should prioritize safeguarding human subjects by implementing appropriate ethical principles. In this research, the following ethical principles were maintained:

Informed consent and voluntary participation:

The steps that were taken to obtain consent were as follows: consent was given to the employees freely (voluntary); participants understood what was being requested from them; and all of them were capable of giving consent. This means that in order to participate in a research study, participants must be aware of the research, understand the information, and have the freedom to make their own decisions. So, confidentiality and privacy were

maintained by giving the employees the cover letter that comes with the questionnaire. Another important thing done to maintain privacy was coding instead of participant names.

Anonymity and privacy for respondents are of paramount importance.

- It is also important to state the research purpose, and failure to do so might cause a problem and make the participant hesitant to take part in the research. Also, the data analysis is to be done keeping in mind the objectivity of the research so that no misinterpretation of the data is made. Also, a lack of objectivity can distort the conclusion. So, no manipulation is done, and the data that is obtained has to be used only for the purpose of the study and not for any other purpose. Also, the information gotten must be discarded after it is used for research, and the information with names shouldn't be saved (Creswell & Creswell 2007)
- Another important thing is avoiding plagiarism. Avoid plagiarizing the work of other researchers, and always thank and acknowledge those who have contributed to your study.
- Acknowledging the use of other authors' writings in any section of the dissertation. Using a reference system like Harvard referencing makes the research approachable, and the information taken from the research paper can be traced to have a link to the original literature that was used in the research. For this research, APA referencing is taken into account (Crespi-Abril & Rubilar 2021)

References

- Abbott, B. W., Bishop, K., Zarnetske, J. P., Minaudo, C., Chapin, F. S., Krause, S., Hannah, D. M., Conner, L., Ellison, D., Godsey, S. E., Plont, S., Marçais, J., Kolbe, T., Huebner, A., Frei, R. J., Hampton, T., Gu, S., Buhman, M., Sara Sayedi, S., Ursache, O., Chapin, M., Henderson, K. D. & Pinay, G. (2019). Human domination of the global water cycle absent from depictions and perceptions. *Nature Geoscience*, vol. 12(7), pp. 533–540.
- Abdo, P., Huynh, B. P., Braytee, A. & Taghipour, R. (2020). An experimental investigation of the thermal effect due to discharging of phase change material in a room fitted with a windcatcher. *Sustainable Cities and Society*, vol. 61, pp. 0–38.
- Abdulrahman 2022. (n.d.).
- Ahadzie, D. K., Proverbs, D. G. & Sarkodie-Poku, I. (2014). Competencies required of project managers at the design phase of mass house building projects. *International Journal of Project Management*, vol. 32(6), pp. 958–969.
- Al-Omari, K. & Okasheh, H. (2017). The influence of work environment on job performance: A case study of engineering company in Jordan. *International Journal of Applied Engineering Research*, vol. 12(24), pp. 15544–15550.
- Alashwal, A. M. (n.d.). University Malaya original literary work.
- Ali, A. S., Chua, S. J. L. & Lim, M. E.-L. (2015). The effect of physical environment comfort on employees' performance in office buildings. *Structural Survey*. Emerald Group Publishing Limited, vol. 33(4/5), pp. 294–308.

- Ali, Z. & Bhaskar, S. B. (2016). Basic statistical tools in research and data analysis. *Indian Journal of Anaesthesia*, vol. 60(9), pp. 662–669.
- Alinaitwe, H. M., Mwakali, J. A. & Hansson, B. (2007). Factors affecting the productivity of building craftsmen - studies of Uganda. *Journal of Civil Engineering and Management*, vol. 13(3), pp. 169–176.
- Amoatey, P. & Baawain, M. S. (2019). Effects of pollution on freshwater aquatic organisms. *Water Environment Research*, vol. 91(10), pp. 1272–1287.
- Amos, R., Georgiou, M., Kiayias, A. & Zhandry, M. (2020). One-shot signatures and applications to hybrid quantum/classical authentication. *Proceedings of the Annual ACM Symposium on Theory of Computing*, pp. 255–268.
- Andargie, M. S. & Azar, E. (2019). An applied framework to evaluate the impact of indoor office environmental factors on occupants' comfort and working conditions. *Sustainable Cities and Society*. Elsevier, vol. 46(April 2018), p. 101447.
- Arabia, S. (2019). Key Performance indicators in partial fulfillment of the requirements for the degree.
- Arar, M. & Jung, C. (2021). Improving the indoor air quality in nursery buildings in United Arab Emirates. *International Journal of Environmental Research and Public Health*, vol. 18(22).
- Attar, a a, Gupta, P. a K. & Desai, P. D. B. (2012). A Study of Various Factors Affecting Labour Productivity and Methods to Improve It . *Civil Engineering*, pp. 11–14.
- Awad, J. & Jung, C. (2021). Evaluating the indoor air quality after renovation at the Greens in Dubai, United Arab Emirates. *Buildings*, vol. 11(8).

- Ayundasari, D. Y., Sudiro, A. & Irawanto, D. W. (2017). Improving Employee Performance Through Work Motivation and Self-Efficacy Mediated By Job Satisfaction. *Jurnal Aplikasi Manajemen*, vol. 15(4), pp. 587–599.
- Azuma, K., Ikeda, K., Kagi, N., Yanagi, U. & Osawa, H. (2017). Evaluating prevalence and risk factors of building-related symptoms among office workers: Seasonal characteristics of symptoms and psychosocial and physical environmental factors. *Environmental Health and Preventive Medicine*. BioMed Central Ltd., vol. 22(1).
- Babbie, E. (2010). Research design "The practice of social research. Sandbox.Informatics.Iupui.Edu, pp. 85–88 [online]. Available at: <http://sandbox.informatics.iupui.edu/~kmacdorm/courses/ResearchDesign/Presentations/Babbie4ResearchDesign.pdf>.
- Baradel, F., Murphy, K. & Schmid, C. (2019). LEARNING VIDEO REPRESENTATIONS USING, pp. 1–12.
- Behn, R. D. (2003). Why Measure Performance? Different Purposes Require Different Measures. *Public Administration Review*, vol. 63(5), pp. 586–606.
- Bougie, E. (2009). Aboriginal Peoples Survey, 2006: School experiences of off-reserve First Nations children aged 6 to 14. Statistics Canada Catalogue no. 89-637-X--No.001.
- Brgoszewska 2018. (n.d.).
- Britannica 2023. (n.d.).
- Candido, C., Lamberts, R., De Dear, R. & Bittencourt, L. (2010). Towards a Brazilian standard for naturally ventilated buildings: Guidelines for thermal and air movement

acceptability. Proceedings of Conference: Adapting to Change: New Thinking on Comfort, WINDSOR 2010, (April), pp. 9–11.

Carrer, P. & Wolkoff, P. (2018). Assessment of indoor air quality problems in office-like environments: Role of occupational health services. *International Journal of Environmental Research and Public Health*, vol. 15(4).

Castral, T. C., Warnock, F., Leite, A. M., Haas, V. J. & Scochi, C. G. S. (2008). The effects of skin-to-skin contact during acute pain in preterm newborns. *European Journal of Pain*, vol. 12(4), pp. 464–471.

Chan, P. & Kaka, A. (n.d.). Chan, P and Kaka, A (2004) Construction productivity measurement: a comparison of two case studies. CONSTRUCTION PRODUCTIVITY MEASUREMENT: A COMPARISON OF TWO CASE STUDIES. Heriot Watt University. Association of Researchers in Construction Management.

Chang, T. Y., Zivin, J. G., Gross, T. & Neidell, M. (2019a). The effect of pollution on worker productivity: Evidence from call center workers in China. *American Economic Journal: Applied Economics*. American Economic Association, vol. 11(1), pp. 151–172.

Chang, T. Y., Zivin, J. G., Gross, T. & Neidell, M. (2019b). The Effect of Pollution on Worker Productivity: Evidence from Call Center Workers in China, vol. 11(1), pp. 151–172.

Cheng, Z., Lei, N., Bu, Z., Sun, H., Li, B. & Lin, B. (2022a). Investigations of indoor air quality for office buildings in different climate zones of China by subjective survey and field measurement. *Building and Environment*. Elsevier Ltd, vol. 214(August 2021), p. 108899.

- Cheng, Z., Lei, N., Bu, Z., Sun, H., Li, B. & Lin, B. (2022b). Investigations of indoor air quality for office buildings in different climate zones of China by subjective survey and field measurement. *Building and Environment*. Elsevier Ltd, vol. 214.
- Cheong Peng, A.-Y., Ali, A. S. & Ahmad, F. (2013). Održavanje poslovnih zgrada: model predviđanja troškova. *Građevinar*, vol. 65, pp. 803–809.
- Cherian, J., Gaikar, V., Paul, R. & Pech, R. (2021). Corporate culture and its impact on employees' attitude, performance, productivity, and behavior: An investigative analysis from selected organizations of the United Arab Emirates (UAE). *Journal of Open Innovation: Technology, Market, and Complexity*. Elsevier Masson SAS, vol. 7(1), pp. 1–28.
- Costello, A., Abbas, M., Allen, A., Ball, S., Bell, S. & Bellamy, R. (2009). Managing the health effects of climate change *Lancet and University College The Lancet* [online]. Available at:
<http://linkinghub.elsevier.com/retrieve/pii/S0140673609609351%5Cnpapers2://publication/uuid/071FC337-5303-496A-945A-FA52BA4E0133>.
- Crespi-Abril & Rubilar 2021. (n.d.).
- Creswell, J. W. & Creswell, J. W. (2007). *Qualitative inquiry & research design : choosing among five approaches*. Sage Publications.
- Davies and Smith. (2005). The relationship between preventive maintenance characteristic and the maintenance performance of high-rise office building office building in Malaya Au Yong.
- Denscombe. (2010). *Rules For Social Research: Guidelines for Good Practice*.

- Denscombe. (2014). The role of research proposals in business and management education.
- Efeoma, M. O. (2017). The Influence of Clothing on Adaptive Thermal Comfort : A Study of the Thermal Comfort of Office Workers in Hot Humid Conditions in Enugu , Nigeria
Doctor of Philosophy (PhD) in Architecture The University of Edinburgh.
- Elias, A. A., Cavana, R. Y. & Jackson, L. S. (2001). Stakeholder Analysis to Enrich the Systems Thinking and Modelling Methodology. Proceedings of the 19th International Conference of the Systems Dynamics Society, (November 2016), pp. 52–70
[online].Available at:
http://www.systemdynamics.org/conferences/2001/papers/Elias_1.pdf.
- Fang, S. H., Lin, T. N. & Lee, K. C. (2008). A novel algorithm for multipath fingerprinting in indoor WLAN environments. IEEE Transactions on Wireless Communications, vol. 7(9), pp. 3579–3588.
- Feige 2013. (n.d.).
- Field 2010 6 444-453.pdf. (n.d.).
- Funminiyi, A. K. (2018). Impact of Workplace Environmental Factors on Employee Commitment: Evidence from North East Nigeria. International Journal of Scientific Research and Management, vol. 6(07), pp. 575–585.
- Ghoddousi, P. & Hosseini, M. R. (2012). A survey of the factors affecting the productivity of construction projects in Iran. Technological and Economic Development of Economy. Taylor and Francis Ltd., vol. 18(1), pp. 99–116.

- González-Leonardo, M., López-Gay, A., Newsham, N., Recaño, J. & Rowe, F. (2022). Understanding patterns of internal migration during the COVID-19 pandemic in Spain. *Population, Space and Place*, vol. 28(6).
- Gosain, R., Abdou, Y., Singh, A., Rana, N., Puzanov, I. & Ernstoff, M. S. (2020). COVID-19 and Cancer: a Comprehensive Review. *Current Oncology Reports. Current Oncology Reports*, vol. 22(5).
- Goyal & Anikender 2011. (n.d.).
- Groat and Wang. (2013). *Architectural Research Methods*.
- Hair, E., Halle, T., Terry-Humen, E., Lavelle, B. & Calkins, J. (2006). Children's school readiness in the ECLS-K: Predictions to academic, health, and social outcomes in first grade. *Early Childhood Research Quarterly*, vol. 21(4), pp. 431–454.
- Hakan Erkutlu. (2008). The impact of transformational leadership on organizational and leadership effectiveness. *Journal of Management Development*, vol. 27(7), pp. 708–726.
- Hameed: Taherdoost. (2016). *Sampling Methods in Research Methodology ; How to Choose a Sampling Technique for Research* Hamed Taherdoost To cite this version : HAL Id : hal-02546796 *Sampling Methods in Research Methodology ; How to Choose a Sampling Technique for*. *International Journal of Academic Research in Management (IJARM)*, vol. 5(2), pp. 18–27.
- He, X., Zhong, W., Au, C. T. & Du, Y. (2013). Size dependence of the magnetic properties of Ni nanoparticles prepared by thermal decomposition method. *Nanoscale Research Letters*, vol. 8(1), pp. 1–10.

Hirst, Michael, and Dana 2011. (n.d.).

Hsiao, C., Steve Ching, H. & Ki Wan, S. (2012). A panel data approach for program evaluation: Measuring the benefits of political and economic integration of Hong Kong with Mainland China. *Journal of Applied Econometrics*, vol. 27(5), pp. 705–740.

Humphreys et al. (2007). Field Studies of Indoor Thermal Comfort and the Progress of the Adaptive Approach.

Ingwenagu. (2016). Fundamentals of research methodology and data collection. LAP Lambert Academic Publishing, Nigeria, (May 2016), pp. 19–21.

Ishaq, H. M., Iqbal, M. Z. & Zaheer, A. (2009). Effectiveness of performance appraisal: Its outcomes and detriments in Pakistani organizations. *European Journal of Social Sciences*, vol. 10(3), pp. 479–485.

John 2018. (n.d.).

Julie 2015. (n.d.).

Jung, C. & Awad, J. (2021). The improvement of indoor air quality in residential buildings in dubai, uae. *Buildings*, vol. 11(6).

Kamaruzzaman, S. N., Egbu, C. O., Zawawi, E. M. A., Ali, A. S. & Che-Ani, A. I. (2011). The effect of indoor environmental quality on occupants' perception of performance: A case study of refurbished historic buildings in Malaysia. *Energy and Buildings*, vol. 43(2–3), pp. 407–413.

Kersemaekers, W., Rupperecht, S., Wittmann, M., Tamdjidi, C., Falke, P., Donders, R., Speckens, A. & Kohls, N. (2018). A workplace mindfulness intervention may be

associated with improved psychological well-being and productivity. A preliminary field study in a company setting. *Frontiers in Psychology*. Frontiers Media S.A., vol. 9(FEB).

Kunst, J. R., Tajamal, H., Sam, D. L. & Ulleberg, P. (2012). Coping with Islamophobia: The effects of religious stigma on Muslim minorities' identity formation. *International Journal of Intercultural Relations*. Elsevier Ltd, vol. 36(4), pp. 518–532.

Lansari, A., Tubaishat, A. & Mahmoud Al-Rawi, A. (2007). Using an Outcome-Based Information Technology Curriculum and an E-Learning Platform to Facilitate Student Learning. *Issues in Informing Science and Information Technology*, vol. 4, pp. 461–471.

Leblebici 2012.pdf. (n.d.).

Leech, N. L. & Onwuegbuzie, A. J. (2011). Beyond Constant Comparison Qualitative Data Analysis: Using NVivo. *School Psychology Quarterly*, vol. 26(1), pp. 70–84.

Leitão, N. C. (2021). The effects of corruption, renewable energy, trade and CO2 emissions. *Economies*, vol. 9(2).

Lewis, A. S., Reid, K. R., Pollock, M. C. & Campleman, S. L. (2012). Speciated arsenic in air: Measurement methodology and risk assessment considerations. *Journal of the Air and Waste Management Association*, vol. 62(1), pp. 2–17.

Liang, R., Chen, R., Yin, P., van Donkelaar, A., Martin, R. V., Burnett, R., Cohen, A. J., Brauer, M., Liu, C., Wang, W., Lei, J., Wang, L., Wang, L., Zhang, M., Kan, H. & Zhou, M. (2022). Associations of long-term exposure to fine particulate matter and its

constituents with cardiovascular mortality: A prospective cohort study in China.

Environment International. Elsevier Ltd, vol. 162(February), p. 107156.

Lim, D. S., Morse, E. A., Mitchell, R. K., & Seawright, K. K. Ins 34(3), 491-516.

<https://doi.org/10.1111%2Fj.1540-6520.2010.00384.x>. (2010). No 主観的健康感を中心とした在宅高齢者における健康関連指標に関する共分散構造分析Title.

titutional environment and entrepreneurial cognitions: A comparative business systems perspective. Entrepreneurship theory and Practice., (564), pp. 1–73.

Lob dell, 2022. (n.d.).

Lolli, F., Coruzzolo, A. M., Peron, M. & Sgarbossa, F. (2022). Age-based preventive maintenance with multiple printing options. International Journal of Production Economics. Elsevier B.V., vol. 243(March 2021), p. 108339.

Lowther, S. D., Dimitroulopoulou, S., Foxall, K., Shrubsole, C., Cheek, E., Gadeberg, B. & Sepai, O. (2021). Low level carbon dioxide indoors—a pollution indicator or a pollutant? A health-based perspective. Environments - MDPI, vol. 8(11), pp. 1–25.

Mannan, M. & Al-Ghamdi, S. G. (2021). Indoor air quality in buildings: A comprehensive review on the factors influencing air pollution in residential and commercial structure. International Journal of Environmental Research and Public Health, vol. 18(6), pp. 1–24.

Martin, Mel, and Susan 2015. (n.d.).

Marzouk, M. & Atef, M. (2022). Assessment of Indoor Air Quality in Academic Buildings Using IoT and Deep Learning. Sustainability (Switzerland), vol. 14(12).

- Mata, T. M., Martins, A. A., Calheiros, C. S. C., Villanueva, F., Alonso-Cuevilla, N. P., Gabriel, M. F. & Silva, G. V. (2022). Indoor Air Quality: A Review of Cleaning Technologies. *Environments - MDPI*, vol. 9(9).
- McGill, E., Er, V., Penney, T., Egan, M., White, M., Meier, P., Whitehead, M., Lock, K., Anderson de Cuevas, R., Smith, R., Savona, N., Rutter, H., Marks, D., de Vocht, F., Cummins, S., Popay, J. & Petticrew, M. (2021). Evaluation of public health interventions from a complex systems perspective: A research methods review. *Social Science and Medicine*. Elsevier Ltd, vol. 272, p. 113697.
- Moreno-Rangel, A., Sharpe, T., McGill, G. & Musau, F. (2020). Indoor air quality in passivhaus dwellings: A literature review. *International Journal of Environmental Research and Public Health*, vol. 17(13), pp. 1–16.
- Municipalities, department of urban planning and. (2018). An administrative decision regarding classification instructions for engineering consulting offices in Abu Dhabi.
- Munonye, J., Osuji, E., Olaolu, M., Okoisu, A., Obi, J., Eze, G., Ibrahim-Olesin, S., Njoku, L., Amadi, M., Izuogu, C. & Azuamairo, G. (2022). Perceived Effects of COVID-19 Pandemic on Food Security in Southeast Nigeria. *Frontiers in Sustainable Food Systems*, vol. 6(July).
- Nazaroff, W. W. (2013). Exploring the consequences of climate change for indoor air quality. *Environmental Research Letters*, vol. 8(1).
- Ngenoh, E., Kurgat, B. K., Bett, H. K., Kebede, S. W. & Bokelmann, W. (2019). Determinants of the competitiveness of smallholder African indigenous vegetable farmers in high-

value agro-food chains in Kenya: A multivariate probit regression analysis.

Agricultural and Food Economics. *Agricultural and Food Economics*, vol. 7(1).

Norhidayah, A., Lee, C. K., Azhar, M. K. & Nurulwahida, S. (2013). Indoor air quality and sick building syndrome in three selected buildings. *Procedia Engineering*. Elsevier B.V., vol. 53(2010), pp. 93–98.

Novikov, A. M. & Novikov, D. A. (2012). *Communications in Cybernetics, Systems Science and Engineering*. Kybernetes.

Nur 2012. (n.d.).

Öhrn, M., Wahlström, V., Harder, M. S., Nordin, M., Pettersson-Strömbäck, A., Bodin Danielsson, C., Olsson, D., Andersson, M. & Slunga Järvholm, L. (2021). Productivity, satisfaction, work environment and health after relocation to an activity-based flex office—the active office design study. *International Journal of Environmental Research and Public Health*, vol. 18(14).

Oliva, F. L. & Kotabe, M. (2019). Barriers, practices, methods and knowledge management tools in startups. *Journal of Knowledge Management*, vol. 23(9), pp. 1838–1856.

Paciência, I., Madureira, J., Rufo, J., Moreira, A. & Fernandes, E. de O. (2016). A systematic review of evidence and implications of spatial and seasonal variations of volatile organic compounds (VOC) in indoor human environments. *Journal of Toxicology and Environmental Health - Part B: Critical Reviews*, vol. 19(2), pp. 47–64.

Parmaksiz, K., Rastgeldi Dogan, T. & Yesilnacar, M. I. (2021). Exposure of indoor air quality in office environment to workers and its relationship to health. *El-Cezeri Journal of Science and Engineering*, vol. 8(1), pp. 231–244.

- Patten, M. L. & Newhart, M. (2017). Understanding research methods: An overview of the essentials, tenth edition. Understanding Research Methods: An Overview of the Essentials, Tenth Edition, (November), pp. 1–338.
- Persily, A. & Leber, D. (2006). NISTIR 7330 A Collection of Homes to Represent the U . S . Housing Stock A Collection of Homes to Represent the U . S . Housing Stock, p. 31.
- Pisello, A. L., Pigliautile, I., Andargie, M., Berger, C., Bluysen, P. M., Carlucci, S., Chinazzo, G., Deme Belafi, Z., Dong, B., Favero, M., Ghahramani, A., Havenith, G., Heydarian, A., Kastner, D., Kong, M., Licina, D., Liu, Y., Luna-Navarro, A., Mahdavi, A., Nocente, A., Schweiker, M., Touchie, M., Vellei, M., Vittori, F., Wagner, A., Wang, A. & Wei, S. (2021). Test rooms to study human comfort in buildings: A review of controlled experiments and facilities. Renewable and Sustainable Energy Reviews, vol. 149, pp. 1–19.
- Raulin, G. and. (2010). survey.
- Raziq, A. & Maulabakhsh, R. (2015). Impact of Working Environment on Job Satisfaction. Procedia Economics and Finance. Elsevier B.V., vol. 23(October 2014), pp. 717–725.
- Rindi, G., Klimstra, D. S., Abedi-Ardekani, B., Asa, S. L., Bosman, F. T., Brambilla, E., Busam, K. J., de Krijger, R. R., Dietel, M., El-Naggar, A. K., Fernandez-Cuesta, L., Klöppel, G., McCluggage, W. G., Moch, H., Ohgaki, H., Rakha, E. A., Reed, N. S., Rous, B. A., Sasano, H., Scarpa, A., Scoazec, J. Y., Travis, W. D., Tallini, G., Trouillas, J., van Krieken, J. H. & Cree, I. A. (2018). A common classification framework for neuroendocrine neoplasms: an International Agency for Research on

Cancer (IARC) and World Health Organization (WHO) expert consensus proposal.

Modern Pathology, vol. 31(12), pp. 1770–1786.

Roelofsen, P. (2002). The impact of office environments on employee performance: The design of the workplace as a strategy for productivity enhancement. *Journal of Facilities Management*, vol. 1(3), pp. 247–264.

Roh, Y., Lee, K., Whang, S. E. & Suh, C. (2021). Sample Selection for Fair and Robust Training. *Advances in Neural Information Processing Systems*, vol. 2(NeurIPS), pp. 815–827.

Rudick, C. K. & Dannels, D. P. (2018). Yes, and ... : continuing the scholarly conversation about mental health stigma in higher education. *Communication Education*, vol. 67(3), pp. 404–408.

Santomauro, D. F., Mantilla Herrera, A. M., Shadid, J., Zheng, P., Ashbaugh, C., Pigott, D. M., Abbafati, C., Adolph, C., Amlag, J. O., Aravkin, A. Y., Bang-Jensen, B. L., Bertolacci, G. J., Bloom, S. S., Castellano, R., Castro, E., Chakrabarti, S., Chattopadhyay, J., Cogen, R. M., Collins, J. K., Dai, X., Dangel, W. J., Dapper, C., Deen, A., Erickson, M., Ewald, S. B., Flaxman, A. D., Frostad, J. J., Fullman, N., Giles, J. R., Giref, A. Z., Guo, G., He, J., Helak, M., Hulland, E. N., Idrisov, B., Lindstrom, A., Linebarger, E., Lotufo, P. A., Lozano, R., Magistro, B., Malta, D. C., Månsson, J. C., Marinho, F., Mokdad, A. H., Monasta, L., Naik, P., Nomura, S., O'Halloran, J. K., Ostroff, S. M., Pasovic, M., Penberthy, L., Reiner, R. C., Reinke, G., Ribeiro, A. L. P., Sholokhov, A., Sorensen, R. J. D., Varavikova, E., Vo, A. T., Walcott, R., Watson, S., Wiysonge, C. S., Zigler, B., Hay, S. I., Vos, T., Murray, C. J.

- L., Whiteford, H. A. & Ferrari, A. J. (2021). Global prevalence and burden of depressive and anxiety disorders in 204 countries and territories in 2020 due to the COVID-19 pandemic. *The Lancet*, vol. 398(10312), pp. 1700–1712.
- Saris, W. E. & Gallhofer, I. (2007). Estimation of the effects of measurement characteristics on the quality of survey questions. *Survey Research Methods*, vol. 1(1), pp. 29–43.
- Sarkhosh, M., Najafpoor, A. A., Alidadi, H., Shamsara, J., Amiri, H., Andrea, T. & Kariminejad, F. (2021). Indoor Air Quality associations with sick building syndrome: An application of decision tree technology. *Building and Environment*. Elsevier Ltd, vol. 188(November 2020), p. 107446.
- Saunders et al. (2012). sustainability assessment: the state of the art, pp. 1–8
[online].Available at: papers2://publication/uuid/075BFDB0-E62F-4FF4-BF1F-A8C75CA8C229.
- Sciences, M., Campus, H., Kerian, K., Sciences, H. & Bahru, J. (2009). Indoor Air Quality in an Automotive Assembly Plant in Selangor, Malaysia. *Health (San Francisco)*, vol. 40(1), pp. 187–192.
- Sekaran, U. & Bougie, R. (2013). *Research methods for business : a skill-building approach*. Wiley.
- Sharahi, S. & Abedian, M. (2009). Performance Measurement. *Contributions to Management Science*, (1989), pp. 21–42.
- Sharma, G. (2017). Pros and cons of different sampling techniques. *International journal of applied research*. *International Journal of Applied Research*, vol. 3(7), pp. 749–752
[online].Available at: www.allresearchjournal.com.

- Soomro, B. A. & Shah, N. (2019). Determining the impact of entrepreneurial orientation and organizational culture on job satisfaction, organizational commitment, and employee's performance. *South Asian Journal of Business Studies*, vol. 8(3), pp. 266–282.
- Spengler, J. D. (2012). Climate change, indoor environments, and health. *Indoor Air*, vol. 22(2), pp. 89–95.
- Spinazzè, A., Cattaneo, A. & Cavallo, D. M. (2020). COVID-19 Outbreak in Italy: Protecting Worker Health and the Response of the Italian Industrial Hygienists Association. *Annals of Work Exposures and Health*, vol. 64(6), pp. 559–564.
- Surawattanasakul, V., Sirikul, W., Sapbamrer, R., Wangsan, K., Panumasvivat, J., Assavanopakun, P. & Muangkaew, S. (2022). Respiratory Symptoms and Skin Sick Building Syndrome among Office Workers at University Hospital, Chiang Mai, Thailand: Associations with Indoor Air Quality, AIRMED Project. *International Journal of Environmental Research and Public Health*, vol. 19(17).
- Tahir, T. & Ghafoor Awan, D. A. (2015). Impact of working environment on employee's productivity: A case study of Banks and Insurance Companies in Pakistan. *European Journal of Business and Management*, vol. 7(1), pp. 2222–2839 [online]. Available at: www.iiste.org.
- Tangen, S. (2003). An overview of frequently used performance measures. *Work Study*, vol. 52(7), pp. 347–354.
- Tanir 2022. (n.d.).

- Teklu, T. W., Brown, J. S., Kazemi, H., Graves, R. M. & AlSumaiti, A. M. (2013). A critical literature review of laboratory and field scale determination of residual oil saturation. SPE Production and Operations Symposium, Proceedings, (March), pp. 156–171.
- Thornhill, R. & Fincher, C. L. (2013). The Comparative Method in Cross-Cultural and Cross-Species Research. *Evolutionary Biology*, vol. 40(4), pp. 480–493.
- United Arab Emirates National Committee on Sustainable Development Goals. (2017). UAE National Committee on SDGs, UAE and the 2030 Agenda for Sustainable Development: Excellence in Implementation [online]. Available at: <https://www.un.org/development/desa/dpad/publication/no-4-inequality-and-the-2030-agenda-for-sustainable-development/>.
- Usukhbayar, R. & Choi, J. (2018). Determining the impact of key climatic factors on labor productivity in the mongolian construction industry. *Journal of Asian Architecture and Building Engineering*, vol. 17(1), pp. 55–62.
- Valkenburg, P. M., Peter, J. & Schouten, A. P. (2006). Friend networking sites and their relationship to adolescents' well-being and social self-esteem. *Cyberpsychology and Behavior*, vol. 9(5), pp. 584–590.
- Wierzbicka, A., Omelekhina, Y., Saber, A. T., Bloom, E., Gren, L., Søs, S., Bo, P., Pagels, J. & Raun, N. (2022). Indoor PM_{2.5} from occupied residences in Sweden caused higher inflammation in mice compared to outdoor PM_{2.5}, (September), pp. 1–15.
- Wilhelm, K., Wedgwood, L., Niven, H. & Kay-Lambkin, F. (2006). Smoking cessation and depression: Current knowledge and future directions. *Drug and Alcohol Review*, vol. 25(1), pp. 97–107.

Wipt, P. & George, K. M. (2008). 基因的改变 NIH Public Access. Bone, vol. 23(1), pp. 1–7.

Wolkoff, P. (2018). Indoor air humidity, air quality, and health – An overview. International Journal of Hygiene and Environmental Health. Elsevier GmbH, pp. 376–390.

Wong, M., Gardiner, E., Lang, W. & Coulon, L. (2008). Generational differences in personality and motivation: Do they exist and what are the implications for the workplace? Journal of Managerial Psychology, vol. 23(8), pp. 878–890.

Www.Extech.com. (2009). Extech.

Wyon, D. P. & Wargocki, P. (2013). Effects of indoor environment on performance. Ashrae, vol. 55(3), pp. 46–50.

Yau, Y. H., Chew, B. T. & Saifullah, A. Z. A. (2012). Studies on the indoor air quality of Pharmaceutical Laboratories in Malaysia. International Journal of Sustainable Built Environment. The Gulf Organisation for Research and Development, vol. 1(1), pp. 110–124.

Yoon, S. K., Hegmann, K. T., Thiese, M. S., Burgess, J. L., Ellingson, K., Lutrick, K., Olsho, L. E. W., Edwards, L. J., Sokol, B., Caban-Martinez, A. J., Schaefer-Solle, N., Jones, J. M., Tyner, H., Hunt, A., Respet, K., Gaglani, M., Dunnigan, K., Rose, S., Naleway, A., Groom, H., Kuntz, J., Fowlkes, A. L., Thompson, M. G. & Yoo, Y. M. (2022). Protection with a Third Dose of mRNA Vaccine against SARS-CoV-2 Variants in Frontline Workers. New England Journal of Medicine, vol. 386(19), pp. 1855–1857.

Zukri, A. & Nazir, R. (2018). Sustainable materials used as stone column filler: A short review. IOP Conference Series: Materials Science and Engineering, vol. 342(1).

Appendices

Survey

Dear [Employee Name],

Dear employee I would like to invite you to participate in our employee survey. Your feedback is important to us and will help us to better understand how we can improve the workplace and support the employees' health. The survey will only take about 3 to 5 minutes to complete and is completely anonymous. Your responses will be kept confidential and will not be shared with anyone outside of my survey. To access the survey, please click on the following link: [insert link to survey]. The survey will be available until 25.05.2023, so please take a few moments to complete it at your earliest convenience.

Thank you for your participation and for helping us to make our workplace a better environment for everyone.

1. What is your Gender?

- Females
- Male

2. How old are you?

- Between 20-30 years old
- Between 30-4- years old
- Between 40-50 years old

3. How long have you been working in this company?
- Working in same company for 1-2 years
 - Working in same company for 2-5 years
 - Working in same company for 5-8 years
4. How long do you spend in the building during the day weekly?
- Spend in the building 48-55 hrs.
 - Spend in the building less than 20 hrs.
5. Within your workspace is there any glare (light reflection):
- There is a glare in morning and evening
 - There is no glare
6. How many windows do you have in your office?
- 3 and more windows available
 - No windows available
 - 1-2 windows available
7. How many of the following equipment (photocopier, printer and scanners) do you have it your workspace
- Equipment available in the offices

- Equipment available in the reception

8. Do you have wet ceilings because of leaky water or walls because of leaky building?

- There is wet ceiling due to water leakage
- There is no wet ceiling due to water leakage

9. Do you have damaged floor from reason of leaks or high humidity?

- There is damage floors due to leakage or high humidity.
- There is no damage floors due to leakage or high humidity.

10. Do you have any houseplant in your office?

- There is houseplant in office
- There is no houseplant in office

11. How often do they clean up the floor in your office?

- They cleansed daily
- They cleansed once per week
- They cleansed 2-4 per week

12. How long do you usually keep the windows opened (daytimes)?

- Keep the windows opened less than 2 minutes
- Keep the windows opened from 2-5 minutes
- keep the windows opened from 5-10 minutes

13. How would you describe the indoor Air quality in your office?

- Clean
- Moderate
- Not clean at all

14. How would you describe the indoor Lighting in your office?

- Very satisfied with the indoor lighting.
- Satisfied with the indoor lighting.
- Not satisfied with the indoor lighting.

15. How would you describe the indoor Acoustics in your office?

- The indoor acoustics is fair.
- The indoor acoustics is good.
- The indoor acoustics is bad.

16. Do you feel itching, burning or irritation of eyes? Do you think is it caused by indoor environmental quality?

- IEQ makes me feel tired
- IEQ makes me feel suffering from fatigue
- There is no relation between IEQ and fatigue

17. Overall, how comfortable did you find the furniture (table and chair) in your workspace?

- Comfortable with furniture
- Not comfortable with furniture

18. Your overall satisfaction with the interior environment:

- strongly satisfied with the internal environment
- were satisfied
- not satisfied with the internal environment

19. Your overall satisfaction with the overhead electric lighting in your workstation:

- Very satisfied
- Neutral
- Were not satisfied

20. The overall effect of natural daylighting in your workstation:

- Very satisfied
- Neutral
- Were not satisfied

21. The overall thermal comfort (temperature, air velocity, humidity) in your workstation:

- Very satisfied
- Neutral
- Were not satisfied

22. The ability to control or block the natural daylight in your workstation:

- Very satisfied
- Neutral
- Were not satisfied

23. Approximately how many employees are present in the three meters at the same time?

- 3 employees are present in the three meters
- 4 employees are present in the three meters
- 1-2 employees are present in the three meters

24. Flooring materials in your office rooms

- PVCD
- wooden floor
- carpet
- cork

25. Types of surface walls layers in

- Wallpaper
- Paint
- Tiles

26. Do you think your building is an environmentally friendly or certified green building?

- certified green building
- decertified as a green building