Subjective Evaluation of UAE inhabitant's perceptions of their Residential & Commercial Indoor Environments.

تقييم خاص لرؤى وآراء السكان في دبي فيما يتعلق بالبيئة الداخلية للمباني السكنية والتجارية

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ABSTRACT

Research has perpetually shown us that an Indoor Environment quality is a judged by a detailed evaluation of its Indoor Air quality, Thermal Comfort, Acoustic and Visual Comfort. We also understand that physiological and psychological factors do influence the way people perceive an indoor environment. But, very less research has been conducted upon how an individual's demographics, i.e. their age, gender and origin affects their perception of levels of comfort, health and productivity in an indoor setting.

This thesis shows the findings of investigation into the IEQ comfort, health and productivity through Quantitative (survey questionnaire) and Qualitative evaluation (extensive literature review). The main subject of the research focuses on efforts to address the occupants' responses associated with Comfort and Health as well as the opinions of their working and living environments based on their responses. Based on the evaluations made by 1000 occupants of the IEQ of offices and homes in Dubai, Results are derived from a series of intervention studies in order to determine the effects of all parameters independently as well as to explore further variables responsible for the effects of the indoor environmental inconsistency. By calculations of Average, Standard deviation, Mean and P-values, it was found that in Residential Environments; Gender caused differences in perception of Thermal Comfort and Levels of Productivity. Age was a factor to variance in Health complaints such as Nausea/vomiting, Shortness of breath, Stuffy Nose, Skin rash/itchiness, Eye irritation and Perception of lowered productivity, whereas Origin caused difference in opinion in terms of Thermal Comfort only. In Commercial Environments; Gender was a factor for the variance in the perception of satisfaction in terms of Noise, lighting, thermal comfort and productivity levels. Age was a factor for health complaints in symptoms of Eye irritation, whereas Origin was a cause for difference in perception of Thermal Comfort.

In a majority of the developing cities including Dubai, architects and engineers have not been the target of liability for arising IEQ issues yet, which have resulted in occupants being sick due to the poor IAQ or insufficient day lighting and many other factors. This is causing a great concern in the fields of design and construction as professionals suffer a loss in terms of reputation and money. Due to increase in a competitive construction market in the UAE, it is becoming incalculably essential for owners to maintain higher occupancy rate and meet the increasing demands of sustainable, healthy and comfortable indoor environs to become environmental friendly, care for the occupants as well as attract further tenants. Findings from this study can assist Owners, architects, designers, contractors, policy makers and the government organizations in Dubai to improve their indoor environmental quality and sustain clean and healthy Indoor settings. It is vital that sustainability in the region does not only focus on resource conservation but also on human health, comfort and productivity within building environments. This study hopes to provide insight over the factors affecting occupant perception of Indoor Environmental Quality in relation to building performance.

خلاصة

أظهرت لنا الأبحاث على الدوام أن نوعية البيئة في الأماكن المغلقة تبنى على تقييم مفصل لجودة الهواء فيها والراحة الحرارية والصوتية والراحة البصرية. كما أننا ندرك أن العوامل الفسيولوجية والنفسية تؤثر على الطريقة التي ينظر فيها الناس للبيئة في الأماكن المغلقة. ولكن، أجريت أبحاث أقل على كيفية تأثير الوضع الديموغرافي للفرد، أي السن والجنس والأصل، على إدراكهم لمستويات الراحة والصحة والإنتاجية في بيئة داخلية.

يبين هذا البحث نتائج التحقيق في الراحة في نوعية البيئة في الأماكن المغلقة (IEQ) والصحة والإنتاجية من خلال تقييم كمي (الاستبيان) وتقييم نوعي (مراجعة أدبية واسعة). الموضوع الرئيسي لهذا البحث يركز على الجهود المبذولة لمعالجة استجابات القاطنين المرتبطة بالراحة والصحة فضلاً عن آراءهم حول بيئة أماكن عملهم وسكنهم بناءً على إجاباتهم. استناداً إلى تقييمات ردود 1000 من القاطنين حول البيئة في الأماكن المغلقة (IEQ) في المكاتب والمنازل في دبي، تستمد النتائج من سلسلة من الدراسات المتداخلة من أجل تحديد الآثار المترتبة على جميع العوامل بشكل مستقل وكذلك لاستكشاف مزيد من المتغيرات المسؤولة عن سبب عدم الإنسجام البيئي في الأماكن المغلقة. باحتساب الإنحراف المتوسط والمعياري، ومتوسط النتائج والمقاييس (P value and Mean)، تبين أنه في البيئات السكنية سبب فارق الجنس إختلافاً في النظرة إلى الراحة الحرارية ومستويات الإنتاجية. كما كان العمر عاملاً أساسياً في التباين في الشكاوى الصحية مثل الغثيان/ القيء وضيق التنفس وانسداد الأنف وطفح الجلد/ الحكة وتهيج العين وإدراك الإنتاجية المنخفضة، في حين أن الأصل سبب الاختلاف في الرأي من حيث الراحة الحرارية فقط. في البيئات التجارية، كان الجنس عاملاً للتباين في النظرة إلى الارتياح من حيث الضوضاء والإضاءة والراحة الحرارية

ومستويات الإنتاجية. كما كان العمر عاملاً للشكاوى الصحية وتحديداً في أعراض تهيج العين، في حين كان الأصل سببا للاختلاف في إدراك لراحة الحرارية.

في الغالبية العظمى من المدن النامية بما في ذلك دبي، لم يتولى المهندسين المعماريين والمدنيين المسؤولية عن قضايا IEQ الناشئة حتى الآن، الأمر الذي أسفر عن تفشي المرض بين القاطنين نظراً لنوعية الهواء الداخلي السيئة أو عدم كفاية الإضاءة ليلا والعديد من العوامل الأخرى. هذا يسبب قلقاً كبيراً في مجالات التصميم والبناء إذ يعاني المتخصصين من الخسارة من حيث السمعة والمال. بسبب زيادة السوق تنافسية في مجال البناء في دولة الإمارات العربية المتحدة، أصبح من الضروري للمالكين المحافظة على ارتفاع معدل الإشغال وتلبية الطلبات المتزايدة الصحية والمريحة بشكل مستدام في الأماكن المغلقة المحيطة لتصبح صديقة للبيئة وتهتم برعاية القاطنين فضلاً عن جذب مزيد من المستأجرين. تساعد النتائج المستخلصة من هذه الدراسة المالكين والمهندسين المعماريين والمصممين والمقاولين وواضعي السياسات والمؤسسات الحكومية في دبي على تحسين جودة البيئة الداخلية والحفاظ على إعداد داخلي نظيف وصحي. ومن الأهمية بمكان أن لا تتركز الاستدامة في المنطقة فقط على الحفاظ على الموارد ولكن أيضا على صحة الإنسان، والراحة والإنتاجية ضمن بيئة المبنى. وتهدف هذه الدراسة إلى تقديم رؤية شالمة عن العوامل التي تؤثر على الإدراك الخاص بجودة البيئة الداخلية فيما يتعلق ببناء الأداء.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Being comfortable in a given environment, does not require the environment to only consist of evident comfort factors. The indoor environment also consists of unobvious parameters that can cause the zone to be comfortable or discomfited, for a certain individual depending on their health, clothing, mental levels of stress and principally environmental conditions. An environment that we discuss here would be essentially indoors only. There are a number of indoor environmental dynamics which may or may not cause comfort in a set indoor precinct, other than personal factors that need to be determined beforehand. There are various factors needed to be determined before coming to a conclusion of whether or not a certain indoor environment is healthy and comfortable or not. Firstly an individual's level of sensitivity, health and hygiene need to be analysed before getting a fix at the physical, chemical and biological aspects of an indoor environment. The foremost Comfort parameters that environmental designers look at in an indoor environment are the Thermal comfort, Acoustic comfort, Visual comfort and the Indoor Air Quality which is mainly responsible for the health and ease of an indoor area.

There has been an immense pursuit to tone down the major climatic changes leading to global warming. There has been a comprehensive aspiration for the creation of green buildings with the reduction in usage of energy. Sustainability has become inescapability and not an option, due to which every nation has been talking about being sustainable and creating Green buildings. The populace does not comprehend the meaning of Green buildings. People are only aiming at reducing the energy use and thus by assuming the buildings to be green. There has to be a wider understanding to the term "sustainability" which is not only creating green buildings from the exterior but also crafting comfortable and healthy indoor environments, which is a major concern for the present and future generations to consider and comprehend. Human requirement for comfort, health and productivity are at stake and the most considerate approach to which would be to create healthier indoor environments by having receptive elucidations to all our tribulations and challenges.

Sick building syndrome (SBS) and Building related illnesses (BRI) have impacted three fourths of the world's comfort, health and productivity. Extensive researches have been done during past three decades in order to testify these (Sekhar 2009). In the study conducted by Sekhar (2009), there has been noteworthy progress in understanding the root cause of SBI and BRI which are the sources of toxicity and other indoor contaminants, while no major step has been taken in order to stop them completely. There needs to be more evidence to testify this and also bring about these issues to further attention of the public and healthy safety policy makers as well as contractors and designers.

In order to carry on a subjective evaluation of Commercial and Residential Indoor environments within the region of Dubai, which is a region of United Arab Emirates, we would firstly get into understanding the background of the Country and the region to have a broader perspective in analyzing its current situation in terms of the city, its background historically and geographically and also to understand the culture and living standards of its residents.

1.2 Background Study

1.2.1 United Arab Emirates

With an approximate land area of around 82,000 square kilometres, forms the United Arab Emirates (U.A.E), which is a Middle Eastern country located in the south-eastern Arabian Peninsula. It is an Islamic and Arabic Country and shares its borders with Oman and Saudi Arabia. Most of the land is predominantly formed of the desert sands as well as mountains. The main economic gains of the country are through oil production which is its largest beneficiary invention. Other than oil, the country is also known for its dates industries, farming and pearls trading. In the past 35 years, Dubai has emerged from a traditional to a modern economy. It is one of the greatest revenue earning cities, after Abu-Dhabi. But is one of the centres for travel, trade and business. It has made a wide leap in its economy in the past decade. After its fishing and pearl industries it has now diversified into various different industries including construction and trading. Saadeh (2007, p. 1) stated that "after years of growth that has transformed Dubai from a desert

backwater into a trade and tourism hub, the Gulf emirate is waking up to the environmental impact of 24-hour construction" . Large scale construction has led to set indoor construction in order to cater to the growing needs of homes and offices in Dubai as well as lowered consideration towards the environmental impact on its nations, thus having an urgent need to establish the causes of environmental effects to an indoor environment.

1.2.2 Green Buildings and Construction industry in the UAE

Architecture and construction were at its peak before the financial crisis in the late 2008. Yet, Dubai on its own has managed to overcome the recession due to its great number of hard working populace. It has some of the world's best modern and traditional architecture and also is aiming at constructing many more famous pieces of architectural projects in the upcoming years. As we look into the recent past, Dubai has constructed the world's tallest tower "Burj Khalifa" and many other unbelievable projects such as the palm Islands over the waters, the "Infinity twisting tower" and many more. It has been an ideal prototype for urbanization and modernization in a rapid period of time. For a rapidly growing nation like the U.A.E, rural development and sustainability are major concerns for policymakers, consultants, contractors, as well as the public in order to trim down their harmful environmental impact and natural resource depletion, although the country has surfaced as a centre of trade, solidity, security, and Peace most importantly. According to Abdellatif (2005), "development is happening too fast in Dubai, too fast for Social Structure, too fast for Infrastructure, too fast for the people, too fast for the environment and too fast for us to learn from our mistakes". Hence it's really important for the society as a whole to act into exterior as well as interior sustainability as a whole.

1.2.3 Credibility Gap

U.A.E is one of the 1st ranked countries in terms of having a large carbon footprint. This means that it is one of the most unsustainable countries as per current statistics. The Emirates is a country with the maximum construction practices currently and uses up a lot of embodied energy. Due to this the policy makers, governments and the superiors

of the country are taking up major steps in the U.A.E to make it a sustainable country and to keep the environment intact and ensure sustainability throughout the country. Recently the vice president of the country has declared the UAE Initiative of Green Economy for Sustainable Development. They have focused on addressing the following issues such as: green construction, low carbon emissions, effective building managements, stimulating refurbishment programmes, efficient water management, creating sustainable cities, recycling, sourcing building materials ethically and responsibly, adapting to the impact of climate change, and most designing green.

There has been very little focus on indoor environment quality as well as health related issues to the IAQ. Everybody aims to focus on the carbon foot print and energy saving bit. The human health and comfort is a subject given nil importance in the field of sustainability. This is due to the credibility gap amongst the public, designers, architects as well as policy makers. The American Heritage Dictionary defines 'Credibility gap' as a term used to express and illustrate the public scepticism on certain subjects of matter and situations. It is the ignorance and unawareness of the human populace in the region which causes this issue to remain unsolved and unconsidered.

1.2.4 Current Indoor environmental assessment and Health and Lifestyle

In a recent article on an air quality assessment by Dr.Jacqueline MacDonald in the U.A.E, it was found that indoor air pollution had led to 250 deaths (Todorova 2009). Particulate matter has been found to be in higher limits and air pollution has been associated with heart and lung diseases. This study was conducted by scientists from the University of North Carolina, Chapel Hill. An approximate of 5-38% of premature deaths was caused due to the indoor pollutants and toxins every year in the U.A.E. The results of the study concluded major indoor air pollutants, mainly formaldehyde which was present in furniture, fixtures and fittings. This proved that many health concerns were related to poor indoor air quality in homes and offices where people spend majority of their time at. Majority of the people in Dubai have been suffering from BRI and SBS.

BRI: *Building Related Illness* is a term used to define unambiguous symptoms such as cold, dry throat, skin rash, flu, muscle aches, headaches and many such others credited to indoor building contaminants in badly lit, thermally uncomfortable and poorly ventilated buildings identifies by a medical professional (About, 2013).

SBS: *Sick Building Syndrome* is a similar term used to describe symptoms relating to acute health and comfort effects such as nausea, itchy skin, fever, or even asthma at times linked to the time spent in indoor environments but these symptoms are unrecognizable in contrast to BRI (EPA, 2013).

1.3 Indoor Environmental Quality

Indoor environmental quality is an integrated matter of a human's physical, psychological and physiological state of comfort and well-being. It comprises of a numerous factors for an individual to be comfortable in a given surrounding. Clean and healthy Indoor air quality, acoustical comfort, visual comfort (lighting), thermal comfort as well as physiological comfort can bring about a good or bad level of a particular indoor environment. Certain individual suffer to chemical and/or electromagnetic sensitivities. Thus a toxic indoor environment can bring about various health issues for such human beings. The existence of various harmful organic compounds in the environment such as smoke, dust, radon, CO, lead as well as high levels of C02 and many more can cause unhealthy and poor indoor environments. All these chemicals enter a given indoor environment through, furniture, furnishings, paints, machines emitting electromagnetic fields, poor ventilation, exhaust systems as well as low levels of maintenance. Noise and vibration are also causes for creating electromagnetic differences and triggering various health imbalances and at times could cause seizure attacks in susceptible individuals. Adverse Indoor Air Quality is one of the main causes to ill-health and discomfort to humans at a given indoor environment. It can cause asthma, birth defects, itchy throat, runny nose, flu and cancer at times in the long run. There can be a lot of manmade sources of indoor air pollutants such as hair, dust, pesticides, food, mould as well as moist, etc.. Symptoms such as headaches, poor concentration, fatigue as well as eye, nose and throat infection are linked to bad indoor environmental quality.

Indoor environmental quality is directly interrelated to human health and comfort. Indoor environment depends entirely on the level of indoor pollution from building construction, materials, maintenance as well as indoor air quality. It is extremely important while designing and constructing an indoor environment to use toxic free materials and leave spaces open for ventilation and exhaust of polluted air. It is also important to follow certain guiding principles for the health, safety as well indoor environmental comfort and protection. According to research, 80-85 % of the time of a day is spent indoors (at residences and work) by humans (Refer to Figure 1.1). Hence it is extremely important to understand and evaluate the current dire conditions of working and living interior environments in order to exclude the factors such as SBS and BRI from the lives of people in the current world of intense construction and design, especially in the region of Dubai. There is a lot of pressure and stress in addition to bad indoor settings, which can make health and productivity levels fall drastically.

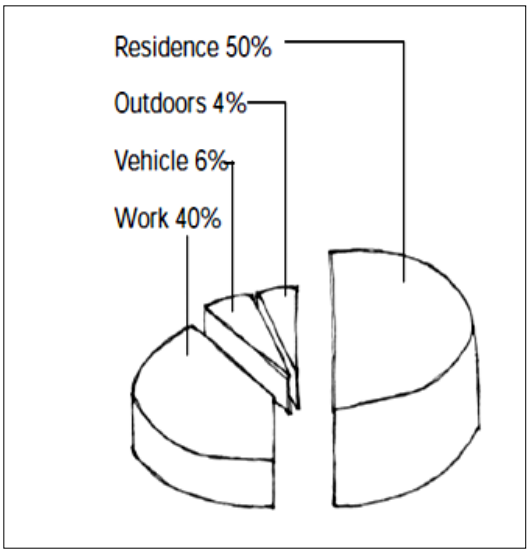


Figure 1.1: Average daily time allocation (Lee et al 1996)

A comfortable indoor environment is a combination of various perspectives being: thermal comfort, visual comfort, Acoustic comfort, indoor Air quality (being one of the important factors relating to indoor environmental quality), as well mental and physical state of well-being. According to Research an indoor environmental quality can be evaluated by calculating levels of noise (Leq), Illumination (lux), CO_2 concentrations, as well as operative temperature (To) in order to check them and compare them to the

standard healthy levels and ranges of acceptance in an office or home environment. Indoor pollution is unswervingly associated with the particular air quality of an indoor environment. This is linked mainly to the health and comfort of individuals. Certain harmful, polluted and toxic environments are linked directly to the cause of primary diseases such as asthma; birth related defects as well as cancer. Hence it is extremely important to have good ventilation, fresh air supply as well as appropriate selection of toxic free indoor materials for the design and built of new homes and offices. The other factors related to indoor environmental quality are the noise levels, air pollution (caused by construction, dust, chemicals and vehicle pollution and water pollution.

An occupants attitude towards the thermal, acoustic , visual and aural perception of comfort have to be studied subjectively in order to understand people's view points on a particular commercial or residential indoor environment. The degree of human satisfaction (depending on the comfort, good health and productivity) largely depends on the discretion of Architects, designers, policy makers, landlords as well as end-users. However the correlations of occupant satisfaction would be different in homes and offices due to the various parameters such as clothing, comfort, machines, and odour as well as thermal and visual quality. Thus it is important to study all the factors well as the common causes relating to indoor environmental quality independently.

1.4 Motivation for the study

Current health conditions and unease in homes and offices has made it vital to further understand what the root cause to lethargy and Building related illnesses are. According, to a survey conducted by the health departments in California and New Mexico, "there are a significant number of people who are sensitive to chemicals and electromagnetic fields" (Miller and Ashford 2001). Along with protecting the nature and its products, it is also imperative to maintain comfortable and healthy indoor environments which will give rise to better stratum of productivity and a better life in general. It is important to understand the indoor environmental quality of spaces in the U.A.E firstly in the region of Dubai. It is also vital to analyse how comfortable individuals are in their respective indoor environments; to really understand their perception; subjective evaluation has to be done to get an overall wide perspective of the people and their current conditions.

1.4.1 Problems

Improper maintenance, ventilation and comfort within commercial and residential buildings can influence the sensitivities of many individuals causing Sick Building syndrome and Building Related Illnesses. There is an approximate of 188 indoor air pollutants, an overdose of which could cause many health defects in certain individuals. These pollutants could be from cleaning and maintaining substances as well as unhygienic living and working conditions.

1.4.2 Need for a Solution

A lot of research and evidence suggests that there is a significant threat to indoor environments due to the release of various toxins from exteriors as well as interior sources of pollutants, which could be from the furniture, finishes as well fixtures. It could also be a problem of bad indoor air quality which again has a lot of reasons varying from personal hygiene issues to poor quality of mechanical (air-conditioning and exhaust) facilities as well as less or no maintenance of these facilities. All this leads to causing significant public health risks, mostly amongst children, elders, the poor as well as a lot of other sensitive individuals. In spite of the proven facts of harmful effects of indoor environments on human health, no major steps or concern has been regarded in consideration to it.

1.5 Aims of the Study

Due to immense urbanization and industrialization there is an increase in the number of offices and majority of the population spend three fourths of their lives indoors. There is a huge necessitate in constructing self-sufficient indoor environments which have satisfactory intake of fresh air, proper air circulation to flush out VOC's, organic matter and excess CO_2 present in the interior milieu. All of this calls for an imperative enhancement in the field of ventilation systems and to provide adequate thermal and humidity levels indoors to make the people feel comfortable and healthy. There is a rise in the number of diseases caused primarily due to unhealthy interior spaces. Diseases

such as “sick building syndrome”, asthma, skin allergies, chest infections, flu’s as well extremely detrimental sickness such as cancer and many other chronic diseases are caused due to the inefficiencies of a ventilation system. There are many other sources of contamination such as dust, moulds as a result of humidity, hair, pollens and ozone from outdoor surroundings. The aim of the study is to build more research basis for developers, media, citizens, designers, architects, engineers and researchers in order to get in depth information about the efficiency of indoor environments and how other factors such as demographics of individuals play a role in affecting individual’s health, comfort and levels of productivity.

1.6 Significance of the Study

The research is basically based on current and previous studies and understandings of various modes of indoor environmental evaluations. We will focus largely on the Middle East and Dubai to be more specific, as the survey is conducted within the region of Dubai. It also focuses mainly household and working environments; hence the examinational survey is conducted at homes and offices on a large scale to study the impacts of these environments on human health, comfort and productivity. Research includes an extensive literature review to understand the indoor environments in various countries. It will then focus in a subjective evaluation of IEQ in Dubai mainly by conducting large scale surveys in order to understand the perception of Indoor environments in homes and offices by the people and for the people. This research will help architects, contractors, and designers mainly in understanding how simple decisions taken in the design process of residential and commercial buildings can achieve a healthier and productive Indoor Environment. By comparing the results obtained from all the Residential and Commercial Surveys, a good evaluation of the problems and solutions of indoor environments in the U.A.E will be achieved.

1.7 Thesis Outline

This dissertation consists of 7 chapters including the following:

Chapter 1: Introduction

This part focuses on the fundamental focus of the dissertation, which is the Subjective Evaluation of Indoor Environmental Quality in Dubai. The factors affecting it as well as many other basic definitions related to the subject. It also covers the historic and geographic values of the region, including its fidelity for the construction industry. It articulates about the credibility gap and health and Lifestyle of individuals residing in the city. The motivation and significance of the study is also mentioned here, along with the research scope and outline.

Chapter 2: Literature Review

Research papers are discussed in this section in comparison to the topic. It provides knowledge in order to generate research parameters as well as understand the research methodologies used throughout various studies. Research papers will be analysed in depth as well as compare and contrast different approaches which will further provide a baseline of knowledge in order to pursue the research paper.

Chapter 3: Methodology

This section of the study will investigate various types of methods used in different studies of different years and times, their advantages and disadvantages will be discussed in terms of assessing the right approach towards each study. The general result of this chapter will determine the proper research method to be obtained in order to generate the best and the most accurate results.

Chapter 4: Results and discussions

This part of the chapter looks at various current and used surveys that have been carried out in the past in which provided valid results. Comparing various such surveys , lead to the finalization of a particular survey structure as an optimum survey format and layout best used and then analysed using various software's such as Microsoft Excel and SSLS in order to gain accurate data and analysis. Here the data recorded and analysed from the

surveys which are talked about and scrutinized using various perspectives in the field study of indoor environmental quality. Current subject evaluation is done in order to understand the current health and comfort standards within the region of Dubai. This is further discussed in order to attain a goal of perfection and standardization after consideration of various requirements to make healthier living conditions in the U.A.E

Chapter 5: Conclusions and Recommendations

Here we conclude with the remarks and results achieved from this study including a large scale research and survey conducted. This section would also contain suggestion in order to progress the research topic in various other conditions and times and to gain productive information studying the paper. It would recommend various ways to improve the health, safety as well as comfort standards for living and working environment within Dubai and U.A.E as a whole.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

The main aim of the literature review is to evaluate and study various research papers which speak about in-depth information on indoor environments and their levels of comfort and health. It also focuses on the past and current studies involving and assessing our topic of research. A lot of papers have been studied and understood to get a wide understanding of the current studies regarding the same. Methodologies have also been studied in order to conclude the most appropriate method for this particular research. Most of the research papers use a comparative approach between two or more types of methods to conclude with best results possible, to achieve required outcomes. Here existing journals and papers are reviewed to present accessible knowledge to the subject of Indoor environmental quality in the world as well as in Dubai. It develops up to date understanding in the study of Indoor health and comfort as well as the factors causing discomfort, ill-health as well as reduction in the levels of productivity.

2.2 Impact of Indoor Environmental Quality in Offices and Homes

2.2.1 Indoor Air Quality

Indoor air quality is a measurable dominant factor for indoor environments; it is the comfort level of air present in a given indoor environment which is inhaled by humans that has a pollutant concentration, a measureable air temperature, humidity and velocity. A good indoor air quality largely depends on the absence of masses of concentration of chemical, biological and particulate contaminants. IAQ is one of the most important factors in determining the comfort level of an Indoor environment, Due to the fact that a bad IAQ can lead to various volatile diseases in a human. It also creates a difference in performance and productivity of an individual residing or working in a set environment.

2.2.1.1 Concentration of Indoor Contaminants and their Sources:

- ✓ *Chemical*

Chemical concentrations of Indoor Contaminants are volatile organic compounds (VOC's) and airborne chemicals having the ability to be extremely poisonous when in contact with skin or even inhaled. They enter the body through one of the three processes: inhalation, skin absorption as well as ingestion. Some of the examples of VOC's are Formaldehyde, radon, Lead, Carbon Monoxide, Vinyl Chloride, Hydrofluoric acid, solvents (e.g. Benzene), disinfectants, pesticides as well as high levels of CO_2 are listen in Table 2.1. VOC's are ubiquitous to indoor environments and some are also present from the outdoor inorganic compounds such as Ozone. Human activities, various types of pollution, building product emissions, as well as unfiltered air cause Indoor Pollution.

Typical Indoor Cotaminants (VOCs) and Their Source		
Contamination Source	Emission Source	VOC
	Breath	Acetone, Ethanol, Isoprene,
Human Being	Skin Respiration & Perspiration	Nonanal, Decanal, alpha-Pinene
	Flatulence	Methane, Hydrogen
	Cosmetics	Limonene, Eucalyptol
Consumer Products	Household Supplies	Alcholos, Esters, Limonene
Office Equipment	Printers, Copiers, Computers	Benzene, Styrene, Phonole
Combustion	Engines, Appliances, Smoke	Unburnt Hydrocarbons
Building Materials	Paints, Adhesives, Solvents, Carpets	Formaldehyde, Akanes, Alcohols, Aldehydes, Ketones, Siloxanes
Furniture	Poly Vinyl Chloride (PVC)	Touleme, Xylene, Decane

Table 2.1: Sources and types of VOC's (Applied Sensor 2010)

Radon, Asbestos, Nitrogen Oxide, Carbon Monoxide, formaldehyde and Carbon Dioxide are the other major chemicals responsible for indoor air pollution. Radon is emitted from the soils, Asbestos and formaldehyde is found from the insulation of the ceilings, from furnishings especially wooden products. Nitrogen oxide and carbon monoxide is emitted from unflued gas such as heaters in residences, whereas carbon dioxide is the exhaled air which does not get outside the indoor environment and is a result of indoor pollution when it is not replenished with clean oxygenated air.

There is a limit to level of acceptability of these compounds beyond which the health of person starts to get low. These harmful chemical compounds may be present in many homes and can enter a house-hold through furniture's, furnishings, finishes, fragrances, disinfectants as well as through water and gas. One of the best ways to avoid these from entering your household or office environment is by avoiding toxic agents within many substances and opting for natural and non-toxic alternatives by being more cautious and well-informed. One of the other ways of getting rid of such VOC's is by having good ventilation and exhaust systems which will facilitate the exit of these chemical toxins out of an interior environment and supply clean, fresh oxygenated air to indoor environments.

Environmental Tobacco Smoking (ETS) is another factor to major sources of chemical contaminants in an Indoor environment. Tobacco smoking is one of the main sources for increase in harmful airborne particle concentrations within a given environment and a major exposure to humans. Indoor air quality can be acutely affected by Environment tobacco smoke (ETS). Hackshaw et al (1997) stated that this can lead to high risks of lung cancer, heart diseases and other respiratory infections for humans living under such acute environmental conditions. Even a passive smoker residing or working in a smoking environment can become a victim to these diseases and even reduce his/her life span eventually. According to research and experiments conducted by Spengler et al (1981); Coultas et al (1990); Leaderer and Hammond (1991) and Ozkaynak et al (1996); environments with smokers have found to be containing and increased average indoor particle level by at least 20 to 30 grams in comparison to environments without smokers. According to the research conducted by Miller and Nazaroff (2000), there are only two ways of controlling or reducing the ETS exposures which are either administrative or technical or even both. Administrative controls include a restricted environment where smoking is prohibited; it could be in public or private buildings. It discourages people to generate unhealthy Indoor environments. There are a few programmes which could help support non-smoking campaigns as well as educate smokers against the risks of smoking. According to Leaderer et al (1984) and Moschandreas and Vuilleumier (1999), Technical changes would include increase of ventilation rates in order to reduce the ETS particulate concentration, as well as a control particle chamber, filtration segregation and a good ventilation system would

help in gaining lower particulate rate indoors. All this will help create good indoor air quality within residential and commercial environments.

- ✓ *Biological*

Biological contaminants within an indoor environment are of various kinds such as fungi, virus, mould, bacteria, mites; insect's etc. They could be either visible or microscopic in size due to which it can be quite difficult to see them with naked eye. The sources of these biological contaminants could be unhealthy living or working environments, pets, insects, plants as well as human dander, sweat and other waste products. These contaminants can lead to various ill health effects such as allergy, fever, asthma, hypersensitivity, irritation, diarrhoea, cancer and various other diseases (Seltzer 1994). Nevalainen and Morawska (2009) suggest that the susceptibility of diseases can vary depending on the age, gender, health and nature of a human being. Hygiene, cleanliness, air filtration, humidifiers can all help in maintaining a good environment which will not support such microbial organisms and other biological contaminants to survive in indoor environments.

- ✓ *Particulate*

Particulate matters are basically tiny solid matters or particles which could be in a liquid state as well within an indoor environment. These matters could be formed mainly due to human activities such as construction, smoke from industries, vehicle pollution, furniture, paints etc. or it could be a result of natural processes within the atmosphere such as sandstorms, draughts, volcano's etc. (Behzadi 2011). Particulate matter will prove harmful to humans only if it exceeds a certain weight, size and amount present within a given indoor environment. It can range from 2.5 till 10 micrometre size in diameter (Kleinman 2000). In an experiment conducted by Colome et al (1992), the PM_{10} mass concentrations were measure in 10 homes out of which 9 of them had asthmatic patients in South California. Over 50 % of all outdoor measurements and over 30% of indoor particulate concentrations exceeded the standards for PM_{10}. In another experiment by Begum et al (2009), Particulate concentrations were found to be lower in homes which used LPG (a cleaner fuel), than other biomass fuels. It was also found to be

lower in households with better ventilation systems and the carbonaceous material was the major component of the PM_{10}.

2.2.1.2 Environmental Factors:

- ✓ *Air Temperature*

Air temperature is defined as the measure of how hot or cold the air is. It is also one of the most universally used parameters to compute the weather of a particular indoor or outdoor environment. It basically affects a lot of other conditions such as the rate of evaporation, relative humidity, wind speed and direction, precipitation patterns and types, such as whether it will rain, snow, or sleet (FONDRIEST 2013). Air temperature in an indoor environment is one of many important factors that relates to the comfort of an individual thermally. When it gets too warm, people tend to feel stuffy and congested in a particular space. It can also lead to the feeling of nausea and suffocation, and eventually lower the levels of productivity (Heidorn 1997). An extremely warm condition can also give rise to out gassing of toxins from furnishings, furniture as well as finishes. Extremely cold air temperatures alternatively can too add immense discomfort and ill-health. Outdoor air temperature can also cause to affect the indoors in efficiently due to which it is important to have an efficient air conditioning and ventilation system, especially in the U.A.E.

- ✓ *Velocity*

Velocity of air in a given indoor environment is the pressure of flow of air in order to maintain thermal comfort by appropriate air movement. Indoor air quality is largely depended on the air movement at a comfortable temperature which differs for office, home and public indoor atmospheres. A person can feel very stuffy, sweaty and thermally uncomfortable if adequate air velocity is not provided in an interior. Indoor air movement patterns are formed by a mixture of various occupant‘s activities, the number of people present indoors as well as the efficiency of the ventilation systems (EPA 2009a). Very few numbers of studies have been conducted regarding the relation of velocity to indoor air quality. There have been a few studies on schools and the

supply of fresh air to classrooms as well as how thermal sensation has a great impact on the progress and productivity of humans (Magnier et al 2012). Hence it's very necessary to have an appropriate ventilation system which provides adequate velocity of fresh air at the correct temperature requirements and least loss of air to the outdoors (Heidorn 1997).

- ✓ *Humidity*

Humidity is one of the other major factors to thermal comfort, as if it is not well monitored, it can cause dry skin, body odour, inflammation dry eyes, sick building syndrome and many other symptoms which can cause irritation in moods and lower rates of productivity. Extreme humidity is a condition especially in the U.A.E where the summers are extremely hot and humid. Extra efforts have been taken to increase the ventilation systems in the indoor environments which can lower humidity but can sometimes lead to extreme cold conditions indoors and also cause a great energy loss. Some indoor environments have set up humidifiers in order for the indoor environment s to be thermally comfortable and not give rise to mould and bacteria and unhealthy surroundings (Wolof and Kjaergaard 2007). Increased humidity indoors also causes a raise in the number of VOC's, particles as well as Ozone. According to Qi and Deng (2009), the performance of a MIMO (multiple-input and multiple-output) control strategy which is based on the linearized dynamic model of the experimental DX A/C system, is capable of effectively maintaining an indoor thermal comfort level by maintaining a constant level of indoor humidity. It is important to investigate and understand the contribution of each factor to indoor humidity and to establish an effective method for the design and control of indoor humidity.

2.2.1.3 Health Impact and Comfort

- ✓ *Sick Building Syndrome*

Sick Building Syndrome (SBS) is a combination of ailments associated with the living and working environments of an individual (Wikipedia 2013). Some of the symptoms include nausea, nose and throat infection, headaches, itchiness and lower levels of energy and concentration.

According to the health and safety Executive report in the UK, an approximate of 30-50% of buildings suffers to SBS, with up to 85% of its occupants suffering from SBS symptoms. There is a huge problem of SBS in offices and homes which is causing in lower levels of productivities and many other health complications. Sick Building syndrome is an indoor environmental concern that has been studied and confirmed by various kinds of disciplines such as environmental agencies, contractors, policy makers; medicine as well as many other industries (Redman et al 2011). It can be a factor to various chemical reactions within a building, Refer to figure 2.1.

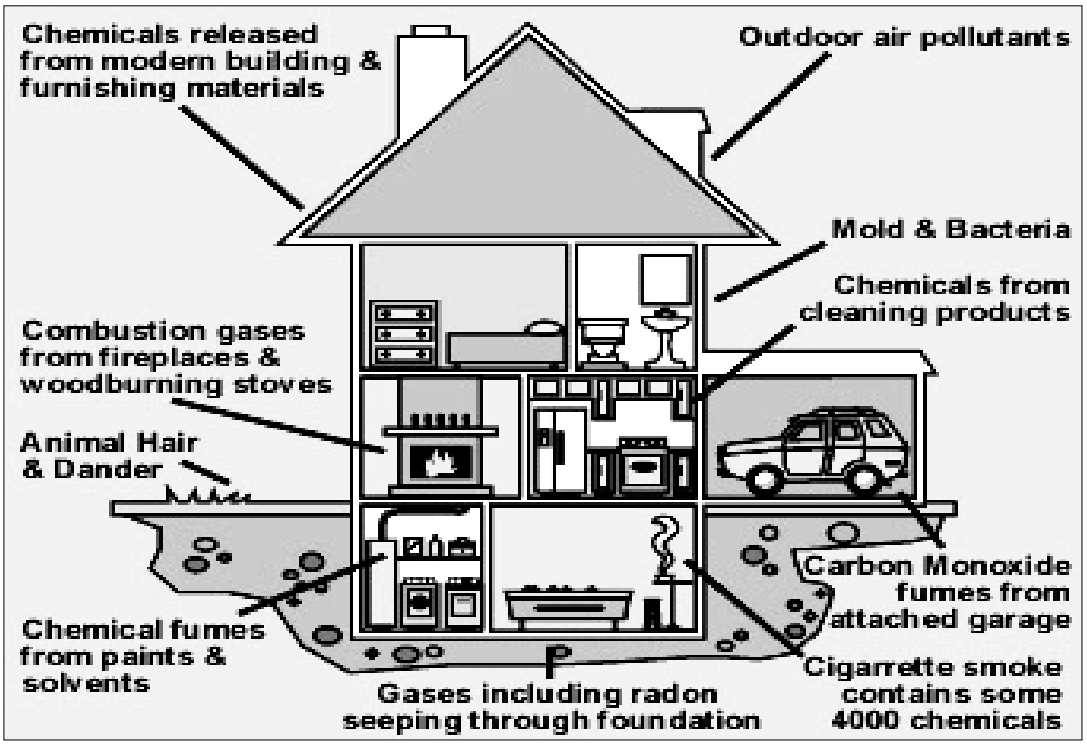


Figure 2.1: Indoor Air Pollution Source (U.S.Environmental Protection Agency 1991)

SBS causes various tribulations ranging from the mere feeling of being uncomfortable to everlasting diseases of humans. Various Indoor pollutants are a reason for SBS. There could be other reasons causing ill-health, unease and lethargy such as environmental sensitivity, levels of hygiene – personal and public as well as smoking and spread of other gaseous substances in an indoor environment.

- ✓ *Environmental Sensitivity*

Environmental sensitivity occurs from bad immunities to external and internal factors. These are immediate reactions of humans when in contact with certain chemical and biological substances. Certain individuals when exposed to chemical substances or any harmful VOC's may not react immediately or even for a long period of time due to their strong immunity levels, individual who fail to be like that and react immediately when in contact with VOC's are less immune and more environmental sensitive to toxic substances and chemicals present in a given environmental setting. Some people are allergic to few or more chemical and biological substances, for example: being allergic to dust, pesticides, perfumes, colognes, scented cleaners, soaps etc.. This sort of sensitization is a part of environmental sensitivity. There are multiple reactions that occur in a human body when exposed to certain chemicals, varying also on the levels and quantities of the chemicals. Some of these reactions also may occur among structurally related chemicals as well as chemical combinations of certain substances. There are many other individuals who are sensitive to electromagnetic radiations caused by cell phones, fax machines, laptops and other electronic devices.

Multiple chemical sensitivity (MSC): is defined as the environmental intolerance of certain individuals to any sort of exposure to certain chemical substances in the environment which occurs due hypersensitivity in certain humans. It is yet a controversial finding, but many links have proven it to be linked to environmentally sensitive human beings which get affected by low levels of chemicals and cause a chemical imbalance within the human body.

2.2.1.4 Performance and Productivity

Indoor environmental odours, unease and no thermal comfort could also be an answer to different levels of hygiene for people living in a particular home or people working together in a given fixed indoor setting. It is very hard to control others levels of hygiene and this could cause a lot of unease and bad odour if populace pay less attention to hygiene and cleanliness. A lot of perfume and cosmetic chemicals can also cause discomfort for certain other individuals living or working in a similar environment. Personal hygiene is the first steps to good health and well-being. If taken good care of

personal hygiene one can prevent the spread of germs and diseases, chemical sensitivities, exposure to contaminants and chemicals as well prevent themselves from skin and other forms of allergies. Some of the conditions such as: Head Lice, Dandruff, Bad Breath, Ear Wax, Body Odour, Perspiration, Urinary Infection, Pinworms as well as Athletes Foot. All this can greatly influence the levels of productivity whether at work or at home. Depending on the Layers of clothing a person wears, he or she could thermally comfortable or uncomfortable. It is extremely important to check on your own sense of clothing and hygiene before censuring the weather as well the indoor environmental systems. Research has proved that the quality of Indoor air quality has the largest influence on the levels of performance and productivity of an individual. Room temperature, humidity, air velocity, pollution levels as well as fresh air can directly affect an occupant's productivity (Lan and Lian 2009). According to Alnaser (2008), a green building with healthy indoor air quality improves health conditions, reduces the chances of illness of occupants and increases occupant productivity.

2.2.1.5 Attendance Rates

Research proves that an unhealthy and unclean indoor office environment can make a person sick and lower his attendance at work. Alnaser (2008), also states that a green building with clean and efficient indoor air quality can decrease absenteeism by 15%. It is extremely important for an individual to be thermally comfortable as it can influence the psychological and behavioural factors of a human immensely (Lin 2009). Rosen and Richardson (1999) conducted an experiment to check whether the improvement in the IAQ would reduce the rate of absenteeism due to various sicknesses in day care centres. The experiment found that an average reduction of 25% of fine particle concentration reduced the absenteeism from 8.31% to 3.75% in a period of 1 year.

2.2.2 Acoustics

Acoustic comfort in an indoor environment is an equally important factor for comfortable indoor environments. According to a survey conducted by Huang et al (2012), indoor environmental satisfaction levels are equally dependent on both temperature and noise and have equal power over the comfort of an individual in any

given indoor surrounding. Any excess sound or voices, normally of high intensities which are undesirable and cause irritation or discomfort by occupants, is considered as noise pollution. Residential or Commercial indoor environments having poor acoustics will create difficult environments for humans to live and work in, as a result of which lower rates of productivity and health are formed. "Acceptable noise levels for outdoor and indoor as recommended by ISI (1954-1968). A permissible maximum outdoor noise level for urban residential areas is 35-45 dB." (Preservearticles 2012)

2.2.2.1 Sources of Indoor Acoustic Pollution:

- ✓ *Industries and Traffic*

Industries, Traffic (including air, water and road), fire crackers and construction are few of the major causes to indoor noise pollution, although these are outdoor sources, their level of noise gets indoors. Industries whether factories, construction, fabrication, mining, chemical, warehouses and others can create a loud noise pollution which can lead to disturbance within the neighbouring areas if the buildings are not well acoustically protected , which majority of the builders or owners do not wish to invest in as they feel it to be a minor part of an indoor environment. Even a construction or demolition of a building can raise the noise pollution in a given area leading to discomfort of residents in the neighbouring area. Traffic or movement of cars, buses, trains, aircrafts etc.. can lead to increasingly high decibels of sound within an exterior and interior environment. The other technology which has become increasingly necessary in this modern age can also be a major source to acoustic discomfort such as telephones, copy machines, fans, air conditions, audio as well as videos.

- ✓ *Natural/Biological*

Biological sources of noise pollution are man made noises, be it humans or animals (including birds and other mammals). Movement of humans, talking, laughing, screaming can all be of acoustic discomfort to some. According to Miglani (1986), "20 dB

is whisper, 40 dB is the noise in a quiet office, 60 dB is normal conversation, 80 dB is the level at which sound becomes physically painful."

- ✓ *Others*

Many other sources including agricultural noise, concerts, sirens; from ambulance, hospitals, schools, military noise, Consumer products, workshops, etc. can peak intensities above 120 dB and cause acoustic discomfort to humans.

2.2.2.2 Health Impact and Comfort

Noise pollution can cause various types of discomfort to humans; it can cause emotional, psychological and physiological disturbances which are not so easy to measure. It reduces the efficiency of an individual. The physiological disturbances vary from auditory and non-auditory. Auditory could be temporary ear exhaustion or deafness. Non auditory effects are disturbance, annoyance and body related illnesses such as blood pressure, hypertension or fatigue. Sound pollution and various disturbances caused during sleep cause a downfall of mood as well as result in lowered quality of sleep. It also caused respiratory and cardiac ill effects in low insulated homes (Tulen et al 1986). According to Vermeer and Passchier (2000), "there is sufficient scientific evidence that noise exposure can induce hearing impairment, hypertension and ischemic heart disease, annoyance, sleep disturbance…" He also suggests that other than just causing hearing damage, exposure to noise pollution also causes a reaction to the perception of sound which is mostly dependent on the type of noise. All the health impacts caused by excessive exposure to sound are also dependent on a person's sensitivity levels. At sudden elevated sound levels, there is a possibility of mechanical damage to the outer and the inner ear. Other than heart diseases, congenital defects and hypertension, there is something called Noise-Induced Stress-Related Health Effects that is caused due to exposure of noise.

2.2.2.3 Performance and Productivity

According to Vermeer and Passchier (2000), annoyance, psychosocial well-being, and psychiatric hospitalization are some of the main results of exposure to noise pollution. Annoyance out of which is one of the most occurred effect to noise. A lot of research has also proved that noise induces temporal changes in the cardiovascular system which can lead to lowering the efficiency of a person at home or office depending on the environments of high noise exposures. Experiments conducted worldwide have provided large evidence that uncontrollably loud noises can result in great reduction of cognitive performance. It also leads to physiological challenges such as vulnerability, reduced focus and attention as well as reduced hearing of speech and various other sound signals. Few other studies by Karsdorf et al (1968), held at schools showed that high exposure to traffic noise showed impairment in school children while performing cognitive tasks. Also a study at Munich, showed that school children schooling near the airport were less reciprocate towards reading and comprehension and also had reduced long term memory (Hygge et al 1996 and Haines et al 1998) , all of which improved drastically after the closing of the airport.

2.2.2.4 Attendance Rates

According to Epidemiologic studies, when industrial workers are exposed to sound levels rising above 75-90 dB, the rate of absenteeism increases. It also proved that mortality rate increases with high exposure to noise (Vermeer and Passchier 2000). Due to the level of noise pollution as well as their ill health impacts, attendance in offices and other work places have thoroughly reduced in areas with high decibel levels and high exposures. This also varies from different types of workplaces. For example an office on a higher level of a building will have lesser exposure to vehicle and human noise pollution, whereas an industry or a factory would have increased exposure to the noise caused within its territory due to the production requirements. High exposures also affect comfortable sleep, which can further lead to malfunction of humans and their productivity levels at work and finally also be the cause to absenteeism at work.

2.2.3 Thermal Comfort

Thermal comfort is a biological, physical and mental state of wellbeing of human satisfaction in a given environment. It is affected by factors such as temperature, humidity, air flow (velocity), insulation, ventilation, metabolic rate, clothing and sensitivity of different individuals. Offices and homes can quite often be extremely hot or cold affecting the thermal comfort of people living in working in those environments. Various studies have shown that thermal comfort varies from body to body as even people from the same family can have different comfort levels in a similar environment. The Centre for the Built Environment states that, "Current comfort standards specify a 'comfort zone,' representing the optimal range and combinations of thermal factors (air temperature, radiant temperature, air velocity, humidity) and personal factors (clothing and activity level) with which at least 80 percent of the building occupants are expected to express satisfaction." This goal is often not achieved by architects, contractors and designers and not well considered (Godish 2010).

According to Fanger's studies, thermal dissatisfaction that can be articulated by the majority of people that are exposed to moderate thermal environments in mechanically ventilated offices, according to the ISO 7730 standards index which is also known as the predicted mean vote (PMV) is calculated. The model constitutes what is now known as the ISO 7730 standard and it predicts the degree of thermal dissatisfaction which can be expressed by a large group of people exposed to moderate thermal environments in mechanically ventilated offices.

2.2.3.1 Environmental Factors

- ✓ *Air Temperature*

Indoor air temperature is one of the most important factors controlling thermal comfort and good IAQ. It is mostly controlled by the efficiency of an HVAC system inside a building. It is not only responsible for thermal comfort but also is an indirect result to the quality of air, SBS and also has a large impact to the performance and productivity of humans at homes as well as offices. According to Seppanen et al 2006, the performance

of office staff is more efficient at 21-22°C, and reduces with higher temperatures of about 23-24 °C. 22°C is one of the most efficient levels of temperature for offices. Anything above that causes increase in percentage of reduction in performance. There is a quantitative correlation between performance, productivity and temperature, which is also widely dependent on the type of building, type of work as well as type and number of occupants in a given indoor environment. At instance, higher temperature could be linked with lower ventilation which may further reduce the productivity and cause various SBS symptoms and environmental sensitivities within humans. Thermal sensation is defined as the correlation of humans between the heat exchange and the environment. It also varies depending on the heat balance of human bodies (Tanabe et al 1994).

Tanabe et al (1994) conducted a study to measure the non-uniform thermal environments with a skin surface controlled mannequin. Measurements were done with local air supple from an under floor air distribution system in a thermally non- uniform workstation inclusive of heat sources such as computers and task lights which showed asymmetries in heat sources and airflow. Berglund et al (1990) used a wide amount of data in order to test the performance in various thermal conditions. He then envisaged the effective temperature, by using which he analysed the performance of normally clothed office workers and also related that thermal stress was one of the best indicators of performance and productivity. On the contrary effects of low temperatures on performance have been less researched about. Low temperatures have been often linked to performance of hand related jobs due to the dexterity of limbs that get affected first with lowering of temperatures. According to Meese et al (1984), the dexterity of the limbs gets affected with temperatures lowering below 20 – 22 °C.

- ✓ *Velocity*

Thermal Comfort is highly dependent firstly on the Temperature of the wind and secondly on the velocity with which the wind is approaching us. Velocity is nothing other than the speed at which the air moves across. Airflow in different directions can also cause variations in the thermal comfort in a set location. It reduces the pressure of wind in one direction, hence causing a state of being thermally uncomfortable. A number of

factors can affect the velocity of external air in a building, such as position and orientation of building, windows sizes, interior partition, and effects of balcony and roof shape (Prianto and Depecker 2001). Maximum air speed in a building can keep it cool and well ventilated in hot and humid climatic conditions.

- ✓ *Humidity*

Humidity is the vaporized water in the atmosphere while it gets heated. It also evaluates the concentration of water in the air. Relative humidity is nothing but the percentage of humidity. Humidity on an average in between 40% to 70% does not have a significant effect on thermal comfort, but anything beyond that can affect the comfort levels of individuals (Levin 1995). Humidity also differs and varies in different indoor environments. A manufacturing room may have high humidity levels due to high emissions, where as a hotel lobby may have lower levels of humidity and remains cooler. Whenever the humidity of indoor air rises, the evaporation of water from the body surface reduces and eventually the sweat increases (HSE 2010). One of the main means of heat loss for individuals is by the evaporation of water from the body surface which does not happen at higher humidity levels and often makes it uncomfortable for the residing and working occupants. This also affects the performance and productivity of individuals. (Schneider 2002)

- ✓ *Others*

There are several other factors affecting the thermal comfort in a given indoor environment such as the availability of indoor and/or outdoor cooling/heating. The age, gender, background, mental and physical stress levels and clothing, odour levels, type of milieu and many others are factors which can vary the level of thermal comfort amongst individuals in a given set indoor environment (EPA 2009b). Thermal comfort can be accounted for 70% of the population. Not every individual can feel the same way and not the most thermally comfortable settings can prove equally comfy for all natives.

2.2.3.2 Health Impact and Comfort

A thermally uncomfortable indoor setting can give rise to indoor pollution, due to humidity, odour, and perspiration of human beings as well as poor ventilation and excretion of polluted air. Good ventilation is an important factor to thermal comfort as well as health and comfort. It helps in removal of toxic air and pollution form an indoor environment, resulting in the flow of fresh and healthy living and working conditions (Lee et al 1996). Humans today have a far lower tolerance to outdoor pollutants than previous eras as now people are used to living and working more in the indoor environments than being outdoors. Medical technologies have advanced and this is consenting physically weaker people to cope better in the antagonistic world. All these advances lead to extreme environmental sensitivity, making it even more difficult for individuals to adapt to even the low levels of environmental contaminants (Lee et al 1996), which can occur at uncomfortable thermal conditions.

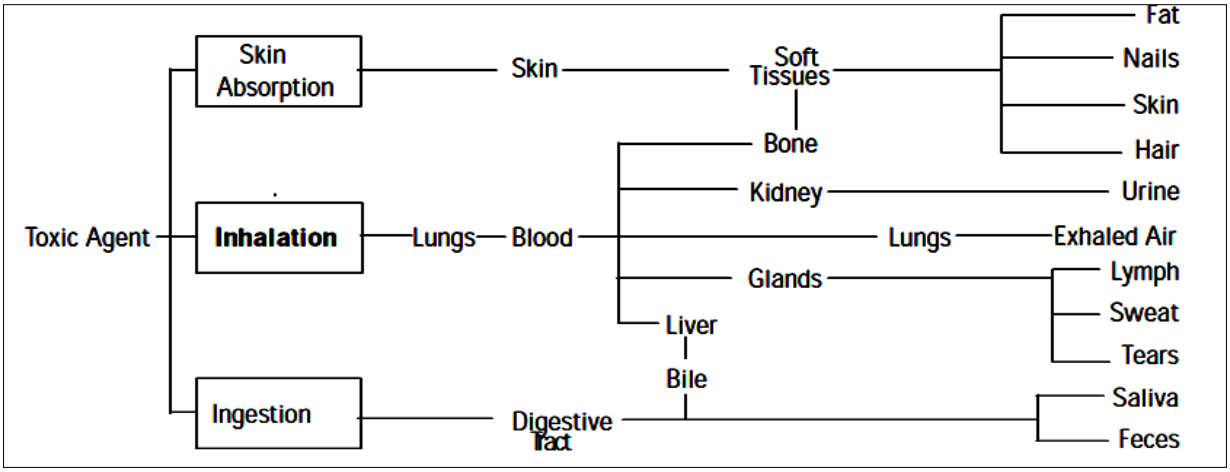


Figure 2.2: The pathways for toxic agents in the human body. (Source: Lee 1996)

Toxins can enter the body in 3 ways:

- Inhalation;
- Skin absorption; and
- Ingestion.

According to WHO (1946): the definition of human health is: “Health is a state of complete physical, mental and social well-being, not merely the absence of disease or infirmity.” Hussein and Rahman (2009), state that mental and psychological well-being is very crucial to human health and comfort and mind is one of the most powerful tools to determine or perceive thermal comfort. Human health and comfort is dependent on numerous variables as stated above.

2.2.3.3 Performance and Productivity

If a given indoor setting is thermally uncomfortable an individual’s physical activity suffers. The average comfort body skin temperature is around 33 ° C; any fluctuations of ±1.5 °C might not lead to thermal discomfort. Any fluctuations beyond that can cause variable levels of discomfort which may not cause an instant physical or medical condition, but can have serious effects on temper, moods, self-esteem, exertion and exhaustion as well as reduced levels of productivity (New Zealand Department of Labour 2007). It is very crucial to maintain a stable and comfortable thermal setting in a given environment, or else it may create tense and pressured conditions which negatively influences the performance and productivity of an in individual (CCOHS 2011). There are also a lot of personal and environmental factors such as depending on the activity level, clothing, and other physical and thermal parameters, individuals acceptance to thermal comfort varies. An adequate equilibrium to all of these conditions may help in achieving the best thermally acceptable indoor environment.

2.2.3.4 Attendance Rates

According to a research held by Shendell et al (2004), there was a link between the attendance rate and the thermal comfort in schools. In some of the classrooms where the ventilation rate was less, accumulation of VOC’s occurred and their absenteeism rate increases by 10 – 20 percent. Hathaway et al (1992) proved that a thermally comfortable indoor environment can majorly help in the reduction of absenteeism by almost 35% in buildings. He also found that people working in green buildings had not been absent for more than an average of 3 days per year. Another study by Issa et al

(2011) showed that the absenteeism rates decreased by 2–7.5% and students performance increased by 2.5–17.5% in green schools.

2.2.4 Visual Comfort

Visual comfort is the sense of satisfaction of the mind with the visual surroundings. Visual comfort is defined by two things; one of them being the amount of light present in an environment to see the surrounding and the other is the elimination of disturbing effects of lighting like over illumination, glare or unbalanced luminance. Daylight and Electrical lighting are the two main sources to visual comfort in indoor settings. The controlled factor for attaining visual comfort has been the illuminance level of light, measured in Lux. Huang et al (2011) stated that overall above 300 Lux illumination intensity, people were more satisfied with the visual comfort of the indoor environment. Lower levels of illumination, especially in offices made it harder for the occupants to read, write, or work and concentration levels dropped. Very high illumination intensity would also create visual discomfort. Another research study proved that in working environments the most comfortable illumination intensity range was between 1500 to 3000 Lux. Huang et al (2011) also confirmed in his study, that the higher the level of illumination was the higher satisfaction levels of individuals in terms of visual comfort.

Monitored Energy Performance for Controlled Daylight and Visual Comfort is one of the ways to achieve a visually comfortable indoor environment. Wienold (2007) says that there are ways to protect a building from glare as well as massive solar loads such as movable shading devices, blinds, controlled lighting, which not helps the building from high irradiation but also helps in saving energy. According to Ncube and Riffat (2012), a visually comfortable indoor environment has the illuminance levels, illumination uniformity, color characteristics, day lighting, and equal distribution of light, glare and flicker rates as well as proper room surface reflectance in relation and in right balance for a particular task.

2.2.4.1 Factors Affecting Visual Comfort

- ✓ *Day lighting*

Day lighting in an indoor environment is the amount of natural (solar) light that enter the Indoors through, windows, doors and other means. Most of the times it provides sufficient illumination during day time, hence artificial lighting is utilized least. Heschong (2002) affirmed that the appropriate use of day lighting using techniques could prove quite useful to visual comfort as well as energy saving strategies. She also stated that day lighting has potential benefits to health and productivity. Measurement to various schools using different amount of day lighting, showed that those with most window areas (day lighting) showed higher scores of students in academics of an average increase from 7% to 18% than the ones with least day lighting. Students in classrooms with the most window area or day lighting were found to have 7% to 18% higher scores on the standardized tests than those with the least window area or day lighting. The visual comfort was brought about by improved visibility due to higher illumination levels through day lighting, which also proved more supportive to the mental stimulation and better mood and behaviours.

- ✓ *Illuminance levels (lux)*

According to Saade and Ramadan (2008) the illuminance level (lux) is the main parameter in order to achieve visual comfort. The levels although completely depend on the type of activity in a particular indoor setting. On an average the preferred levels vary between 300 and 1000 lux for residential indoor environments (Kolokotsa et al 2001). According to The CIBSE Code for Interior Lighting by Baker (1994), specific amount of illumination levels should be at least 500 lux, and color rendering should be on an average from 60 to 80 lux. Luminance distribution is yet another important factor to achieve visual comfort.

- ✓ *Glare*

Glare is when human eye finds a lot of discomfort in viewing anything due to the presence of bright light. Veitch and Newsham (1996) have "proposed that lighting quality exists when the luminous conditions support the behavioural needs of individuals in the lit space." Glare can be one of the sole causes to discomfort including VCP. The ideal balance between lux levels and equal distribution of luminance can prevent glare to arise. According to a research by Vietch et al (1996), the overall quality of visual comfort and lighting was inversely related to the brightness caused my reflected images. So if the reflected image in a VDT screen was brighter, the rating of the lighting quality would become lower. Glare would eventually be an after effect of which, thus cause great visual discomfort. Glare created due to the sun, can be reduced by either creating manual or automatic blinds to block the excessive sun rays or by blocking it completely from the external lighting and by just making use of artificial lights.

2.2.4.2 Health Impact and Comfort

Visual discomfort can create a major impact in damaging the eyesight and or even creating blindness. Perry et al (1987), assumes that non uniform luminance distributions can cause a gloomy environment result in stress and or even depression if there is a shift from cone- to rod-based retinal processing. Efficient lighting and visual comfort can be both; energy efficient as well helps in achieving high quality levels of human well-being.

2.2.4.3 Performance and Productivity

Evans (1984) detected that by the individuals control over lighting in an indoor environment can reduce the stress levels of workers and also affect positively towards the performance and health of the inhabitants. However if a good lighting design is worked out in offices and homes, it is not necessary to provide to every given individual's need independently. It was also examined that different lighting types and levels need to be delivered for different type of living and Working environments. It also needs to be catered according to the different cultural and psychological requirements. A survey conducted by Veitch (2001), showed that task performance can be increased

by the provision of uniformed and personalized task lighting with appropriate levels of lighting according to the requirements.

2.2.4.4 Attendance Rates

A study had been conducted by Juslén (2006), on the visual comfort of a Dutch food manufacturing company. The illumination levels of the indoor environment were approximately 300 Lux. After a few weeks additional local lighting of 500 to 1000 lux was added on a weekly basis. The rate of absenteeism tested during before the addition of illumination levels and after was noted. It showed that after the addition of illumination (lux) levels to the work place, the absenteeism had reduced by more than 17%. And the productivity had increased by 3%. A good lighting design could help lower absenteeism and increase turnover (Veitch 2001).

2.3 Perception of Indoor Environmental Comfort (Limit of Acceptability)

- ✓ *Physiological and Psychological Aspects*

Studies state that Physiological comfort is the ability for an individual to physiologically adapt. The metabolic adjustment or systemic response of an individual to the environmental stimulus in order for them to cope with a changing environment such as varied thermal (air, temperature, humidity), visual (lighting, color balance and eye comfort), acoustic comfort (sound) is also known as the physiological adaptation. According to Dear and Brager (1998), Physiological adaptation is a combination of genetic adaptation (intergenerational) as well as acclimatization (within the lifetime of an individual). For example the thermal requirements and preferences of an individual can be altered by a past thermal history.

Psychological comfort is in fact the mental satisfaction of individual to given indoor environmental conditions. It is also a combinational result of genetic adaptation (intergenerational) as well as acclimatization (within the lifetime of an individual). It can also be altered owing to past experiences as well as expectations (Dear and Brager

1998). A thermally, visually and acoustically comfort setting for one individual may not be the definite for another due to the difference in the physiological and psychological adaptations of individuals. Psychological adaptation is the perception of the sensory organs in relation to past experiences as well as bodily expectations. According to Glaser (1966) and Frisancho (1981), "Relaxation of expectations can be likened to the notion of habituation in psychophysics where repeated exposure to a stimulus diminishes the magnitude of the evoked response." Glaser (1966) and Frisancho (1981) also state that "Relaxation of expectations can be likened to the notion of habituation in psychophysics, where repeated exposure to a stimulus diminishes the magnitude of the evoked response." 100% satisfaction and Indoor environmental comfort happens through appropriate adaptation of an individual's senses and physical state to the indoor climatic environment. There is no general adaptation of all humans as it completely depends on an organism's behavioural, physiological and psychological response to repeated environmental simulation (Clark and Edholm 1985).

- ✓ *Sociological Aspects*

Sociological Aspects of a human being area a mere combination if various factors affecting an individual's personality and lifestyle including family, neighbourhood, political issues, stress, pressure, exposure to disasters, work and home environment, influence by friends, religion and thoughts and beliefs and many others. An individual faces this on an everyday basis which creates some impact over their health, perception as well as productivity. Krieger et al (2002) found that few tenants did not complain about their indoor environmental quality due to the fear of the landlords and the fear of losing their homes in a competitive housing market in Seattle. An experiment by Lan and Lian (2009) showed that temperature difference had played a role on tension and anger emotions which lead to disturbance of mood and affected productivity levels, thus proving that any symptom of stress and discomfort can lower the health, comfort and productivity of an individual.

- ✓ *Economical Aspects*

Lower incomes, financial debts, and large family dependence can add a huge amount of stress and load over an individual. This tension can lead to a variation in the perception of an Indoor Environment and also lower the health and comfort of an individual in a set indoor environ. Poor countries like India and Africa, have also found to be having large populations suffering from diseases due to bad quality housings and inadequacy of clean and clear water and air.

2.3.1 Factors affecting physiological and psychological comfort:

- ✓ *Demographic Nature of Inhabitants (Age, Gender and Origin)*

Indoor Environmental comfort is affected by a number of variables such as age, gender, origin, the rate of metabolism of an individual, activity levels as well as food and health. Due to the fact that none of these factors are the exact same for all inhabitants, different individuals will have different expectance of levels of indoor comfort. Wyon et al (1972) states that although the comfort preferences of different genders does not vary widely, some differences may occur due to the fact that women are more sensitive to temperature differences than men. Also different age group of people and various differences in the type of built of inhabitants have different sweat secretion rate's and eventually prefer different thermal conditions indoors (Frisancho 1981). Skin color is one of the other factors which is basically obtained by the origin of a person and decides their skin color due to the temperature difference. When an individual is exposed to solar radiation, the darker skin absorbs more heat thus causing the individual to have a high skin and ambient body temperature (Ji 2006).

- ✓ *Behavioural adaptation*

Behavioural adaptation is the conscious or unconscious acceptance of comfort of an individual in a given indoor environment. It is actually dependent in the thermal resistance of clothing, metabolic rate, air velocity as well as the activity levels of individuals (Ji 2006). Fanger (1970) conducted a survey to examine the effect of clothing

on comfort levels and found behavioural differences in individuals as well as differences in expectations on thermal comfort levels. Clothing insulation is normally determined of its *clo* value. The clo value is a mathematical illustration of a combination of clothing's thermal resistance. 1 clo = 0.88 ft2_hr_°F/Btu. Nicol and Raja (1996) found that clothing changes were made more in relation to the outdoor temperatures than indoors which caused disappointment in the indoor thermal comfort levels. Research by Benton and Brager (1994), found maximum thermal comfort was achieved when necessary clothing adjustments had been done by individuals. Thus it proves the maximum dependence of comfort on behavioural adjustments rather than habituation.

- ✓ *Physical and Mental Health Levels*

Metabolic rate is an important factor in determining the expectation of thermal comfort. The rate at which the body loses heat is the metabolic rate which is also dependent on the activity level as well as the physical fitness and health of an individual (Dear and Brager 1998). In general an extremely active person generates up to six times more heat than a laid back person. The mental states of a person such as depression, anger, aggression as well as hormonal changes can stimuli the effect of perception of comfort levels be it thermally, acoustically, visually or physiologically.

- ✓ *Sociological Factors*

There are various sociological factors that can widely affect human behaviour which in turn can affect the way people perceive the indoor environmental comfort, such as Religion, Ethnicity, Family, Economic Status, Education, Locality, Life Partner and Children, and Political Systems (Wohlwill 1975).

2.3.2 Performance and Productivity

Physiological and psychological discomfort due to mental or physical factors can cause variations in the internal body temperature and cause thermal discomfort, leading to sweaty, irritable conditions and eventually causing psychological stress (Fanger 1982). All of these cause lower rates of performance and productivity. Research states that the

feeling of discomfort is based on the network of appropriate functioning of the sense organs such as the eyes (visual comfort), ears (acoustic comfort), nose (odour), tactile sensors(mental and physical well-being), heat sensors (thermal comfort), and brain. Environmental conditions play a major role in affecting the productivity of individuals in an indoor setting. Only when an individual is comfortable physiologically and psychologically the mind gets alert hence the body then functions at highest efficiency.

2.3.3 Attendance Rates

Due to the reduction in the ability to perform mental and physical task in an indoor environment, the rates of absenteeism at offices, schools as well as other organizational environments have increased and been associated with physiological and psychological discomfort faced by various individuals (Muddari 2010).

2.4 Energy Consumption, Green buildings & Ratings

Due to an excessive heat gain environment such as Dubai, it is quite a necessity to be having large energy requirements to provide cooling facilities and comfort in indoor environments. According to survey in the past 5 years, glass has become one of the main elements for glazing on building façade's to protect from over glazing and excessive solar heat gain in indoor environments. Inadequate response to indoor environmental comfort has caused in huge rates if energy consumptions as well as lower levels of performance and productivity causing negative health effects. A green building generally includes a few indicators for sustainable building design such as: use of renewable energy, minimal use of fossil fuels in embodied energy of the materials, construction and transport of the building, reuse and recycle of materials, reduction of CO2 emissions and prevention of Indoor air pollution. The other advantages of green buildings include adequate day lighting, Indoors free from VOC's and Sick Building Syndrome's, lower energy and water consumptions, long Life cycle, as well as low absenteeism and high productivity levels (Alnaser 2008). In countries like UAE, where there is enormous heat, the populace spends 90% of their time indoors, due to which there is a high necessity to provide green, sustainable buildings with healthier and energy efficient indoor environments reducing the operational costs by a large number (Alnaser 2008).

2.5 Knowledge Gap

All the research accomplished on Indoor Environmental Quality shows us that good Indoor environments are a combination of not only healthy, hygienic and well-designed homes and offices but also a psychological and physiological state of mental and physical satisfaction with one's indoor environment. Ample research has been done on factors affecting Indoor environments such as IAQ, Thermal comfort, Visual comfort and Acoustic comfort, their causes and effects, but very little research has been conducted over the demographic factors (which are a major cause to the limits of acceptability to indoor environs) that can cause a variation in the perception of Health, Comfort & Productivity in Homes and Offices in the U.A.E especially where construction and traffic are at their peaks causing more pollution and damage to human health, well-being and comfort. Demographic factors can play a major role over the perception of an Indoor environment as physiological and psychological states can have a major impact over the perception of indoor environments in homes and offices. For Example a 20 year old female and a 75 year old male can perceive one set indoor environment differently, accounting to their age, medical history as well as gender. This needs to be understood by surveying various genders, age types as well as origins and understanding how demographics can affect the acceptability and comfort levels in homes and offices. Literature review has not shown us any such type of study in the United Arab Emirates where majority of the residents spend most of their time indoors.

2.6 Research Question

- ✓ How does the IEQ in U.A.E. (mainly in the region of Dubai) affect building occupants' perception to health, comfort and productivity?
- ✓ How do Demographics (Gender, Age and Ethnicity/Origin) of an Individual impact the perception on Indoor Environmental conditions in the U.A.E?
- ✓ Is there a degree of difference in the Indoor Environmental conditions in Residential and Office buildings?

- ✓ What is the responsible for the cause of ill-health implications for UAE residents, weather it is the indoor environmental conditions **OR** the nature of occupation **OR** the current level of wellbeing conditions of individuals?

2.7 Objectives

After understanding the various physical causes to poor Indoor environments, it is incredibly important for sustainability development to focus over the Health, Comfort and productivity of individuals by firstly understanding the causes of human perception over the Indoor living and working conditions.

- ✓ To examine the building occupants perception of indoor environments over health, comfort and productivity in Dubai.
- ✓ To examine the perception of the UAE resident's residential and working indoor environmental conditions and their impacts on health, comfort and levels of efficiency by means of subjective analysis (survey study).
- ✓ To examine the impact of gender and ethnicity over the perception of the Indoor Environmental Quality of UAE residents.
- ✓ To eventually examine the cause of ill-health implications for UAE residents, weather it is the indoor environmental conditions **OR** the nature of occupation **OR** the current level of wellbeing conditions of individuals that are responsible.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This research has reviewed papers approaching all the various methods and philosophies; and the purpose of literature review was finally being able to reach a point to be able to select and rationalize the most accurate and compliant method and process, in order to absolute our research and analysis of indoor environmental quality in Dubai. Life cycle assessment of a few homes and offices is also studied for knowledge expansion in previous researches. Various researchers and specialists who have conducted various studies in this topic were distilled, including their findings and guided methods and tools for further analysis and research. The ultimate goal was to conclude and tie up the paramount method/methods in this particular research to bring about better results and answers to the reasons of bad/good indoor environmental quality in offices as well homes in different areas in the region of Dubai. Literature review has been conducted in order to review the factors necessary to be explored. More than a hundred papers have been carefully examined in regards to Indoor Environmental Quality. There are various methods used in the massive amount of papers assessed in the literature review section of the study. The main methods that have been used in order to evaluate an indoor environmental quality are:

- ✓ Experimental
- ✓ Computer Simulation
- ✓ Literature review/ Research study and Observational
- ✓ Subjective and Perceptive Evaluation (Survey)

This Research focuses on the observation of the inhabitants of U.A.E, mainly Dubai on how they perceive the indoor environmental quality at homes and offices. The main aim of this review is to examine the efficiency of Indoor environments in terms of comfortable healthy living and working conditions, along with IAQ, thermal, acoustic, visual and physiological Indoor environmental comfort. This research will focus on how effective indoor designs have been in Dubai. It has become a necessity to investigate the performance of commercial and residential buildings in the UAE to establish the users' perception of indoor environmental factors as well as satisfaction levels.

This paper aims at doing exactly that by focusing on a survey which has questions relating to the occupants' perception overall in regards to their demographics and building type (Residential or Commercial). Measurements will most likely provide insights into the thermal comfort but the performance is mainly described from the user's point of view in order for it to be sustainable for long term. The methodology of this study is consequential to careful scrutinization of various research papers on Indoor Environmental Quality throughout the world and in the U.A.E. This research is a sequence of Literature review followed by Subjective Evaluation and Analysis of the perception of indoor environments by a number of occupants living and working in Dubai.

3.2 Dubai : Location, Current Climate, Predicted Climate and Energy Profile

Dubai is located between 22.0° and 26.5° N and between 51° and 56.5° E (UNFCCC, 2006) and has a rough area of 4,114 square kilometres. It is a Middle Eastern country located in the Arabian Peninsula with extremely hot and humid desserts and consists of two seasons. Summers are usually high temperatures from May to September rising up to 49°C and more in the vast deserts and June, July are considered the hottest months of the year. Winters are moderately cooler from December to March going up to 6°C and December and January are the coolest months of the year. The humidity levels can be anywhere from 45% to 65% in the coastal areas. The wind speeds are an average of around 6km/hr. at the earth levels above 2meters (UAE MOEW, 2010).This survey had been conducted mostly in the months of April –June (Summer Season).

Due to the rapid urbanization, U.A.E is one of the leading countries in terms of growth and Urban and economic development. Dubai is one of the world's leading construction industries with majority of new projects being planned since early 1990's. It resides a population of around 4,975,000 with an average of 40,200 dollars GDP per capita (CIA, 2011). All of this has had an adverse effect on the increased emission of greenhouse gases, atmospheric pollution as well as changes in climatic conditions on the ecosystems. It has also led to indoor environmental pollution unhealthy and unsustainable indoor systems and large energy requirements. The hasty advancement

has caused the construction of low cost and high profit gaining buildings in order to achieve more by giving less, which has in turn lowered the comfort levels of buildings and increases energy consumptions. Hence arises, the need to evaluate the subjective perception of the inhabitants living and working indoor environments.

3.3 Selection and Justification of Method Chosen

The main aim of this survey methodology is to present the level of user satisfaction and the results acquired for the degradation degree of each epitome glitch as well as the level of performance of each building type in regards to the functionality and demography. This study documents and considers various aspects to the performance and productivity of the building environment keeping the users and occupants viewpoints as the most important study. Sustainability is not only resource conservation but also an increase in the productivity and occupant well-being in an indoor environment. This study hopes to provide exceptional insight for the Design and Construction fields to design as per performance and requirements and not as per design and cost only.

After understanding the main criteria and objectives of this research, Survey Method has been selected to achieve its aims and results. The choice was made by comparing previous literature review of studies done and hence by determining the importance of the perception of an Indoor Environment by the Occupants Solely. Very little research has been conducted in Dubai in terms of Subjective evaluation of Indoor Environments. Survey method used here is not an automated response done over the internet, but a personal visit was headed for many homes and offices has been done in this research in order to get clearer results of the perception of indoor areas by their occupants at that given point in time. Surveys could have been done over the internet, but the results could have varied there due the fact that occupants of office and home environments may or may not have been present in the given environments at that point in time and could have filled in the surveys being either in other set of environments or even by being abroad. The immediate perception of the questions given in the survey would have varied due to various circumstances. Hence it was made sure that surveys were personally handed to the occupants to get higher efficiency and accuracy of results.

Very few small scale surveys have been done in Dubai to analyse the Indoor Environmental Quality. Hence the decision of a wide scale survey method for commercial and residential environments in Dubai was made. Analysis and Results are discussed in the following chapter. The survey is an essential mode to evaluate current Interior design and construction practices in the U.A.E. It talks directly about the current experiences of inhabitants; of their indoor environments as well their challenges faced in their daily comfort and work zones.

Subjective measurements yields have proven statistics and accurate data to the subjective measurements and hence such evaluations are widely used in qualitative as well as quantitative analysis of a matter. This fulfils the needs of clear identification of various parameters in reference to the research objectives. Easy and clear interpretations as well as comparisons can also be made after getting the results.

Over all, this research provides significant impact in order to make change in terms of building construction and interior selection and design. It gives lessons and feedbacks to owners, designers, contractors as well as architects in order for future improvement in terms of sustainability and suitability. It will lead to better quality of living and working in indoor environments and also will address to the varying needs of occupants, by providing opportunities for development of varied stages in the field of design and construction. The questionnaire designed could be used for many more future studies as well as act as a useful management tool for commissioning of targeted sustainable construction in the U.A.E

3.4 Framework of Research and Preliminary Work

Initial Research was aimed at the literature review which was conducted for the review of the study on the Indoor Environmental Quality throughout various parts of the world. It was focused on various types of methodologies such as simulation, interviews, observational, mathematical calculations and surveys. Previous research papers have examined the issue of indoor comfort by focusing on the measurements of thermal comfort only. This meant lower satisfaction levels to the visual, acoustic, psychological and physiological aspects of an indoor environment. Some papers analysed factors

influencing the comfort of an indoor setting. There has been very less research done for the subjective evaluation of IEQ. No review has been carried out on how the occupants have perceived their indoor environments in the U.A.E. The current literature review and survey was executed in order to congregate more information on this topic

This dissertation is focused on the Indoor Environment of Living (Residential) and Working (Commercial) conditions of people in Dubai (U.A.E), as majority of time spent by the people here is Indoors. Hence our paper focuses on the subjective evaluation (Survey) of the perception of indoor environments by the people and for the people. The commercial and residential buildings that were surveyed within Dubai had covered major areas of the city such as Deira, Sheikh Zayed Road, Jumeirah, Al-Qusais as well as Jebel Ali.

3.4.1 Subjective Study (Occupancy Survey) : The Questionnaire

This research is based on the assessment of occupants reviews of internal environments based on their responses to the Questionnaire relating to a wide range of distinct factors. The survey consists of demographic information of the participants, their current environmental conditions, health complaints as well as their overall levels of satisfaction in their respective office and home environments. The questionnaire aims to gain responses to each of these in terms of “user satisfaction” and “Degree of health complaints”. It also checked with existing indoor environmental pollution, type of building, number of occupants as well as other obtainable mental and physical complaints. Survey questions also aimed at assessing the IAQ and thermal comfort of indoor environments. Some of the questions were adapted from the ‘ASHRAE 55-2004’ and ‘Base Indoor Environmental Quality Survey’ by EPA. Few were modified according to the requirement of the aims and objectives of this research paper and to gain further knowledge and to be able to answer the research questions.

The questionnaire was of two types: Residential and commercial, each being two pages. Each type consisted of three sections. Although the residential and commercial surveys were similar in nature yet they focused separately on the different living and working indoor comfort and health conditions. In order to ease the questionnaire levels, most of

the questions were provided with choices. The three sections comprised of: demographics of the users (e.g.: age, gender, nationality), current environmental conditions (e.g.: type of building, no. of occupants, type of air conditioning, lighting etc.), their health complaints (e.g.: lethargy, headaches, sinus, allergies etc.) and the levels of satisfaction (in terms of IAQ, Noise, lighting and Thermal comfort) of the indoor environment. Refer to Appendix A & B for the survey samples.

This combination of intense literature review and survey techniques helped to review the physical and personal variables such as IAQ, thermal, acoustic, lighting, activity and clothing levels. The basic principle methodology for the survey was to directly get them done at the given indoor environment; be it residential or commercial in order to attain a higher level of accuracy to results. From this perspective, there can be an established connection of indoor environments to the demographics, health, physiological and psychological conditions of the occupants in order to translate them later into proposals which can generate enhanced designs of comfortable indoor environments in Dubai. This subjective data has been collected in the months of April, May and June 2012 in Dubai.

3.4.2 Offices and Homes; Date collection, Expected Outcomes & Sample Characterization

The sampling process is usually divided into five stages according to Diamantopoulos and Schlegelmilch (2002). It firstly aims at determining the sample population, sampling frame, Method of Sampling, the sample size and eventually the sample selection. The desire to extract genuine responses and the need to minimize the time of the survey to avoid withdrawal of the respondent confined the scope of the study to short surveys and manual distributions.

This survey study includes the following:

- ✓ *Sample size (Population)*

A sample size of 1000 people has been decided by the supervisor and I in order to get a wider picture and a greater perception of multiple occupants and their reviews. This size was decided in order to gain the perception of a wide number of users, male and females, from various backgrounds and cultures who are residing in the UAE. It aims to understand how various age groups and originalities perceive the Indoor Environments at homes and offices within Dubai as a region of U.A.E. 500 surveys had been done in office environments and 500 in residential buildings. This was decided due to limited amount of time and resources available.

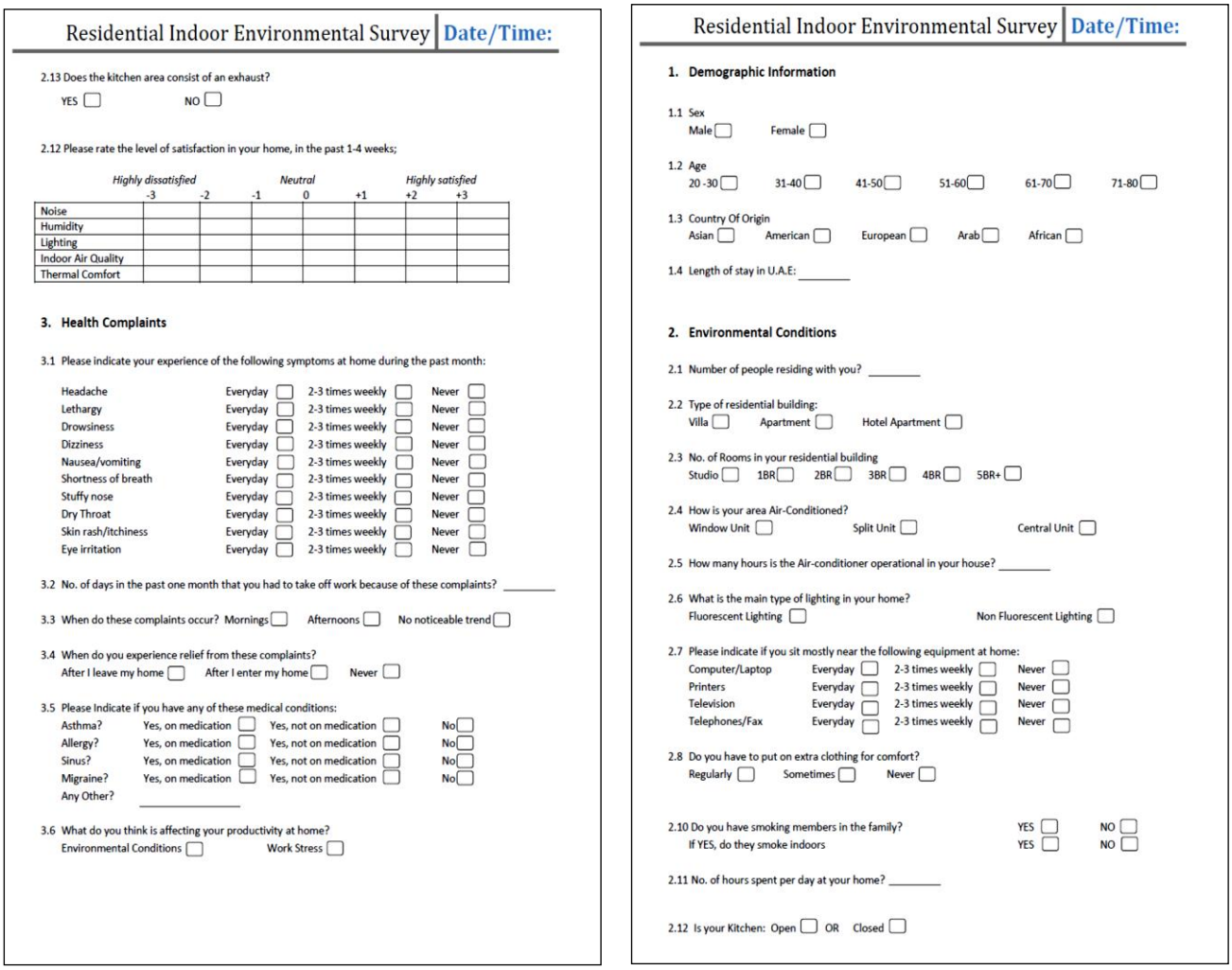
- ✓ *Survey response rate*

A high response rate is a very important observation and it is not just an important necessity of a survey but also is important for the measure which determines a high quality survey (Hox and DeLeeuw 1994). A high response rate echoes a non-biased analysis. Due to the lower response rate via email and internet based survey; a self-hand set survey had been conducted to achieve a higher response rate. Few other discussions had been studied to achieve this too. The overall aim was, to surge response rate, which in turn, reduces probable non-response bias.

- ✓ *Sample Frame*

The frame of the sample was divided in three major sections: Demographic Information, Environmental Conditions and Health Complaints. These three sections included almost all the reasons and causes for an Indoor environment to be as it was. It could be due to the user's age, gender, culture, or their current health conditions or even the indoor environmental design and completion. It was a must to include these sections in order to dig into the root cause of bad indoor environmental quality. Demographic questions were asked to understand the current socio-cultural, age and gender of the occupants and to check whether it had an impact on their perception of Indoor Environments.

Environmental conditions section contained questions regarding current state of living and working conditions such as number of occupants, number of rooms, type of building, ventilation, usage of electronics and telecommunications as well as levels of satisfaction in terms of lighting, acoustics, IAQ and thermal comfort. Health Condition section checked the current health levels of individuals and whether that was the reason to perceiving lower efficiency of Indoor environments. All three sections are as shown in Figure 3.1.



Residential Indoor Environmental Survey | Date/Time:

2.13 Does the kitchen area consist of an exhaust?

YES ☐ NO ☐

2.12 Please rate the level of satisfaction in your home, in the past 1-4 weeks;

	Highly dissatisfied -3	-2	-1	*Neutral* 0	+1	*Highly satisfied* +2	+3
Noise							
Humidity							
Lighting							
Indoor Air Quality							
Thermal Comfort							

3. Health Complaints

3.1 Please indicate your experience of the following symptoms at home during the past month:

Headache	Everyday ☐	2-3 times weekly ☐	Never ☐
Lethargy	Everyday ☐	2-3 times weekly ☐	Never ☐
Drowsiness	Everyday ☐	2-3 times weekly ☐	Never ☐
Dizziness	Everyday ☐	2-3 times weekly ☐	Never ☐
Nausea/vomiting	Everyday ☐	2-3 times weekly ☐	Never ☐
Shortness of breath	Everyday ☐	2-3 times weekly ☐	Never ☐
Stuffy nose	Everyday ☐	2-3 times weekly ☐	Never ☐
Dry Throat	Everyday ☐	2-3 times weekly ☐	Never ☐
Skin rash/itchiness	Everyday ☐	2-3 times weekly ☐	Never ☐
Eye irritation	Everyday ☐	2-3 times weekly ☐	Never ☐

3.2 No. of days in the past one month that you had to take off work because of these complaints? _____

3.3 When do these complaints occur? Mornings ☐ Afternoons ☐ No noticeable trend ☐

3.4 When do you experience relief from these complaints?
After I leave my home ☐ After I enter my home ☐ Never ☐

3.5 Please Indicate if you have any of these medical conditions:

Asthma?	Yes, on medication ☐	Yes, not on medication ☐	No ☐
Allergy?	Yes, on medication ☐	Yes, not on medication ☐	No ☐
Sinus?	Yes, on medication ☐	Yes, not on medication ☐	No ☐
Migraine?	Yes, on medication ☐	Yes, not on medication ☐	No ☐

Any Other? _____

3.6 What do you think is affecting your productivity at home?
Environmental Conditions ☐ Work Stress ☐

Residential Indoor Environmental Survey | Date/Time:

1. Demographic Information

1.1 Sex
Male ☐ Female ☐

1.2 Age
20 -30 ☐ 31-40 ☐ 41-50 ☐ 51-60 ☐ 61-70 ☐ 71-80 ☐

1.3 Country Of Origin
Asian ☐ American ☐ European ☐ Arab ☐ African ☐

1.4 Length of stay in U.A.E: _____

2. Environmental Conditions

2.1 Number of people residing with you? _____

2.2 Type of residential building:
Villa ☐ Apartment ☐ Hotel Apartment ☐

2.3 No. of Rooms in your residential building
Studio ☐ 1BR ☐ 2BR ☐ 3BR ☐ 4BR ☐ 5BR+ ☐

2.4 How is your area Air-Conditioned?
Window Unit ☐ Split Unit ☐ Central Unit ☐

2.5 How many hours is the Air-conditioner operational in your house? _____

2.6 What is the main type of lighting in your home?
Fluorescent Lighting ☐ Non Fluorescent Lighting ☐

2.7 Please indicate if you sit mostly near the following equipment at home:

Computer/Laptop	Everyday ☐	2-3 times weekly ☐	Never ☐
Printers	Everyday ☐	2-3 times weekly ☐	Never ☐
Television	Everyday ☐	2-3 times weekly ☐	Never ☐
Telephones/Fax	Everyday ☐	2-3 times weekly ☐	Never ☐

2.8 Do you have to put on extra clothing for comfort?
Regularly ☐ Sometimes ☐ Never ☐

2.10 Do you have smoking members in the family? YES ☐ NO ☐
If YES, do they smoke indoors YES ☐ NO ☐

2.11 No. of hours spent per day at your home? _____

2.12 Is your Kitchen: Open ☐ OR Closed ☐

Figure 3.1: Two paged Residential Indoor Environmental Survey

- ✓ *Survey Format*

The survey contains easy and straightforward questions which are mainly either multiple choice or one word answers. It also includes multiple choice answers to easy the level of answering. It tries to cover majority of the causes and issues relating to comfortable indoor settings in offices and homes. Refer to Figure 3.1 for the sample of a survey questions.

- ✓ *Sample Selection*

Initial task of sample selection was hard due to the nature of the survey, which was a personal hand held survey and not a computer based online survey. The task took three long months to complete and the survey was done widely in offices in sheikh Zayed road and Deira. Various kinds of office buildings were visited and averages of eight to ten surveys were collected from each office type. A minimum of four offices were surveyed from a building. A long and extensive survey was done similarly for residential buildings by surveying a large number of family and friends in the neighbourhood (Jumeirah) firstly and then from a number of other residential areas such as Deira, Sheikh Zayed, Jebel Ali etc..

- ✓ *Study Area and Distribution*

The study area was Dubai in general and distribution of the survey was done self as well as by attaining a little help from fellow friends, family and colleagues. Most types of buildings such as apartments, villas, hotels, and hostels had been covered, majority of which were rented and not privatized. The survey questionnaires were handed to all possible occupants in homes and offices, regardless of age, gender, nationality and behaviour or work type. Expected outcomes of the survey were analysed to understand the current practice in building systems designed for indoor environments in offices and homes as well as to understand the factors that influence the comfort and productivity of occupants. An extensive survey of 1200 participants had been conducted 200 out of which either did not respond back or inaccurately answered the majority of the survey. The response rate was higher due to the fact that the survey was handed in personally

at homes and offices and a day's time was given to them to answer and return the 23 question short survey of 2 pages.

- ✓ *Sample Characterization in Residential Environments*

The ratio of the Male/Female in terms of the respondents was found to be 51% to 49% as shown in Figure 3.2. 64.6% of respondents were found to be within the age group of 20-40, 28.19% belonged to the age group of 40-60 and a minimalist 7.19% belonged to the age group of 60 and above. Figure 3.3 describes the percentage of respondents in terms of Age in a graphic representation. A whopping 53.4% of respondents were Asian, 8.2% American, 13% European, 20.59% Arabs and 4.8% Africans in Origin (Refer Figure 3.4).

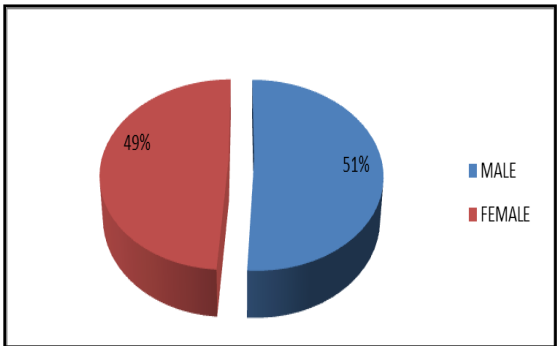


Figure 3.2: Male/Female Response Ratio in Residential Indoor Environments

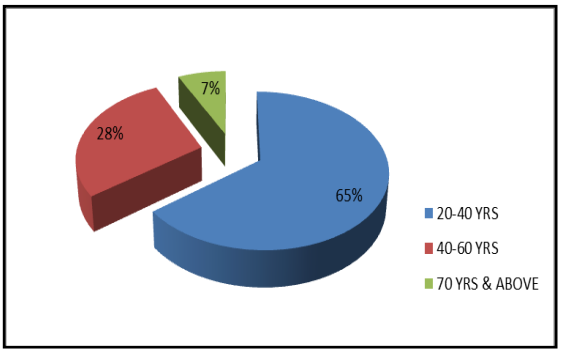


Figure 3.3: Age Response Ratio in Residential Indoor Environments

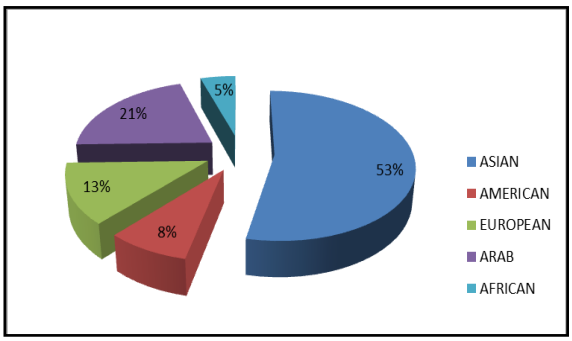


Figure 3.4: Origin Response Ratio in Residential Indoor Environments

✓ *Sample Characterization in Commercial Environments*

Below are the Figures 3.5, 3.6 and 3.7 displaying the demographic percentage of respondent's rates in terms of Gender, Age Group and Origin. The ratio of respondents in terms of male and female genders in commercial environments was observed to be 54% and 46% respectively (Refer Figure3.5). 67% belonged to the age group of 20-40 years, 32.2% belonged in the age group of 40-60 years and a minimalistic 0.8% belonged to the age group of 70 years and above (Refer Figure 3.6). In terms of origin 37.4% of the respondents were found to be Asian origin, 24.2% American, 14% European, 15.4% Arabs and 10% African origins (Refer Figure 3.7).

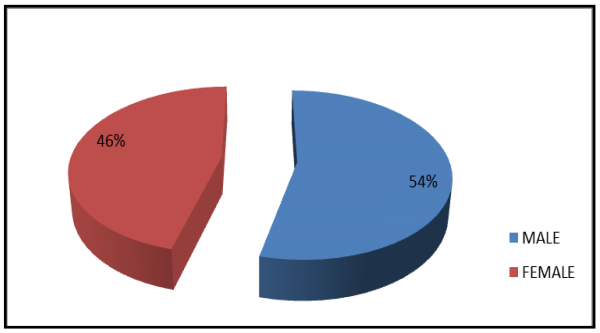


Figure 3.5: Male/Female Response Ratio in Commercial Indoor Environments

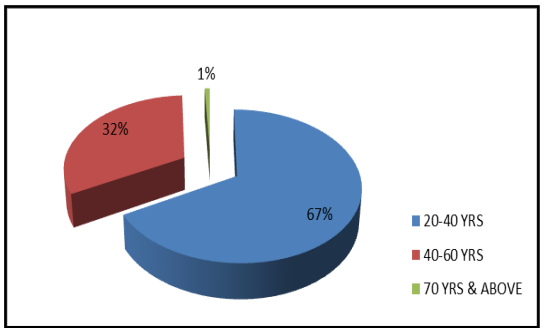


Figure 3.6: Age Response Ratio in Commercial Indoor Environments

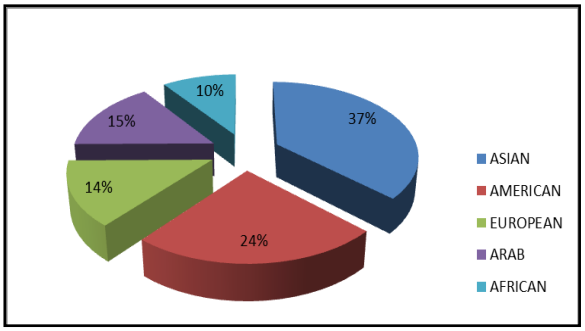


Figure 3.7: Origin Response Ratio in Commercial Indoor Environments

3.5 The Data Analysis Method: Collection, Coding, Entry and Analyzing

Collection: A questionnaire with 23 questions and 2 pages was sent out in various different ways. Firstly the commercial surveys were sent across various offices in different areas of Dubai. It was distributed amongst friends, relatives, classmates, co-workers and many random office buildings throughout the region. Collection of the done surveys was done immediately the same day or next throughout various office buildings, whereas some sent to friends and relatives were collected within a maximum of 7 days. The questionnaire survey was carried out between April and June 2012 and the response rate of the survey was 90%.

Coding and Entry: All the surveys once collected – were separated into sections being residential and commercial. Questions were coded on the rows as numbered in the questionnaire and replies were noted on as numbers to an excel sheet, for e.g. multiple choice answers were termed as 1, 2, 3... And so on to code them into a number. Whenever an opinion or reply to a question was unanswered, the coding on excel would be left blank and no number was noted for that. The chief task of coding and entry of the data on a Microsoft excel sheet was then followed by the analysis of the comparisons of groups to the perception of interior environmental quality. Out of the 23 questions, only the main questions required for the research were calculated in terms of Average, Mean and standard deviation.

Analysis: was done using T-test and Anova directly using online created formulas, by inputting the data for each group and comparisons. T-test had been used to compare 2 groups whereas more than 2 groups were compared using Anova. Mean standard deviation and count (sample size) had been needed and calculated on Excel and then henceforth used to compare results via T-test and Anova.

Comparisons of groups of Residential and Commercial, Male and Female, Various Age groups as well as Various Origins of occupants were used as a basis of comparison for the variation in the perception of comfort levels at homes and offices. The analysis was carried out using two statistical software's online. The results were considered statistically significant when the p value was < 0.05 and statistically insignificant when

the p value was > 0.05. Statistical Significance meant that it was the reason or cause for the variation for a particular question and vice versa for statistically insignificant values.

3.6 Limitation of The study (Key Challenges: problems encountered during the research and Survey)

After signifying the main aim and determining the objectives, survey method was chosen to achieve the aim. Moreover very less survey was performed in Dubai in regards to indoor environmental quality. Although the method was best approved it had its limitations like any other method. The following are the limitations noted in this type of methodology in the region of Dubai.

- ✓ Non responsive behaviour of the populace; Low ranging of Respondents' motivation, honesty, memory, and ability to respond; Unwillingness of respondents to provide information. Some of the respondents were very unwilling to fill in the survey and pressurizing led to lower levels of motivation and honesty in terms of filling in the survey. Many inhabitants were inconsiderate and did not accept to fill in the surveys.
- ✓ Few respondents felt that the Level of Importance to answering the survey was low and non-useful due to the fact that it was a student survey and not a research company or government organization based. Some of the lowest response was mainly by employers and employees of commercial offices due to their limitations of time.
- ✓ Due to the extensive use of computers and technologies, paper-based questionnaires are found harder to fill. Few of the inhabitants were resistant to paper-based survey and suggested using internet based surveys, without knowing the actual reason to the selection of paper based surveys to internet based surveys.
- ✓ Limited selection of options to the answers of the questionnaire: Few of the respondents complained of limited selection in some questions as their option varied to the ones given in the survey. Few of the questions were also answered as Don't Know or even left blank, reason probably being the level of understanding or the ability to respond. Some of the respondents even selected

more than one answer per question, which makes it difficult for coding and analysis.

- ✓ Survey question answer-choices can many a time be a tricky method as it could mislead the respondent to vague data sets as they are comparative simply to a personal theoretical notion about "strength of choice". For example, the choice “Highly Dissatisfied” or “Highly Satisfied” can have different effects to different subjects to various different interpreters. Some of the respondents also had problems in selecting multiple choices as they felt their choices were not mentioned. For e.g. when the question “Please indicate your experience of the following symptoms at home during the past month” was asked, the choices were limited to: Everyday, 2-3times weekly and Never. Few of the respondents answered in the blank spaces as: once a month or once a week etc..
- ✓ Some of the respondents had an inadequate understanding of the subject and few also had the Inability to provide information. This may possibly be due to the following reasons: Lack of knowledge, Lack of time, Lapse of remembrance Or Inability to identify their motives.
- ✓ Sampling error is the other limitation to survey methodology as the sampling error decreases with every increase in sample size. This makes the entry and coding more tedious and time consuming. It is subject to great errors due to the large sample size and various different sample types. However the assumptions of unchanging variations are a percentage given in larger samples.
- ✓ Limitations in terms of resources such time and money. The large sample size needed to be covered individually due to the limitations of money and thus became time consuming taking more time than normal to survey a 1000 inhabitants.

3.7 Overcoming the Limitations in the Survey Methodology

In order to overcome the limitations in Survey methodology, cautious framing and choice of words for questions has been done and explanations to occupants were given when confusion rose. Careful organization of data gathering and coding has also been prepared in order to avoid errors. A time consuming and cautious interpretations of unclear, shattered answers or opinions has also been performed in order to reduce the percentage of inaccuracy. The survey has been created after great thinking and evaluation, and questions have been carefully explained to individuals who are unclear in terms of understanding while the conduction of the Survey.

CHAPTER 4

RESULTS & DISCUSSIONS

4.1 Introduction

This chapter gazes at the results of the Survey and also what is analysed out of them. Up until now we have understood that there are a many reasons to the perception of building performance and productivity. Now we will try to understand the causes to the difference in perceptions by various individuals through survey results. Many results will vary from previous assumptions and a new outlook has to be established towards the Indoor Environmental Quality in Dubai. Due to the climatic conditions where majority of the months are summer, it is important in establishing the current Indoor conditions and coming up with valid evaluations to why and what the reasons for it being so are. Percentages of evaluations have been calculated through Microsoft excel in order to understand the perception of majority of the respondents. P-values are calculated to understand the significance levels of a few important issues with respect to the demographics. Figures and graphs are represented to give a clearer understanding of the many aspects of the survey. A combination of results and discussion to reasons and solutions will be enunciated upon.

A framework had to be developed in order to complete the analysis of the surveys received and studied. The commercial and residential surveys had been studied and analysed differently and compared at the end to verify the similarities and difference found in both the types of indoor environments. Figure 4.1 describes the process of analysis in a flow chart form to understand the process of analysis adapted in this study. Both residential and commercial surveys had been evaluated mainly by its demographics in order to check whether an individual's gender, age or origin could play a role in determining comfort and health in an indoor environ. A use of qualitative and quantitative methods has been adapted for selected questions in the survey where mainly the health, comfort and productivity are studied in context with an individual's demographics, using T-test and ANOVA through calculations of Average, Mean, Count and P-values and hence by analyzing the cause of good/bad indoor environments in homes and offices.

T-test: It is the statistical hypothesis experiment where the distribution pattern is tested and calculated where null hypothesis is held upon. It determines the statistical difference pattern between one or two groups (Wikipedia 2013).

ANOVA: It is the also known as the analysis of variance and is the statistical test for more than two groups of studies by the calculated mean, average and count of the groups with lesser error (Wikipedia 2013).

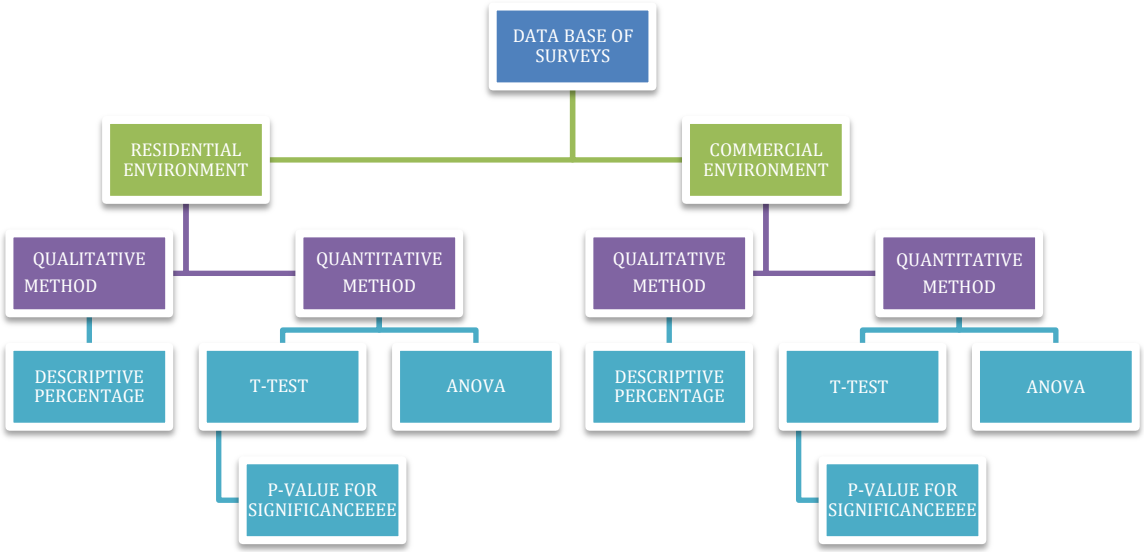


Figure 4.1: Analysis

4.2 Results

4.2.1 Residential Survey

Sample screening began in April 2012 and was completed by June 2012. A 90% response rate was observed which were the eligible surveys conducted. A wide number of households were covered in order to include the various types of residential environments. In a total of 1200 surveys for residential and commercial, a 1000 were collected, 500 being residential and 500 being commercial. Researchers have advocated that "surveys are good for generating quantitative data and enabling a statistical analysis of subgroups". In this survey the data was carefully weighed and scrutinized to avoid biased assessments. When each unit in the population has precisely the same

possibility of inclusion in a sample it is known as a self-weighting design. It was necessary to weigh the data in order to create impartial population estimations (Lee et al., 1996). Hence all the proportions, means, standard deviations, counts and ratios calculated from the sample would be unbiased whether the weights were used or not eventually.

Questionnaire Design: The Survey was divided into three sections, where the first section includes the demographics of the respondents and the other two sections included added information such as the perception of current Indoor environmental conditions as well as health complaints of residents. It was important to understand the current living conditions and health of the residents in order to evaluate the causes of their perceptions for the indoor environments.

- ✓ *The demographics section*

The demographics have been used in order to understand their influence on levels of indoor environment satisfaction and health complaints. The survey also consisted of questions that Inquired about the respondents Length of Stay in the U.A.E, which was not included in this analysis. It was found that Gender is almost equally distributed in residential environments, but residential development has to be mainly catered towards the age group of 20-40% as they were found to be the majority of respondents. Asian and Arabic nationalities are also found to be the majority and hence, construction development of housing should look into catering to the needs of these various race of people rather than focusing on a single type of construction system and try and understand the difference in the needs of different age groups and nationalities.

- ✓ *The Environmental Conditions Sections*

This section inquired about the number of people residing together in a given residential environment. Although this wasn't analysed much it helped in understanding the quality of living according to the availability of space (i.e. the number of bedrooms) and the number of people living together. It also aimed to check the type of residential building occupants lived in. 28.4% of the respondents lived in Villa's, 70% which was the majority

lived in building apartments and a minimal 1.6% was found to be living in hostels or hotel apartments. This suggests to us that it is increasingly important to focus on the construction and design of apartment buildings and cater to the needs of various types of individuals. The number of bedrooms in residences of the occupants was asked for as well. In respect to the type of Air-conditioning system, a shocking 16.2% still used window units, 51.4% used Split Units and the remaining 32.2% had central Air conditioning systems in their residences. This suggests that sustainability is not yet an important criterion in households as occupants still make use of the non-eco-friendly window air-conditioning systems. The survey included the query on the number of hours Air-conditioning systems were on in residences of the respondents and the number of times the electronic equipment's such as Computers/Laptops, Printers, Televisions and/or Telephones and fax have been used in residential environments. The options being either: everyday, 2-3 times a week or Never. On an average most of these equipment were used on an everyday basis which is but natural due to the advancement of technology. The ratio of fluorescent to non- fluorescent lighting used in residential buildings was found to be 57.99%: 41%. A majority of respondents were also found to have put on extra clothing for comfort.

In regards to question about the smoking members in the family and whether or not they smoke indoors. 22.2% of respondents had smoking members out of which 54.05% smoking members smoked indoors. There were a few more questions that were not used for the analysis but aimed at understanding the perception of indoor environments such as Inquiry about the number of hours occupants spent indoors. Checking the type of kitchen whether open or closed plan, Inquiry about the existence of an exhaust in kitchen areas to understand the cause of bad IAQ in homes. These could further be used in a detailed study of different areas in an indoor environment and how their function affects the sustainability and health of residents. Due to limitations of time, this study has focused on the demographics of individuals, and how that affects a person's perception in terms of IEQ.

The main points to be noted here are that majority of the respondents lived in apartment buildings and hence we see building construction at its peak in Dubai. It is thus very necessary to cater to the demands of the occupants than the owners of

residential towers, for a healthier and happier indoor setting. Older non sustainable buildings need to be converted into green and healthy buildings. Smoking should be prohibited not only in most but in all residential and commercial buildings for a healthier indoor environment. Air-conditioning systems should be automated and have intelligent systems to save on excessive use of air conditions and lighting when not required.

- ✓ *The Health Complaints Sections*

The effects of different risk factors on the prevalence of illnesses were investigated. They included Headache, lethargy, drowsiness, dizziness, Nausea, stuffy nose, dry throat, skin irritation and eye irritation are the common illnesses included in this study. Respondents were asked to indicate, on a scale of everyday, 2-3times weekly or never, whether they had experienced the above illnesses. Due to the variations in numbers, 1, 2, and 3 was used for the three choices in order to calculate the count, average, standard deviation and p value in order to determine the level of significance for the determinacy of the perception of health and comfort levels. Microsoft Excel was used to statistically analyse the available figures. The P-value computed by T-test and ANOVA will help to judge whether the results obtained are significantly different from each other or not to judge the cause for poor quality of IEQ.

P value: “p- value is associated with a test statistic. It is "the probability, if the test statistic really were distributed as it would be under the null hypothesis, of observing a test statistic [as extreme as, or more extreme than] the one actually observed” (About 2013). In the results some risk factors showed statistically significant differences (if the P-value was< 0.05) between the comparisons. P –values were mainly calculated to study the relationship between demographics, SBS and perceived IEQ.

The survey also inquired the number of days occupants had to take off work due to the above health complaints and what was time of the day when these complaints had occurred. 40.2 % of respondents complained of ill-health symptoms in the mornings, 5.4% noticed the complaints in the afternoons, 9.8% of the occupants noticed the trend of these complaints to be occurring in the evenings and 44.6% of the respondents perceived no noticeable trend. 33.8% noticed a relief of these symptoms after they left

home, 21% of the respondents noticed the relief after they entered home and 45.2% of respondents did not notice relief of symptoms anywhere. The medical history or existing medical conditions of respondents such as Asthma, Allergy, Sinus, Migraine or any other was surveyed. 10.4% of the respondents suffered Asthma and were on medication, where as 15.4% suffered asthma but were not on medication. 74% of the respondents did not suffer from asthma. 15.2% of the respondents suffered from Allergy and were on medication, 18.8% suffered allergy but were not taking any medication.66.4% of them did not suffer from allergy. 20.8% suffered from Sinus and were on medication, whereas 14.7% suffered from sinus and did not take any medication.64.5% of the respondents did not suffer from sinus. 11% of the respondents suffered from Migraine, 12.8% were suffering and not on medication and the remaining 76.2% did not suffer from Migraine. Inquired whether environmental conditions or work stress was responsible from the productivity of respondents at home.55% blamed the environmental conditions and 45% blamed work stress for the lowered productivity at home.

It is noted here that Majority of the complaints had occurred in the morning, implying that they had formed them over the night at homes. This could be due to the reason of already occurring illnesses of illness occurring after due course of time spent at homes, which could be a result of toxic micro substances living and poor ventilation systems in the indoor environments. The above calculations also prove that the occupants felt a relief from the symptoms after they left home, evidencing the debauched quality of indoor environs. Majority of respondents who were suffering from the symptoms of Asthma, Allergy, Sinus, Migraine and many more were not on medication, implying that these were happening in indoor environments in due course of time without the knowledge or understanding of the causes to the occupants. Majority of the population had no knowledge on building related sickness and toxic volatile substances living indoors due to the size of the micro structures and unseen VOC's present in Indoor environments. Mental and physical stress is a combinational effect to Health Complaints. We understand this due to the studies as well as the variance in the analysis to different origins and age groups, which proves that physiological and psychological causes also result in the difference of the perception of IEQ's.

4.2.1.1 Respondents' Gender versus their opinions in terms of Level of Satisfaction of IEQ and health complaints.

There were two samples based on the gender of the occupant: sample one – male and sample two – female. T-test was done here in order to reveal the rate of significance by calculating the p value was calculated for the questions relating SBS, comfort and health. If the *p value>0.05***,** it meant no significant difference in the two samples, if the *p value<0.05***,** it meant there is a significant difference between the two samples implying that it could be a cause to poor and inefficient IEQ. The P-value of gender had been calculated with respect to all indoor environmental satisfactions as well as health complaints. According to Table 4.1, calculations had shown the following results:

Gender was not found to play an important factor in determining the satisfaction levels of *Noise, Lighting and Indoor Air Quality*, where as it did play a significant role in determining the *Thermal Comforts* in indoor environments. In respect to Health complaints , Gender did not play a significant role in determining Illnesses such as *Headache, Lethargy, Drowsiness, Dizziness, Nausea/vomiting, Shortness of breath, Stuffy Nose, Dry Throat, Skin rash/itchiness, Eye irritation.* The perception of cause for *lowered productivity* at home was affected by gender due to the implications of significantly different samples.

Table 4.1 shows the Average, standard deviation and count of the total number of males and female respondents in respect to the above mentioned parameters. The count represents the total number of males/females that responded to the respective parameters. The average of the Male/Female respondents in terms of Noise, Lighting, IAQ and Thermal comfort was based on the scale of -3 to +3 where -3 was highly dissatisfied, -2 being very Dissatisfied, -1 being dissatisfied, 0 being Neither satisfied nor dissatisfied, +1 being satisfied, +2 being highly dissatisfied and +3 being highly satisfied. In terms of satisfaction levels in Male's the average for the IEQ(including Noise, Lighting, IAQ and thermal comfort) was found to be between -1 and +1 Implying they were just averagely satisfied with the IEQ conditions in homes. Whereas females were also found to be averagely satisfied in terms of Noise, lighting and IAQ, except for thermal comfort where they dissatisfied. In terms of health conditions 1, 2, and 3

denoted complaints occurring every day, 2-3 times weekly and never respectively. Both Males and Females were found to have higher levels of satisfaction as the average was found to be close to 3 denoting never most of the times except in case of lowered productivity which had seemed to be affected due to some reason. In terms of lowered productivities, 1 denoted that it was affected by Environmental conditions and 2 denoted work stress. Females reasoned out lowered productivities to environmental conditions and Males blamed it to work stress. This could be due to the factor that most working men feel lethargic at home after a productive day at work and some women are housewives/ homemakers are mostly at home and believe the IEQ to be bad. The standard deviations in the table show the variation in the range of values for both the genders in terms of Health and Comfort (the four factors of IEQ).

Table 4.1: Effect of Gender on the perception of Indoor Environmental Comfort and Health by evaluating P-value in Residential Environments

QUESTIONS/PARAMETERS	**MALE**			**FEMALE**			
	Average	SD	Count	Average	SD	Count	**P-value**
Noise	0.37	1.74	255	0.14	1.65	245	**0.13**
Lighting	0.25	1.67	255	0.24	1.57	245	**0.92**
IAQ	-0.50	1.72	255	-0.48	1.75	245	**0.86**
Thermal Comfort	1.54	1.67	255	0.46	1.63	245	**< 0.00**
Headache	3.40	0.67	255	3.38	0.67	245	**0.73**
Lethargy	3.07	0.83	255	3.15	0.80	245	**0.27**
Drowsiness	3.68	0.58	255	3.65	0.60	245	**0.58**
Dizziness	3.69	0.55	255	3.68	0.55	245	**0.93**
Nausea/vomiting	3.91	0.25	255	3.91	0.25	245	**0.88**
Shortness of breath	3.67	0.59	255	3.66	0.58	245	**0.80**
Stuffy Nose	3.52	0.61	255	3.57	0.61	245	**0.37**
Dry Throat	3.37	0.62	255	3.41	0.64	245	**0.49**
Skin rash/itchiness	3.76	0.55	249	3.78	0.55	234	**0.59**
Eye irritation	3.52	0.55	255	3.57	0.56	245	**0.28**
Lowered productivity	1.49	0.50	240	1.39	0.48	232	**0.02**

The results have shown us that gender can play a role in the perception of Indoor environments to some extend but not all. It is not the only reason for depraved Indoor environments and health complaints, factors as poor ventilation, toxic gases and materials used in furnishings and electronics and building related sicknesses have also been some of the other reasoning's to poor Indoor Comfort and Health. As we can see in Table 4.1, different genders did perceive the Thermal comfort and productivity levels differently. This could be possible due to stronger sensing abilities or more belligerent lifestyles of the two genders. But as we see majority of the perception has been equal and irrespective of Genders.

4.2.1.2 Respondents' Age versus their opinions in terms of Level of Satisfaction of IEQ and health complaints.

The questionnaire had six sub samples based on age: sample one: 20-30yrs, sample two: 31-40yrs, sample three: 41-50 yrs., sample four: 51-60 yrs., sample five: 61-70 yrs. and sample six: 71-80 yrs. Due to the large number of options and larger numbers, three groups were denoted as following: 1- denoted age group 20-40, 2-denoted age group 40-60 and 2-denoted 60 and above during the analysis of the Age Group Vs. Health and Comfort. The ANOVA test had been done as T-test could have accommodated only 1 or 2 sample comparisons. ANOVA is generally used to compare 3 or more sample comparisons.

The average found for all age groups in terms of IEQ was in between satisfactory and dissatisfactory, whereas in terms of Health, age groups 20-40 and 40- 60 had health complaints 2-3 times weekly whereas age groups 60 and above complained of some mostly every day. The standard deviation of the various age groups was also calculated in order to evaluate the P-values and understand its correlation to health and comfort in home environments be it apartments or villas.

The P-values from Table 4.2 denoted the significance of age over the level of satisfaction in terms of Noise, Lighting, Air-Quality and Thermal comfort. It also compared and correlated age as a factor to the health complaints in individuals at home. When Age as a factor was evaluated by the calculations of mean, average, Standard deviations and P-

values; *Noise, Lighting, Indoor Air Quality and Thermal Comfort* did not have any dependence on Age as a factor. Whereas in respect to health complaints; *Lethargy, Dizziness, Nausea/vomiting, shortness of breath, Stuffy Nose, Skin rash/itchiness and Eye irritation* were found to be dependent on Age as a factor. The P-values of different age groups in respect to *Headache, Drowsiness and Dry Throat* were >0.05, proving no significant difference between the different age groups, hereby confirming no dependence of these health complaints on Age.

Table 4.2: Effect of Age on the perception of Indoor Environmental Comfort and Health by evaluating P-value in Residential Environments

QUESTIONS/ PARAMETERS	**20-40 YRS.**			**40-60 YRS.**			**60 YRS. AND ABOVE**			
	Average	SD	Count	Average	SD	Count	Average	SD	Count	**P-value**
Noise	0.28	1.68	323	0.14	1.74	141	0.50	1.74	36	**0.5**
Lighting	0.26	1.62	323	0.17	1.58	141	0.36	1.82	36	**0.76**
IAQ	-0.45	1.74	323	-0.62	1.67	141	-0.36	1.86	36	**0.56**
Thermal Comfort	0.51	1.65	323	0.45	1.64	141	0.69	1.72	36	**0.74**
Headache	2.39	0	323	2.39	0.66	141	2.58	0.64	36	**0.26**
Lethargy	3.07	0.81	323	2.23	0.81	141	2.16	0.81	36	**0.02**
Drowsiness	2.68	0.59	323	2.67	0.60	141	2.72	0.56	36	**0.91**
Dizziness	2.71	0.52	323	2.63	0.63	141	2.88	0.39	36	**0.04**
Nausea/vomiting	2.91	0.28	323	2.97	0.14	141	2.94	0.23	36	**0.02**
Shortness of breath	2.63	0.63	323	2.78	0.47	141	2.75	0.50	36	**0.03**
Stuffy Nose	2.51	0.65	323	2.67	0.51	141	2.63	0.59	36	**0.02**
Dry Throat	2.37	0.66	323	2.42	0.57	141	2.58	0.60	36	**0.16**
Skin rash/itchiness	2.74	0.61	311	2.88	0.38	139	2.78	0.54	36	**0.04**
Eye irritation	2.52	0.57	323	2.68	0.51	141	2.50	0.56	33	**0.01**
Lowered productivity	1.47	0.50	305	1.41	0.49	132	1.28	0.45	35	**0.04**

Ageing is a natural occurrence and is very known to be susceptible to health conditions as well as mental instabilities. As we see in the Table 4.2 and the results mentioned above, we can come up with a conclusion that age could be one of the factors for the

discernment of various health complaints, mainly lethargy, Dizziness, Nausea/vomiting, shortness of breath, Stuffy Nose, Skin rash/itchiness and Eye irritation. But it is not the factor for poor indoor environmental quality as we can see it has no effect over the perception of Noise, Lighting, Thermal comfort or Indoor Air Quality in indoor environs. There has to be another drive to low quality of Interiors. This can be a combination of effects from the start of the construction with the use of poor quality of toxic materials, bad ventilation systems, and excessive use of electronic devices which radiate electromagnetic waves, harmful in the long run. There has to be a combinational strategy development to improve the living conditions of populace of UAE, by carefully and suitably creating and subletting buildings which work towards happy, healthy and lively indoor environs.

4.2.1.3 Respondents' Origin versus their opinions in terms of Level of Satisfaction of IEQ and health complaints.

5 groups of races were examines that were found to be the respondents of the survey.
Group 1: Asian, Group 2: American, Group 3: European, Group 4: Arab and Group 5: African.

ANOVA had been used similarly in order to calculate the P-value and compare the various nationalities and their opinion to the perception of IEQ as well as their health complaints. Table 4.3 shows the average, SD-standard deviation and count of various origins and thereby P-values have been calculated in order to check the dependence and significance of ethnic groups over their perception of IEQ and Health Complaints.

On an average all groups of ethnicity showed dissatisfaction in terms of IAQ. In terms of Noise Europeans and Africans were dissatisfied compared to other ethnicities, whereas all groups were averagely satisfied with the lighting and Thermal comfort. In terms of health, Europeans and Arabs were found to have health complaints more often than Asians, Africans and Americans. The P-values indicated no significant difference between the 5 groups in the effect of Noise, Lighting and Indoor Air Quality, which means these factors were not affected by origin. On the other hand the P-value for Thermal comfort showed a significant difference between the 5 groups proving that origin did have an impact over thermal comfort. In terms of Health complaints, Origin did not determine any of the following conditions of health impacts. Table 4.3 proves

that Origin has very little to do with the perception of quality of an indoor environment as well as health complaints. An occupant living in Dubai, whether he has come from China, India, Africa, America or Egypt, perceives the current conditions irrespective of where they come from and how they lived. The body adapts to the current living conditions and the immune system improves or degenerates according to the existing atmosphere.

It is the psychological experience of an individual after being in a country and the perception of the IEQ attributes that come as an end result. According to Plotnik and Kouyoumdjian (2011), the definition of perception under psychophysics is: ‘‘the experience we have after our brain assembles and combines thousands of individual, meaningless sensation into a meaningful pattern or image.’’ This suggests that the sensation of current indoor environments is a more powerful simulation of the brain rather than the genetic factors contributing from the race of the people. The calculations and analysis show us that different ethnic backgrounds do have an affect over the perception of an individual level of comfort and health. Americans and Africans complained of thermal discomfort more than other Ethnic groups. In general Europeans complained least in terms of Health. This could be due to their thermal backgrounds or even due to certain physiological, sociological and economic causes. Although saying that, the difference in Origin had not been found as factor in terms of difference in perception for the cause of lowered productivity in Homes. Lethargy was found to be a factor where the various ethnic groups had a difference in opinion on. This could be due to the cultural and social differences found in the groups of various nationalities. Research has shown us that Asians and Africans are found to be hard working than other ethnicities, due to the fact that these countries are under developed and their levels of poverty are found to be higher. It is a race to become a part of the developed countries.

Table 4.3: *Effect of Origin over the perception of Indoor Environmental Comfort and Health, compared by the evaluation of P-values in Residential Environments.*

Questions/	ASIAN			AMERICAN			EUROPEAN			ARAB			AFRICAN			
Parameters	Average	SD	Count	Average	SD	Count	Average	SD	Count	Average	SD	Count	Average	SD	Count	**P-Value**
Noise	0.32	1.74	267.00	0.29	1.61	41.00	0.01	1.55	65.00	0.30	1.70	103.00	0.04	1.83	24.00	**0.71**
Lighting	0.25	1.63	267.00	0.26	1.58	41.00	0.26	1.83	65.00	0.20	1.62	103.00	0.25	1.03	24.00	**1.00**
IAQ	-0.60	1.78	267.00	-0.48	1.45	41.00	-0.33	1.82	65.00	-0.35	1.64	103.00	-0.33	1.78	24.00	**0.63**
Thermal Comfort	0.50	1.61	267.00	0.29	1.58	41.00	0.55	1.64	65.00	0.60	1.67	103.00	0.41	2.14	24.00	**0.04**
Headache	2.43	0.67	267.00	2.29	0.68	41.00	3.42	0.61	65.00	2.36	0.68	103.00	2.37	0.77	24.00	**0.63**
Lethargy	2.14	0.81	267.00	2.07	0.82	41.00	3.00	0.81	65.00	2.20	0.82	103.00	1.92	0.83	24.00	**0.48**
Drowsiness	2.67	0.60	267.00	2.63	0.62	41.00	3.62	0.53	65.00	2.70	0.60	103.00	2.79	0.51	24.00	**0.86**
Dizziness	2.69	0.57	267.00	2.65	0.57	41.00	3.66	0.48	65.00	2.73	2.73	103.00	2.70	0.55	24.00	**0.93**
Nausea/Vomiting	2.92	0.25	267.00	2.92	0.26	41.00	3.86	0.26	65.00	2.93	0.25	103.00	3.00	0.00	24.00	**0.76**
Shortness of breath	2.68	0.58	267.00	2.60	0.66	41.00	3.71	0.49	65.00	2.65	0.63	103.00	2.75	0.53	24.00	**0.62**
Stuffy Nose	2.54	0.62	267.00	2.58	0.63	41.00	3.53	0.63	65.00	2.60	0.61	103.00	2.54	0.51	24.00	**0.95**
Dry Throat	2.37	0.63	267.00	2.39	0.70	41.00	3.45	0.59	65.00	2.44	0.65	103.00	2.29	0.62	24.00	**0.48**
Skin rash/ itchiness	2.77	0.56	259.00	2.82	0.55	39.00	3.73	0.57	62.00	2.76	0.56	99.00	2.91	0.28	24.00	**0.81**
Eye irritation	2.54	0.57	267.00	2.56	0.59	41.00	2.64	0.51	65.00	2.54	0.57	103.00	2.62	0.50	24.00	**0.73**
Lowered Productivity	1.44	0.50	252.00	1.39	0.49	38.00	1.43	0.50	60.00	1.47	0.50	98.00	1.41	0.50	24.00	**0.91**

4.2.1.4 How Smoking affects the perception of level of satisfaction in terms of IAQ in Homes.

Two samples were observed here; 1: presence of smoking members at home, 2: absence of smoking member at home. The average of satisfaction in terms of IAQ was lower for smoking members compared to non-smoking members presence in a home. Table 4.4 shows that the average of health

complaints and lowered productivity was higher for smoking members compared to non-smoking members in a family. Indoor Air Quality was observed to have a P-value<0.05, revealing that there was a significant difference between the two samples, meaning that Smoking did have an impact over the Indoor Air Quality. In respect to health complaints Smoking did not determine the shortness of breath or dry throat, but it did determine the symptoms of stuffy nose and Lowered levels of productivity. Both literature review and calculations prove the significant impact of smoking over the quality of Indoor environs as well as health complaints.

Table 4.4: Effect of Smoking on the perception of Indoor Environmental Comfort and Health Complaints in Residential Environments

QUESTIONS/ PARAMETERS	***SMOKING MEMBERS***			***NON-SMOKING MEMBERS***			
	Average	SD	Count	Average	SD	Count	P-value
Level of satisfaction in terms of IAQ	2.66	0.58	111	2.73	0.59	393	**0.03**
Health Complaints in symptoms of Shortness of breath	2.71	0.59	111	2.67	0.59	393	**0.53**
Health Complaints in symptoms of Stuffy Nose	2.72	0.54	111	2.52	0.63	393	**0.00**
Health Complaints in symptoms of Dry Throat	2.48	0.61	111	2.37	0.64	393	**0.10**
Perception of lowered productivity	1.45	0.49	104	1.41	0.49	372	**0.04**

Tobacco smoke is one of the major sources of exposure of airborne toxic particles in the atmosphere, be it indoors or outdoors. Although; age, gender and origin can have secondary effects on respiratory and other diseases, smoking is the primary cause for degeneration of health. Important steps need to be taken to achieve a goal to achieve a smoke free indoor environment and if not at least to come up with some techniques that need to be established to exploit the toxic airborne particles to stay indoors.

4.2.2 Commercial Survey

500 completed surveys were analysed in order to understand the perception of indoor environments in offices. Various types of office buildings and office environments were studied through surveys. A similar questionnaire such as the residential survey was prepared in order to compare both residential and commercial indoor environments and

to understand the perception of both. Commercial surveys differed in a few ways, where questions regarding job category, type of workstation, nature of occupation etc.. were added and replaced by members of family and type of residential buildings. Similar to the respondents for the residential survey the male to female ratio was not majorly different and was found to be 54%:46% in commercial environments. The percentage of age group respondents was mainly 20-40 years, which proves that this is the main age group the construction industry needs to cater to. Origin wise, for Commercial Surveys majority of the respondents were found to be Asians and Americans.

54.2% of the respondents had an enclosed room to themselves in offices and 44.8% had an open concept type of workstation.1% of the respondents had not responded to this question which could mean they either did not understand the question or did not have any workstation to themselves and worked on sites mainly. In regards to comfort, 43.2% of the respondents needed to put on extra clothing for comfort in office environments regularly, 36% had to put on extra clothing sometimes and 20.8% of them had to never put on extra clothing for comfort, i.e. a minority of only 20.8% of respondents were found to be thermally comfortable in indoor environments and did not suffer extremely cold air conditioning systems or temperatures. In regards to odour, 24.8% always felt an unpleasant odour, 42.8% felt the unpleasant odour at times and 32.4% did not have an unpleasant odour in their office environments. This shows that the majority of them did many a times face unpleasant odour confirming need of proper ventilation and exhaust systems in commercial building environments. In terms of stuffiness in office environments, 14.6% always felt stuffy, 37.4% felt stuffiness at times and 48% never felt stuffy. This proved that it is a major concern to have thermally comfortable indoor office environments, as 43.2% of the respondents have been noted to put on extra clothing for comfort and 52% of them complained of stuffy environments proving extremely high temperature difference and thermally uncomfortable settings. As we all notice in Dubai generally the trend in Indoor Environments is to have fixed cooling systems in Buildings and Offices which are generally from 20 – 22 degrees that are normally very cold for people to be accepted indoors. It is very important to cater to separate thermal needs as it could majorly affect the productivity needs as well as wastage of unnecessary energy. Due to inefficiency in ventilation systems, populace have felt a strong sense of odour in commercial indoor environs which may be due to a number of reasons

including food, unhygienic people of environs, and lack of exhaust systems, perspiration, paints or even smoking.

In regards to physical and mental levels of stress in office environments: 45.8% of the respondents felt low, 45.6% felt moderate and a minimal 8.6% felt high in terms of physical stress. In terms of mental stress; 28.59% of the respondents felt low, 47.8% felt moderate and 23.61% felt high in office environments. This showed that mental stress and physical was equally accounted for resulting in draining out of individuals in turn resulting in the lowered levels of productivity of people in offices. Conferring to the questions about when the health complaints occurred, 36.8% of the respondents said mornings, 16.4% responded afternoons and 46.8% responded a no noticeable trend. In regards to experiencing relief from these complaints; 30.4% responded after they left their workstations, 22% responded after they left their office buildings and 47.6% responded never. When inquired about the respondents medical conditions; 15.8% suffered from asthma and were on medication, 34.6% suffered but were not on medication and 49.6% did not suffer from it. 13.2% suffered from allergy and were on medication, 22.8% suffered but were not on medication and 64% did not suffer from it. 26.6% suffered from sinus and were on medication, 20.2% suffered but were not on medication and 53.2% did not suffer from it. 21.6% of the respondents suffered from migraine and were on medication, 23.4% suffered but were not on medication and 55% did not suffer from it. In regards to lowered productivity; 66% blamed it on environmental conditions and 34% blamed it on work stress.

Office environments are found to having maximum levels of mental and physical stress. A major cause for this is unpleasant indoor settings, poor ventilation and lack of Natural daylight, which creates a depressed and unpleasant environment in addition to the already occurring work stress that the occupants go through every day. It is hence a necessity to create environmental friendly, aesthetically pleasing settings where occupants can be at ease and work more efficiently.

4.2.2.1 Respondents' Gender versus their opinions in terms of Level of Satisfaction of IEQ and health complaints in Commercial Environments.

Commercial surveys; similar to residential surveys helped in the analysis of the influence of Gender on the satisfaction levels of IEQ and health impacts in Offices. Two samples based on male and female were observed and T-test was done to calculate P-values and understand the rate of significance between the 2 sample studies. Two groups of 1: Male and 2: Female were evaluated by calculations of Mean (Average), Standard deviation, count of the number of males and female respondents and thereby calculating their P-values using T-test.

In regards to IEQ, the average calculated in Table 4.5 for Males was found to be lower in terms of Noise, Lighting and IAQ and higher in terms of Thermal Comfort, proving that women were found to be more disappointed with Thermal Comfort and men were found to be disappointed with Noise, Lighting and IAQ in offices. In regards to Health complaints, men had a lower average compared to females implying that, women suffered more often to health complaints. Productivity levels were found to be affected by both Male and Female workers, causes for which can be indefinite. The Mean, Standard deviation and count of respondent's answers helped to evaluate the P-value resulting in the analysis of level of significance in the difference of results, implying the causes to the perception of level of health and comfort in commercial indoor environments.

Table 4.5, demonstrates that the P-value for Noise and Thermal comfort are <0.05, attesting significant difference between the two groups. This corroborates the dependence of *Noise* and *Thermal Comfort* over Gender type. Gender did not play a role in determining the levels of satisfaction in Lighting and Indoor Air Quality. In regards to Health complaints, gender did not determine symptoms of Headache, Lethargy, Drowsiness, Dizziness, Nausea, Shortness of breath, Stuffy Nose, Dry throat, Skin rash or Eye irritation. The P-value for lowered productivity in offices was <0.05, proving a significant difference between the two groups of gender, essence being that Gender did play a role in determining variations in the *levels of productivity*.

In commercial Indoor milieus, Gender is found to have an impact over the perception of Comfort in terms of Noise and Thermal comfort. This could be due to the fact that at times women are more sensitive to temperature, due to their biological type. Women

are far more sensitive than Men as they go through more mental and physical stress than men and bear with a lot in various aspects of life. They are meant to be handling homes and offices, whereas men are mainly found to be handling offices only. After a certain Age, the tolerance level of women is widely affected by multi-tasking with homes, offices, children and other family oriented anxiety.

Table 4.5: Effect of Gender over the perception of Indoor Environmental Comfort and Health, compared by the evaluation of P-values in Commercial Environments.

QUESTIONS/PARAMETERS	***MALE***			***FEMALE***			
	Average	SD	Count	Average	SD	Count	**P-value**
Noise	-0.66	1.63	272	-0.33	1.71	228	**0.03**
Lighting	-0.14	1.69	272	0.12	1.80	228	**0.09**
IAQ	-0.65	1.69	272	-0.52	1.75	228	**0.39**
Thermal Comfort	0.76	1.75	272	0.04	1.77	228	**< 0.00**
Headache	3.04	0.75	272	3.07	0.69	228	**0.68**
Lethargy	3.16	0.74	272	3.18	0.77	228	**0.74**
Drowsiness	3.40	0.69	272	3.46	0.65	228	**0.39**
Dizziness	3.52	0.64	272	3.53	0.67	228	**0.88**
Nausea/vomiting	3.60	0.60	272	3.59	0.58	228	**0.79**
Shortness of breath	3.55	0.60	272	3.56	0.58	228	**0.83**
Stuffy Nose	3.51	0.64	272	3.54	0.63	228	**0.66**
Dry Throat	3.61	0.58	272	3.63	0.57	228	**0.73**
Skin rash/itchiness	3.61	0.60	272	3.59	0.60	228	**0.69**
Eye irritation	3.60	0.60	272	3.58	0.63	228	**0.72**
Lowered productivity	1.35	0.47	272	1.37	0.48	228	**0.04**

Gender is also found to have a significant impact over the perception of levels of productivity. This could be due to the fact that levels of productivity may vary in the heads of Males and Females as one could have a higher goals and objectives than the other or it may be due to the reason that women have higher physical and mental stress which could be affecting their productivity. It could even be due to the fact that some genders are far more sensitive to in efficient indoor environments.

4.2.2.2 Respondents' Age versus their opinions in terms of Level of Satisfaction of IEQ and health complaints in Commercial Environments.

The questionnaire had six sub samples based on age: sample one: 20-30yrs, sample two: 31-40yrs, sample three: 41-50 yrs., sample four: 51-60 yrs., sample five: 61-70 yrs. and sample six: 71-80 yrs. Due to the large number of options and larger numbers, three groups were denoted as following: 1: 20-40 yrs., 2: 40-60 yrs. and 3: 60 yrs. and above. Table 4.6 shows the average, standard deviation, count and P-values for the three groups. The ANOVA test had been done to compare 3 or more sample comparisons.

In terms of IEQ, the Average was found to be lowest for the age group of 60 years and above, implying their level of dissatisfaction with office environmental quality. The 20-40 years of age group were found to be more dissatisfied in terms of Noise and Thermal Comfort and the age group of 40-60 complained of dissatisfaction with respect to lighting and IAQ. If we were to analyse this kind of response it is clear that aged people's bodily functions are more affected than young people. It is clear from the calculations that the age group of 60 yrs. and above were found to be more dissatisfied with the overall IEQ. The age group of 40-60 complained of inefficiency of lighting systems due to the fact that as you grow older the retina degenerates and higher levels of light are required preferably natural lighting. The IAQ was also complained of more by the age groups of 40-60 probably due to the fact that their levels of immunity were weaker in comparison to the younger age group. As we all know the age group of 20-40 is the period where humans are more sensitive, moody and intolerable. Due to this reason, populates from the 20-40 years of age group complained about poor levels of Acoustics in indoor environments and bad quality of thermal comfort.

After evaluations of the P-values as per Table 4.6, it was found that in commercial Environments, Age was not found to be the reason for bad Indoor environments, but it did prove to have some effect on health complaints such as *Symptoms of Lethargy* and *Eye Irritation*. Age was not a factor in most of the areas as it had no significant impact over how the respondents perceived their office environments.

Table 4.6: Effect of Age over the perception of Indoor Environmental Comfort and Health, compared by the evaluation of P-values in Commercial Environments.

QUESTIONS/ **PARAMETERS**	***20-40 YRS.***			***40-60 YRS.***			***60 YRS. AND ABOVE***			
	Average	SD	Count	Average	SD	Count	Average	SD	Count	**P-value**
Noise	0.44	1.64	335	0.55	1.75	163	-0.50	0.58	4	**0.78**
Lighting	0.99	1.76	335	0.95	1.72	163	-0.75	0.96	4	**0.69**
IAQ	0.46	1.68	335	0.26	1.76	163	-0.25	3.20	4	**0.43**
Thermal Comfort	0.81	1.81	335	1.03	1.69	163	0.25	1.89	4	**0.39**
Headache	3.08	0.70	335	3.01	0.77	163	2.25	0.50	4	**0.6**
Lethargy	3.16	0.74	335	3.16	0.77	163	2.75	0.50	4	**0.03**
Drowsiness	3.42	0.67	335	3.44	0.67	163	2.25	0.50	4	**0.76**
Dizziness	3.54	0.63	335	3.48	0.70	163	2.75	0.50	4	**0.6**
Nausea/vomiting	3.62	0.57	335	3.55	0.62	163	2.50	1.00	4	**0.57**
Shortness of breath	3.57	0.59	335	3.53	0.60	163	2.75	0.50	4	**0.71**
Stuffy Nose	3.52	0.63	335	3.53	0.65	163	2.50	0.57	4	**0.92**
Dry Throat	3.61	0.60	335	3.64	0.53	163	2.50	0.57	4	**0.65**
Skin rash/itchiness	3.59	0.60	335	3.64	0.58	163	2.50	1.00	4	**0.54**
Eye irritation	3.55	0.63	335	3.65	0.57	163	3.00	0.00	4	**0.04**
Lowered productivity	2.32	0.47	335	2.34	0.48	163	1.25	0.50	4	**0.74**

Table 4.6, shows that Age is not responsible for the levels of comfort in terms of Light, Noise, IAQ and Thermal comfort and these are perceived the way they are , irrespective of the Age group. Age however does have an impact of the Health Complaints as we all know that age can cause certain impacts on the Human body. Age –Related changes are known to have occurred and alter lifestyle changes as well as create some health related complaints.

4.2.2.3 Respondents' Origin versus their opinions in terms of Level of Satisfaction of IEQ and health complaints in Commercial Environments.

5 groups of races were examined amongst the respondents of the commercial survey; Group 1: Asian, Group 2: American, Group 3: European, Group 4: Arab and Group 5: African. The 5 groups were compared using ANOVA and calculations of their P-values for the same factors as repeatedly mentioned.

The Average observed amongst the 5 groups of Ethnicities was found to be equally low implying dissatisfaction in terms of IEQ comfort factors such as Noise, Lighting and IAQ. Thermal Comfort however varied amongst all nationalities and Asians and Africans were found to have complained the most in regards to Thermal discomfort in office environs. In regards to Health Complaints, all ethnicities showed equal perception in regards to the below mentioned health parameters (Refer to Table 4.7). Also in regards to lowered levels of productivity Origin did not seem to change the perception of individuals and most of them were found to have blamed work stress for lowered levels of productivity, hence by proving that Environmental conditions within an environment cannot entirely be blamed for health, comfort and productivity of individuals in office environments.

Standard Deviation (SD) seemed to be equally distributed amongst the 5 nationalities and hence the P-value calculated for Origin as a factor did not signify any health complaints in offices and did not impact the productivity levels. The determination of Indoor environments and health complaints had very little to do with the occupants Nationality. Origin was only found to be a reason for the difference in the perception of lowered thermal comfort. This could be accounted to various genetic hot and cold body temperature differences in various populations and race's. Ethnic groups have been related to many sociological and biological factors which can cause an influence over the perception and belief of thermal comfort in an environment, which includes cultural, socio-economic factors, stress levels as well as health care. The variations in the origin of the populace have an impact on the thermal comfort in commercial settings, as observed by the current survey referring to Table 4.7.

Table 4.7: Effect of Origin over the perception of Indoor Environmental Comfort and Health, compared by the evaluation of P-values in Commercial Environments.

Questions/	ASIAN			AMERICAN			EUROPEAN			ARAB			AFRICAN			
Parameters	Average	SD	Count	Average	SD	Count	Average	SD	Count	Average	SD	Count	Average	SD	Count	**P-Value**
Noise	-0.5	1.71	187	-0.55	1.59	121	-0.56	1.81	70	-0.31	1.73	77	-0.75	1.43	45	**0.71**
Lighting	0.05	1.71	187	-0.12	1.7	121	0.05	1.88	70	-0.19	1.82	77	0.06	1.75	45	**0.8**
IAQ	-0.63	1.74	187	-0.62	1.67	121	-0.34	1.68	70	-0.7	1.78	77	-0.6	1.72	45	**0.75**
Thermal Comfort	-0.2	1.76	187	-0.06	1.75	121	0.04	1.73	70	0.01	1.9	77	-0.26	1.62	45	**0.04**
Headache	2.1	0.72	187	2.01	1.73	121	2.11	0.77	70	2.11	0.7	77	1.93	0.68	45	**0.51**
Lethargy	2.16	0.75	187	2.21	0.73	121	2.17	0.81	70	2.24	0.76	77	2.09	0.73	45	**0.81**
Drowsiness	2.49	0.65	187	2.34	0.72	121	2.5	0.65	70	2.4	0.69	77	2.49	0.62	45	**0.28**
Dizziness	2.56	0.63	187	2.54	0.68	121	2.55	0.62	70	2.45	0.73	77	2.57	0.58	45	**0.79**
Nausea/Vomiting	2.61	0.61	187	2.62	0.55	121	2.55	0.67	70	2.62	0.56	77	2.69	0.55	45	**0.8**
Shortness of breath	2.62	0.56	187	2.61	0.58	121	2.5	0.63	70	2.5	0.66	77	2.51	0.58	45	**0.35**
Stuffy Nose	2.53	0.65	187	2.54	0.63	121	2.6	0.6	70	2.46	0.68	77	2.64	0.57	45	**0.58**
Dry Throat	2.67	0.59	187	2.62	0.59	121	2.61	0.57	70	2.54	0.61	77	2.75	0.43	45	**0.34**
Skin rash/ itchiness	2.6	0.64	187	2.7	0.51	121	2.57	0.62	70	2.62	0.58	77	2.55	0.65	45	**0.49**
Eye irritation	2.6	0.6	187	2.58	0.65	121	2.55	0.67	70	2.68	0.56	77	2.62	0.57	45	**0.69**
Lowered Productivity	1.35	0.48	187	1.35	0.48	121	1.32	0.47	70	1.32	0.47	77	1.31	0.46	45	**0.98**

4.2.2.4 How Smoking affects the perception of level of satisfaction in terms of IAQ in Offices.

Two samples were observed here;
1: presence of smoking members at offices, 2: absence of smoking member at offices

Smoking was found to be a major factor for determining the levels of satisfaction in terms of Indoor Air Quality and also in the perceived lower productivity in offices. As we all know, smoking has its ill-effects not only to the human body but also the environments be it outdoors or indoors. The lack of quality ventilation can however depreciate the quality

of IAQ further than it does. Table 4.8 describes the mean, standard deviation as well as P-values for the levels of satisfaction in IAQ and how there is statistically significant difference between smoking and non-smoking members in household of respondents. The health complaints such as Shortness of breath, stuffy nose and dry throat are perceived not to be affected by presence of smoking members. However the lowered productivity is definitely affected by smoking as a factor. The average in Table 4.8 shows us how dissatisfied respondents are with IAQ.

Table 4.8: Effect of Smoking on the perception of Indoor Environmental Comfort and Health Complaints in Commercial Environments

QUESTIONS/PARAMETERS	***SMOKING MEMBERS***			***NON-SMOKING MEMBERS***			
	Average	SD	Count	Average	SD	Count	**P-value**
Level of satisfaction in terms of IAQ	-0.62	1.72	157	-0.55	1.72	343	**0.03**
Health Complaints in symptoms of Shortness of breath	2.60	0.57	157	2.56	0.60	343	**0.61**
Health Complaints in symptoms of Stuffy Nose	2.47	0.65	157	2.57	0.63	343	**0.10**
Health Complaints in symptoms of Dry Throat	2.63	0.59	157	2.64	0.58	343	**0.85**
Perception of lowered productivity	1.29	0.45	157	1.36	0.48	343	**0.03**

Smoking has found to be the cause for lower levels of satisfaction in Indoor Air Quality, as we know it is a major cause to indoor pollution and insalubrious inhalation. According to EPA (2011), smoke contains around 4,000 substances, most of which are known to cause serious diseases such as cancer as well as respiratory related illnesses.

4.3 Summary

The evaluations done in this chapter are aimed at exploring additional parameters to the perception of Indoor environmental quality and possible design alterations in order to increase the performance and productivity of a building environment. An indoor environment quality is measured by factors such as comfort in terms of acoustics, thermal, visual and IAQ. It is also determined by a basic physiological, psychological and health factors of individuals using the building and analyzing its performance. Different sets of human being can analyse the same set of building in various ways according to

their mental and physical levels of well-being and their cultural and physical needs of expectations from a building's performance.

In this study we have analysed the reasons for difference in perception to be due to the demographics and tried to study if that really is an important factor in determining the degree of difference in perception of building performances. Here we have roughly evaluated the current environmental conditions of respondents in context with their demographics as well as current levels of health and tried to link these factors in order to understand and study the evaluation of UAE's inhabitants residential and commercial environments. It was found that majority if the respondents were not satisfied with their living and working environments. Some complained of poor quality of Indoor Air Quality, while others criticized of poor levels of thermal, visual or acoustic comfort. The reasons found were that a majority of percentage could be blamed to bad quality of HVAC performance, Smoking indoors, bad quality of exhaust systems and unpleasing aesthetic and inconsiderate design features in building design and construction. Miller and Ashford (2001) have explained that there are a significant number of people that are sensitive to chemical and electromagnetic fields and an in appropriate HVAC system can add to this by creating SBS amongst the occupants. The other percentage of responsibility to the perception of bad IEQ accounted to the difference in age groups, gender and origin. The older a human being was the unhealthier he/she was and the more he/she complained of in regards to health and comfort levels in an indoor environ. Gender did not play a significant role in determining the variance in IEQ, but it was an important factor in terms of thermal comfort and also had a difference in opinion in residential and commercial environments. Male's complained of lowered productivity in homes. In commercial environments, gender added to the perceived lowered satisfaction in terms of comfort in Noise and Lighting levels. Origin was also found to be only responsible for the degree of difference in perception of thermal comfort in homes and offices and not in terms of health or productivity as presumed earlier. Literature review of this study has given us an in depth explanation to the causes of lowered levels of IEQ in terms of health and comfort and how environmental sensitivity and SBS are triggered due to the IAQ; concentration of contaminants which may be particulate, biological or chemical and Clothing, Acoustics, Visual Comfort, Thermal comfort and variance in Perception of Indoor Environmental Comfort; which are the Physiological

and Psychological Aspects. Dear and Brager (1998) confirmed that the Physiological adaptation is a combination of genetic adaptation (intergenerational) as well as acclimatization (within the lifetime of an individual). For example the thermal requirements and preferences of an individual can be altered by a past thermal history such as past living environments (difference in thermal conditions of various countries). They also confirmed that psychological comfort is the mental satisfaction of individual to given indoor environmental conditions as well as a combinational result of genetic adaptation (intergenerational) as well as acclimatization (within the lifetime of an individual). It can also be altered owing to past experiences as well as expectations. Here come the demographics in play which we have tried to evaluate and understand in this study as mentioned above and below for comparison and discussion.

4.3.1 Comparison of Residential and Commercial in lowering the Levels of Satisfaction in terms of IEQ and health complaints of individuals

In ***Residential*** indoor environments, gender affected the Levels of satisfaction in terms of Thermal Comfort as well as lowered the productivity at home; Age caused Health Complaints in symptoms of Lethargy, Nausea/vomiting, Shortness of breath, Stuffy Nose, Skin rash/itchiness, Eye irritation and lowered productivity. Origin was found to be the cause for the lowered Levels of satisfaction in terms of Thermal Comfort.

Table 4.9: Comparison of the demographics; gender, age and origin Affecting the perceived lowered IEQ and Health Complaints in residential (R) and commercial (C) Indoor environments.

Analysis/ Factors	GENDER (R)	AGE (R)	ORIGIN (R)	GENDER (C)	AGE (C)	ORIGIN (C)
Level of satisfaction in terms of Noise	x	x	x	✓	x	x
Level of satisfaction in terms of Lighting	x	x	x	✓	x	x
Level of satisfaction in terms of IAQ	x	x	x	x	x	x
Level of satisfaction in terms of Thermal Comfort	✓	x	✓	✓	x	✓

Health Complaints in symptoms of Headache	X	X	X	X	X	X
Health Complaints in symptoms of Lethargy	X		X	X		X
Health Complaints in symptoms of Drowsiness	X	X	X	X	X	X
Health Complaints in symptoms of Dizziness	X	X	X	X	X	X
Health Complaints in symptoms of Nausea/vomiting	X	✓	X	X	X	X
Health Complaints in symptoms of Shortness of breath	X	✓	X	X	X	X
Health Complaints in symptoms of Stuffy Nose	X	✓	X	X	X	X
Health Complaints in symptoms of Dry Throat	X	NO	X	X	X	X
Health Complaints in symptoms of Skin rash/itchiness	X	✓	X	X	X	X
Health Complaints in symptoms of Eye irritation	X	✓	X	X	✓	X
Perception of lowered productivity	✓	✓	X	✓	X	X

✓ Implying YES the factors did have an implication over the perception over the listed analysis

x Implying NO the factors did not have an implication over the perception over the listed analysis

In ***Commercial*** indoor environments, Gender affects the Level of satisfaction in terms of Noise, Lighting and Thermal Comfort. It also is the cause of perceived lowered productivity. Age causes Health Complaints in symptoms of Lethargy and Eye irritation. Although gender, age and origin were perceived to be causing inefficient thermal comfort and a few health complaints, majority of the results proved that bad Indoor environmental quality was the reason for Lowered productivity in Offices and homes. There has been a noticeable similarity in the perception of Thermal Comfort being affected by Gender and Origin as it could be a strong factor in determining the physical comfort level, be it in homes or offices. Also Age was found to affect Eye irritation in homes and offices. Lowered Productivity in homes and offices was affected by Gender commonly.

Smoking on the other hand in ***Residential*** indoor environments causes lowered Levels of satisfaction in terms of IAQ, causes Health Complaints in symptoms of Stuffy Nose and perceived lowered productivity at homes. Origin was a factor for lowered levels of satisfaction in terms of Thermal Comfort. Whereas in ***Commercial*** indoor environments smoking causes lowered Levels of satisfaction in terms of IAQ and perceived lowered productivity. Hence we could conclude that smoking had been an important cause to health complaints in homes and a strong cause to lowered productivity in homes and offices.

Table 4.10: Comparison of the Smoking in residential (R) and commercial (C) Indoor environments causing lowered IEQ and Health Complaints.

Analysis	Does SMOKING affect the perception of the following (Homes)	Does SMOKING affect the perception of the following (Offices)
Level of satisfaction in terms of IAQ	✓	✓
Health Complaints in symptoms of Shortness of breath	X	X
Health Complaints in symptoms of Stuffy Nose	✓	X
Health Complaints in symptoms of Dry Throat	X	X
Perception of lowered productivity	✓	✓

✓ Implying YES Smoking did have an implication over the perception over the listed analysis

x Implying NO Smoking did not have an implication over the perception over the listed analysis

4.3.2 Implications of the findings in U.A.E in comparison with existing knowledge in literature review.

In general smoking was found to be an important factor in causing inefficient indoor environments as well as in the cause of building related illnesses, which may or may not be entirely blamed on smoking. It is in fact a combination of smoking as well as bad

ventilation systems as well as thermally uncomfortable environments. The surveys also showed that majority of the population had to use extra clothing in offices and natural ventilation was the least used in indoor environments. This could not be entirely blamed on the weather as winters in Dubai are quiet cool and can be very well utilized with appropriate ventilation systems. Literature review conducted proved the various causes of ineffective indoor environments were the sick building syndrome and environmental sensitivity to the indoor contaminants (biological and physical) as well as to the Environmental factors. Surveys in the U.A.E prove that in addition to that there are a few demographic motives to it; although those cannot be changed a healthier IEQ can always be achieved by appropriate designing and commissioning of residential and commercial building construction and design.

4.3.3 The cause of ill-health implications for UAE residents (whether it is the indoor environmental conditions OR the nature of occupation OR the current level of wellbeing conditions of individuals that are responsible.)

In the U.A.E, the main reasons of bad Indoor Environments is the inconsiderate approach to build and design and cost saving strategies to it. There is very little exertion from the governments, Owners, Architects as well as Building contractors and Designers to achieve a healthy and comfortable Indoor Environment. The cause of sick building syndrome and environmental sensitivity comes from a combination of mainly current indoor environmental conditions, smoking, mental levels of stress as well as old age in terms of demographics. The major reasons for Bad indoor environmental quality is that owners are more bothered about saving the cost and not about the health and safety of habitants. Money has become a priority in our society and has led to all evil within the whole world. Construction is at its peak in The U.A.E and a strict amount of research and measure needs to be taken by the government to ensure the health and safety of its occupants in order to have higher life spans and better quality and productivity within individuals living and working here.

CHAPTER 5

CONCLUSION

5.1 Research/ Literature Review Findings

In relation to Indoor Air Quality, Literature review has proved to us that there is a limit to level of acceptability of volatile organic compounds beyond which the health of person starts to get low. These harmful chemical compounds may be present in many indoor environments and can enter a house-hold through furniture's, furnishings, finishes, fragrances, disinfectants as well as through water and gas. Tobacco smoking is one of the major sources of harmful airborne particulate concentrations indoors. According to research and experiments conducted by Spengler et al (1981); Coultas et al (1990); Leaderer and Hammond (1991); Ozkaynak et al (1996); environments with smokers have found to be containing and increased average indoor particle level by at least 20 to 30 grams in comparison to environments without smokers. Literature review concludes that a bad indoor air quality can be a product of chemical contaminants, biological contaminants as well as environmental factors such as air temperature, velocity and humidity.

In relation to Acoustics, there are various sources of acoustic discomfort especially in industrial and traffic areas. Noise pollution is a major cause to emotional, psychological and physiological disturbances which are not so easy to measure. It reduces the efficiency of an individual. The physiological disturbances vary from auditory and non-auditory. Auditory could be temporary ear exhaustion or deafness. Non auditory effects are disturbance, annoyance and body related illnesses such as blood pressure, hypertension or fatigue. Sound pollution and various disturbances caused during sleep cause a downfall of mood as well as result in lowered quality of sleep.

In relation to Thermal Comfort, inefficient HVAC systems indoor are mainly responsible for poor thermal comfort due to inability of the systems to provide adequate temperature, velocity, humidity as well clean air. According to HSE (2010), whenever the humidity of indoor air rises, the evaporation of water from the body surface reduces and eventually the sweat increases. Also the thermal comfort of one individual may vary with another individual's level of thermal comfort. Thermal comfort can be accounted for 70% of the population. Not every individual can feel the same way and not the most thermally comfortable settings can prove equally comfy for all natives.

In relation to Visual Comfort, literature review mainly discusses the lighting systems provided in an indoor environment as they are the main causes to visual comfort. These include daylight as well as electrical lighting and many buildings fail to provide a balance between both causing poor visual comforts. According to Ncube and Riffat (2012), a visually comfortable indoor environment has the luminance levels, illumination uniformity, color characteristics, day lighting, and equal distribution of light, glare and flicker rates as well as proper room surface reflectance in relation and in right balance for a particular task.

In relation to Physiological and psychological Comfort, Genetic, physical and mental adaptation to the climatic conditions of a city which includes indoor and outdoor environments. Literature review also proves to us that the demographics of an individual including their gender, origin and age play a major role in determining their level of adaptation to an indoor environment. Sociological factors, behavioural factors as well as Physical and Mental Health levels can determine an individual's level of physiological and psychological comfort in an indoor environment. Demographics have further been used as a base in the survey in order to confirm its significance and its applicability towards acceptance and construction of indoor environments in relation to Age, Gender and Origin and their variations in the belief to various forms and types of indoor comfort.

5.2 Survey Verdicts

This paper has offered the findings on a study of indoor environmental quality (IEQ) within Dubai using a set of two types of questionnaires. The results of both types of survey have been scrutinized for reports. The analysis in addition to the effect of demographics also gave in information on building types, job type, lighting factors, use of electrical appliances and many more. It was found that 70% of the respondents lived in building apartments, 51.4% of the respondents used split units as air conditioning systems, 57.99% used fluorescent lighting in comparison to non-fluorescents and a majority of them were found to have put on extra clothing for comfort. Electric lighting was used for almost all the time in residences, proving that daylight could be initiated and promulgated in order to decrease health complaints and energy usage and increase

productivity and circulation. Survey analysis was mainly done to analyse the influence of demographics on the perception of Indoor Environmental Quality. Gender, Age and Origin were the basis of comparison to the levels of indoor environmental satisfaction as well as health complaints.

The analysis of the residential surveys done on 500 occupants provided logical and established conclusions as to why the perceptions of an indoor environment vary within a given indoor area. Gender played an important role in the determination of thermal comfort as well as lowered the productivity levels at home. Male have a tendency to be more labour oriented, not implying directly in various fields of work and hence tend to feel more warm compared to females. In residential environments it was observed that the requirement of cooler air conditioning systems was most often by Men than Women. In terms of lowered productivity woman were found to be the main complainers. The reason for this could vary from psychological, physical or sociological causes. According to the tests and calculations done on survey records, age was found to be a cause for health complaints such as Lethargy, Dizziness, Nausea/Vomiting, Shortness of Breath, Stuffy Nose, Skin Rash/Itchiness and Eye Irritation. Origin however, played the least important role in the determination of IEQ perceptions and Health complaints. Smoking indoors was found to be one of the major causes to health deterioration as well as bad quality of Living environments. It lowered the level of satisfaction in Indoor Environments as well as lead to many Health complaints by individuals. Tobacco smoking is one of the main sources of exposure of toxic materials indoors and outdoors.

In regards to the commercial survey analysis, it was observed that Gender played a role in the determination of lowered perceived Acoustic and Thermal comfort. Women were more sensitive towards noise as well as cold temperatures. Age did not lower the perception of Indoor environmental quality whereas it did determine certain health complaints such as Lethargy and Eye Irritation in commercial indoor environments. Origin did not verify the perceptions neither health complaints of individual but it was found to have an impact on the perception of lowered thermal comfort. Smoking in commercial environments had similar reaction to the perception of Indoor Air Quality as was observed in Residential Environments.

5.8 Overall Fallout of the Study

✓ *How Does The IEQ In U.A.E. (Mainly in the Region of Dubai) Affect Building Occupants' Perception to Health, Comfort And Productivity?*

When inquired about the inhabitants living conditions in Dubai, occupants were rather in sensitive towards how and where they lived. Majority of the residents felt the living conditions were acceptable (neither too harsh neither too perfect), the reason for this could be due to the factor that the populace are less clued-up and erudite on the topic of sustainable and healthy interiors and least do they know what causes ill-health and lack of concentration and performance in living environs. Although majority of the population was also found to be living in smaller apartment type of buildings with more family members and lesser rooms, in addition to poor ventilation and air-conditioning systems as well as low quality or no exhausts in some cases. Many residents suffered from a number of health complaints ranging from asthma to cancer, reasons being unknown to them. In Office environments people mostly complained about the thermal discomfort due to the fixed air temperature and lack of personal authority in a bigger common area, especially in buildings where the air-conditioning systems are centrally operated and managed. Majority of the survey respondents had to wear extra clothing for comfort and complained of lack of performance and productivity. Some respondents even complained of stuffy and smelly office environments, this could be mainly due to the bad ventilation systems and lack of personal and environmental hygiene.

✓ *How Do Demographics (Gender, Age And Ethnicity/Origin) of an Individual Impact the Perception on Indoor Environmental Conditions in the U.A.E?*

Through the multiple surveys conducted throughout the residential and commercial environments across most of Dubai, there has been a wide variety of differences across the perception of an indoor environment. Gender and origin can be one of the causes for the difference in perception of thermal comfort; Age could be one of the factors for the discernment of various health complaints, mainly Lethargy, Dizziness, Nausea/Vomiting, Shortness of Breath, Stuffy Nose, Skin rash/itchiness and Eye irritation in residential environments. Whereas in commercial environs gender causes difference

in perception of comfort in terms of noise and thermal comfort, Age causes health complaints like lethargy and eye irritation and Origin causes difference in Perception of Thermal comfort. Smoking is also found to be an additional imperative cause to perception of Bad IAQ in homes and offices.

Survey analysis has proved that Gender does play a role in the determination of thermal comfort and lowered productivity in homes whereas in offices gender affects the perception of noise, thermal comfort and productivity. Ethnicity on the other hand doesn't have any major implications except for thermal comfort in Homes and Offices. Age on the other hand has way more implications over health effects as well perceptions and productivity levels in commercial and residential environs.

✓ *Is There a Degree of Difference in the Indoor Environmental Conditions in Residential and Office Buildings?*

In terms of survey analysis there was very less degree of difference between the environmental conditions in homes and offices. Although in terms of acoustic and lighting comfort, Gender was found to play a role in the perception in commercial environments and not in residential environments. Also in terms of health complaints such as Nausea/Vomiting, Shortness of breath, stuffy nose, skin rash and eye irritations were found to be affected more commonly in residential environments with Age being a major factor for it. As we know this could be due to the reason that aged people normally spend majority of their time in residential environments due to retirement and health factors. The perception of lowered productivity occurred in both residential and commercial environments whereas the factors of residential were found to be Gender and Age and in offices were Gender only for obvious reasons know to us.

✓ *What Is Responsible for the Ill-Health Implications to UAE Residents, whether it is the Indoor Environmental Conditions* ***OR*** *the Nature of Occupation* ***OR*** *the Current Level of Wellbeing Conditions of Individuals?*

The overall analysis of the survey results has revealed that more than one third, i.e. 40.2% of the respondents for the residential survey suffered from ill-being in the

mornings after a night's sleep at home. 33.8% noticed a relief of these symptoms after they left home proving that the home environmental conditions had some impact on the health of the occupants. Majority of the respondents complained of health complaints such as asthma, sinus, Migraine and lethargy which eventually resulted in lowered productivity. In offices as well similar fallouts were detected. 45.8% of the respondents felt low in relation to physical stress and 28.59% of the respondents felt low in relation to mental stress. In regards to experiencing relief from these complaints; 30.4% responded after they left their workstations and 66% blamed it on environmental conditions. These data force us to believe that be it homes or offices, one of the foremost reasons for poor health has been the indoor environmental conditions. Secondly, age has been determined as a factor of pre-existing health complaints in individuals, where bad quality of indoor environments can act as a fuel to already existing fire.

The survey results have given us a list of understanding to the preferred indoor environmental conditions by occupants:

- ✓ Individuals need to be more educated on what causes poor environmental conditions and have to be aware of their behavioural consequences such as smoking, unhygienic ambience and excessive use of electronics and other toxic substances such as paint and cleaning detergents.
- ✓ Majority of the respondents were not concerned about indoor environments and did not know how to solve them as they thought of the issues to not be major.

Large scale awareness is very necessary in order to increase people's understanding to types of indoor environmental qualities and how they can have a major impact on the health and productivity levels of individuals in homes and offices.

5.3 Study Limitations

- ✓ It is rather difficult to espouse universal solutions in all fields in order to achieve the best indoor environmental quality. Every indoor environment needs to be

treated separately according to the number of people, type of people and type of usage of space.

- ✓ Thermal comfort was different in different types of buildings as well as different climatic conditions were not taken in account as the survey was done during summers. Therefore these results are based on only one type of climatic condition and different seasonal surveys need to be conducted in order to achieve the best overall solution.
- ✓ More detailed experiments need to be conducted in various types of homes and offices to evaluate that.
- ✓ Not all aspects to indoor environmental quality could be evaluated in the current survey due to the limitation of time .

5.4 Recommendations

- ✓ Thermal comfort is one of the most important aspects to residents in Dubai, and hence a detailed paper with a high priority needs to be prepared in order to analyse thermal comfort more profoundly and explicitly.
- ✓ Governmental policy and regulations need to be created in order to have an accredited system for the design and construction of indoor environments.
- ✓ Gaps have to be identified between the Architect, Owner, Designer, Contractor and Occupants.
- ✓ Many other factors unrelated to IEQ should be understood such as positioning of the workstations or positioning of the building for better daylight, ventilation as well as for better visual and acoustic comfort.
- ✓ One of the general recommendations to Owners and architects should be to manage and control indoor environmental comfort needs on a case by case approach and future studies need to be examined to understand the dynamics of a human body and its needs.
- ✓ Delegating customized approach to indoor environments has been supported by a lot of studies that prove that these can benefit the occupant's health and also provide better working solutions by improving the productivity with satisfied IEQ.

5.5 Suggestions for Future Works

- ✓ An IAQ specific team needs to also examine current environmental conditions in the U.A.E to come up with better solutions and specifics for the build and design of indoor environments HVAC as well as lighting and sound system and also to come up with IAQ certification for enhanced results.
- ✓ Policy implications need to be studied in depth for U.A.E in order to understand why the design and build has failed to provide adequate IEQ to the residents. Recent policies haven't proved sufficient and are mainly concerned with physical design and certain objective measures for green buildings. Policy makers could undergo a detailed examination of the collected surveys and use some more experimental studies through all the seasons for establishing the overall IEQ enhancements for design and build of newer construction developments.
- ✓ An in-depth study also has to be developed for green and healthy indoor environments in order to develop satisfactory IEQ for occupants in residential and commercial complexes.

One of the ways to do the above is by detailed investigation on site, interviewing respondents specifically on the environmental and physical parameters as well as by conducting experiments in the respondent's homes and offices to conclude on the reason for the bad IEQ as well as their health complaints. Such a detailed study can make use of the current survey as well and establish a pattern or analysis and create the relationship between health complaints and environmental parameters. A framework for comfort and health needs to be developed by taking into account the human body firstly and then the environment secondly. A holistic and integrative team needs to be formed in order to do so. There have to be a lot of interactions between the occupants as well as the designers/contractors to achieve the best solution. A design and management team can also be hired to do so. A case by case approach would work more in depth in terms of IEQ. This can have huge implications on the future growth and economy of the country. It is also hoped that this study may have some implications on the thoughts and beliefs as well as creating better understanding over the subject of Indoor Environmental Quality.

5.6 Closing Remarks

The findings of this study advocate that Origin has the least to do with indoor environmental quality whereas gender and Age can play some role not all in determining the perception of an IEQ. Demographic variables no doubt play some role in changing the views and opinions of individuals but as a whole the environmental factors play a much wider role. It was astonishing to observe that personality characteristics of occupants did not influence Comfort as expected, but it did influence health in some aspects, particularly in terms of the impact of gender and age on thermal comfort and health complaints. Smoking has also found to be one of the very important sociological factors to bad IAQ and health. Active and passive smoking have major effects over the health and comfort of an individual.

In an overall summarization, this study focuses on the significance of environmental parameters and also provides great focus on creating change in respect to the way building environments have been treated. This study gives us feedback of occupants and workers as well as their needs and expectations on their changing and ever growing needs for comfort and health that an indoor environment should provide to them. This study can also empower and provide a bench mark for future research and development for building design, environmental management and clientele satisfaction. It will not only benefit the stakeholder but also the clientele and architectural/design and construction agencies and the government as a whole, where the country will benefit from the positive indoor environmental changes which will create a rise in the productivity , level of comfort and overall health of the occupants. It will also help save on resources and maintenance as the best is already provided to them keeping the environment in concern and focus and making use of more natural than artificial parameters.

REFERENCES

Abdellatif, E. (2005). Personal Interview. 13 June 2005.

Abdou, O. A., Murali, K. & Morsi, A. (1996). Thermal performance evaluation of a prefabricated fiber-reinforced plastic building envelope system. *Energy and Buildings* (24), pp. 77-83.

About (2013). *P-value - dictionary definition of p-value* [online]. [Accessed 7 August 2012]. Available at http://economics.about.com/od/termsbeginningwithp/g/pvaluedef.htm

About (2013). *Indoor Environmental Quality (IEQ): building related illness, sick building syndrome and what to do about it* [online]. [Accessed 7 June 2012]. Available at http://sustainability.about.com/od/GreenBuilding/a/Indoor-Environmental-Quality-Sick-Building-Intro.htm.

Al Marashi, H. & Bhinder, J. (2008). From the tallest to the greenest -paradigm shift in Dubai. *CTBUH 8th World Congress* [online]. Dubai, United Arab Emirates, 3-5 March.

Alnaser, N.W. (2008). Towards sustainable buildings in Bahrain, Kuwait and United Arab Emirates. *The Open Construction and Building Technology Journal. V*ol. (2).

Answers (2013). *What was the credibility gap?* [online]. [Accessed 5 Jan 2012]. Available at http://wiki.answers.com/Q/What_was_the_Credibility_gap.

Applied Sensor (2010). *Typical indoor contaminants and their sources*: *ventilation energy savings while maintaining premium air quality* [online]. [Accessed 10 March 2012]. Available at http://www.appliedsensor.com/pdfs/AirQuality_Brochure.pdf.

Baker, J. (1994). *CIBSE code for interior lighting*. *PubMed* [online]. Vol. 50(2), pp.2-5.

Begum, B.A., Paul, S.K., Hossain, M. D., Biswas, S.K., & Hopke, P.K. (2009). *I*ndoor air pollution from particulate matter emissions in different households in rural areas of Bangladesh.*Building and Environment* (44), pp. 893-903.

Behzadi, N. (2011). *Health and comfort implications of indoor air quality and thermal conditions in Dubai elementary schools*. MSc. Thesis. British University in Dubai.

Benton, C.C., & Brager, G.S. (1994). Sunset building: final report - a study of occupant thermal comfort in support of PG&E's advanced customer technology test (act2) for maximum energy efficiency*. Center for Environmental Design Research*. Berkeley, California, 8 June.

Berglund, L., Gonzales, R. & Gagge, A. (1990). Predicted human performance decrement from thermal discomfort and ET. *Proceedings of the fifth international conference on indoor air quality and climate.* Toronto, Canada.

CCOHS (2011). *Thermal comfort for office work* [online]. [Accessed April 2012]. Available at http://www.ccohs.ca/oshanswers/phys_agents/thermal_comfort.html.

Clark, R.P. and Edholm, O.G. (1985). *Man and his thermal environment*. London: E. Arnold.

Cohen, S., Evans, G.W., Krantz, D.S. & Stokols, D. (1980). Physiological, motivational and cognitive effects of aircraft noise on children: moving from the laboratory to the field. *PubMed*. Vol. (35), pp.231-243.

Colome, S.D., Kado, N.Y. Jaques, P. & Kleinman, M. (1992). Indoor-outdoor air pollution relations particulate matter less than 10 nano meter (um) in aerodynamic diameter (pm10) in homes of asthmatics. *Atmospheric Environment* (26a), pp. 2173-2178.

Coultas, D. B, Samet, J .M., McCarthy, J.F. & Spengler, D . (1990) .Variability of measures of exposure to environmental tobacco smoke in the home. *American Journal of Respiratory and Critical Care Medicine.* Vol*.* (142), pp. 602-606.

Damon, A. & Wohlwill, J. F. (1975). Physiological anthropology: Behavioral response and adaptation to environmental stimulation. New York: Oxford University Press.

Dear, D. J. & Brager, G. S. (1998). Developing an adaptive model of thermal comfort and preference. *ASHRAE Transactions.* Vol. 104 *(*1) pp. 145-167.

Diamantopoulos, A. & Schlegelmilch, B.B. (2002). *Taking the fear out of data analysis*. London: Thomson.

Environmental Journalism Canada *(2012). Air pollution [o*nline]. [Accessed 3 Jan 2012]. Available at http://environmental journalismcanada.wikispaces.com/Air+pollution.

EPA (1991). *Indoor air facts no. 4: sick building syndrome (revised)* [online]. [Accessed 5 Jan 2012]. Available at http://www.epa.gov/iaq/pubs/sbs.html.

EPA (1991). *Guidelines for Developmental Toxicity Risk Assessment* [online]. [Accessed 3 March 2012]. Available at
http://www.epa.gov

EPA (2009a). *IAQ Reference Guide* [online]. [Accessed 3 March 2012]. Available at http://www.epa.gov/iaq/schools/tfs/guide2.html.

EPA (2009b). *IAQ Reference Guide* [online]. [Accessed 3 March 2012]. Available at http://www.epa.gov/iaq/schools/tfs/guidee.html.

EPA (2011). *Health effects of exposure to secondhand smoke* [online]. [Accessed 3 March 2012]. Available at http://www.epa.gov/smokefre/healtheffects.html

EPA (2013). *Sick building syndrome* [online]. [Accessed 3 March 2012]. Available at http://ofmpub.epa.gov/sor_internet/registry/termreg/searchandretrieve/termsandacronyms/search.do?search=.

Evans, G.W. (1984). *Environmental stress: The office environment as a source of stress*. New York: Cambridge University Press.

Fanger, P.O. (1970). *Thermal comfort—analysis and applications in environmental engineering*. Copenhagen: Danish technical press.

Fanger, P.O. (1982). *Thermal comfort - analysis and application in environmental engineering.* Malabar, Fl: Krieger Publication Company.
Fondriest. (n.d.).*What is air temperature?* [online]. [Accessed 28 May 2012] Available at http://www.fondriest.com/news/airtemperature.htm.

Frisancho, A.R. (1981). *Human adaptation*. USA: University of Michigan Press.

Glaser, E. M. (1966). *The physiological basis of habituation.* New York: Oxford University Press.

Godish, T. (2010). *Indoor Environmental Quality.* Florida: Lewis Publishers.

Gridskipper (2008). *Futuristic city springs to life in the desert* [online]. [Accessed 3 Jan 2012]. Available at http://gridskipper.com/archives/entries/65882/65882.php.

Gulf News (2011). *Air quality tested in 600 UAE homes* [online]. [Accessed 5 Jan 2012]. Available at http://gulfnews.com/news/gulf/uae/environment/air-quality-tested-in-600-uae-homes-1.611075 .

Hackshaw, A.K., Law, M.R. & Wald, N.J. (1997). The accumulated evidence on lung cancer and environmental tobacco smoke. *British Medical Journal*. Vol.315, pp. 980–988.

Haines, M.M., Stansfeld, S.A., Job, R.F.S. & Berglund, B. (1998). Chronic aircraft noise exposure and child cognitive performance and stress. *Cambridge University press*. Vol. (1&2), pp. 329-335.

Hathaway, W.E., Hargreaves, J.A., Thompson, G.W. & Novitsky, D. (1992) *A study into the effects of light on children of elementary school age – a case of daylight robbery* [online]. [Accessed 10 March 2012]. Available at http://www.naturallighting.com/cart/store.php?sc_page=62.

Heidorn K. (1997). *A simple guide to personal thermal comfort* [online]. [Accessed 24 March 2012]. Available at http://www.islandnet.com/~see/living/winter/personalcomfort.htm.

Heschong, L. (2002). Daylighting and human performance. *ASHRAE Journal* [online]. [Accessed 10 March 2012]. Available at http://bookstore.ashrae.biz/journal/journal_s_article.php?articleID=395.

Hox, J.J. & de Leeuw, E.D. (1994). A comparison of non response in mail, telephone, and face-to-face surveys: applying multilevel models to meta-analysis. *Quality and Quantity*. Vol.28, pp. 329 –344.

HSE (2010). *The six basic factors* [online]. [Accessed 10 April 2012]. Available at http://www.hse.gov.uk/temperature/thermal/factors.htm.

Huang, L., Zhu, Y., Ouyang, Q. & Cao, B. (2012). A study on the effects of thermal, luminous, and acoustic environments on indoor environmental comfort in offices, building and environment. *Building and Environment* (49), pp. 304-309.

Hussein, I. & Rahman, M. H.A. (2009). Field study on thermal comfort in Malaysia. *European Journal of Scientific Research*. Vol. 37 (1), pp. 134-152.

Hygge, S., Evan, S G. & Bullinger, M. (1995). Chronic noise and psychological stress. *Psychological Science*. Vol. (6), pp. 333-338.

Hygge, S., Evans, G. & Bullinger, M. (1996). The Munich airport noise study: cognitive effects on children from before to after the changeover of airports. *CSA Illumina* [online]. [Accessed 3 March 2012]. Available at

http://md1.csa.com/partners/viewrecord.php?requester=gsandcollection=ENVandrecid=4091673.

IHS. (1994). CIBSE code for interior lighting. *The Chartered Institution of Building Services Engineers* [online]. [Accessed 10 March 2012]. Available at http://products.ihs.com/Ohsis-SEO/120709.html.

Issaa, M.H., Rankina, J.H., Attalla, M. & Christiana, A.J. (2011). Absenteeism, performance and occupant satisfaction with the indoor environment of green Toronto schools. *Indoor and Built Environment*. *Vol.* 20 (5), pp. 511-523.

Ji, S.H. (2006). *Shifting of thermal comfort zone due to outdoor temperature* [online]. MSc. Thesis. The University of Texas at Austin [Accessed 12 May 2012]. Available at http://soa.utexas.edu/sustainabledesign/docs/seung.pdf.

Jo, W. & Sohn, J. (2009).The effect of environmental and structural factors on indoor air quality of apartments in Korea. *Building and Environment* (44), pp. 1794–1802.

Juslén, H. (2006). Lighting and productivity in the industrial working place. *Lighting Engineering*. Vol. *(*XI) pp. 53-62.

Karsdorf, G. & Klappach, H. (1968). Effects of traffic noise on health and achievement of high school students of a large city. *PubMed* [online]. Vol. 14 (1), pp. 52-54.

Kleinman, M. T. (2000). *South coast air quality management district: the health effects of air pollution on children* [online]. [Accessed 10 March 2012]. Available at http://www.aqmd.gov/forstudents/health_effects_on_children.pdf.

Kolokotsa, D., Tsiavos, D., Stavrakakis, G.S., Kalaitzakis, K. & Antonidakis, E. (2001). Advanced fuzzy logic controllers design and evaluation for buildings' occupant's thermal–visual comfort and indoor air quality satisfaction. *Energy and Buildings* (33), pp. 531-543.

Krieger, J., Takaro, T.K., Allen, C., Song, L., Weaver, M., Chai, S. & Dickey, P. (2002). The Seattle–king county healthy homes project: implementation of a comprehensive approach to improving indoor environmental quality for low-income children with asthma. *Environmental Health Perspectives*. Vol. 110 (2), pp.311-322.

Lai, A.C.K., Mui, K.W. & Wong, L.T. (2009). An evaluation model for indoor environmental quality (ieq) acceptance in residential buildings. *Energy and Buildings (*41), pp. 930-936.

Lan, L. & Lian, Z. (2009). Use of neurobehavioral tests to evaluate the effects of indoor environment quality on productivity. *Building and Environment* (44), pp. 2208–2217.

Leaderer, B.P., Cain, W.S., Isseroff, R. & Berglund, L.G. (1984). Ventilation requirements in buildings. II. Particulate matter and carbon dioxide from cigarette smoking. *Atmospheric Environment* (18), pp 99-106.

Leaderer, B.P. & Hammond, S.K. (1991). Evaluation of vapour phase nicotine and respirable suspended particle mass as markers for environmental tobacco smoke. *Environmental Science and Technology*. Vol. (25), pp 770-777.

Lee, T.G., Biasio, D.D. & Santini, A. (1996). *Vital signs: health and the built environment: indoor air quality* [online]. [Accessed 10 March 2012]. Available at http://arch.ced.berkeley.edu/vitalsigns/res/downloads/rp/iaq/iaq.pdf.

Levin, H. (1995). Physical factors in the indoor environment. *Occupational Medicine*. Vol. 10 (1), pp 59-94.

Lin, T.P. (2009). Thermal perception, adaptation and attendance in a public square in hot and humid regions. *Building and Environment* (44), pp. 2017–2026.

Magnier, L., Zmeureanu, R. & Derome, D. (2012). Experimental assessment of the velocity and temperature distribution in an indoor displacement ventilation jet. *Building and Environment* (47), pp. 150-160.

Meese, G., Kok, R., Lewis, M. & Wyon, D. (1984). A laboratory study of the effects of moderate thermal stress on the performance of factory workers. *Ergonomics*. Vol. 27(1), pp. 19-43.

Middle East Events (2010). *U.A.E continues to lead green building practices and initiatives in GCC inaugural green building Middle East summit and expo in Abu Dhabi to discuss green direction for region* [online]. [Accessed 3 Jan 2012]. Available at http://www.middleeastevents.com/site/pres_dtls.asp?pid=9979.

Miglani, D. (1986). *Noise pollution: sources, effects and control* [online]. [Accessed 24 March 2012]. Available at http://www.legalserviceindia.com/articles/noip.htm.

Miller, C.S. & Ashford, N.A. (2001). *Indoor Air Quality Handbook: Multiple Chemical Intolerance and Indoor Air Quality.* New York: McGraw-Hll.

Miller,S.L. & Nazaro,W.W. (2000). Environmental tobacco smoke particles in multizone indoor environments. *Atmospheric Environment* (35), pp. 2053-2067.

Mohsen, M. A., (2005). Towards green buildings: glass as a building element—the use and misuse in the gulf region. *Energy and Buildings* (53), pp. 26-33.

Moschandreas, D.J. & Vuilleumier, K.L. (1999). ETS levels in hospitality environments satisfying ASHRAE standard 62- 1989, "ventilation for acceptable indoor air quality". *Atmospheric Environment* (33), pp.4327-4340.

Muddari, D. (2010). *Public health consequences and cost of climate change impacts on indoor environment* [online]. [Accessed 10 March 2012]. Available at http://www.epa.gov/iaq/pdfs/mudarri.pdf.

Ncube, M. & Riffat, S. (2012).Developing an indoor environment quality tool for assessment of mechanically ventilated office buildings in the UK - a preliminary study. *Energy and Buildings* (53), pp. 26-33.

Nevalainen, A. & Morawska, L. (2009). *Biological agents in indoor environments: assessment of health risks*. [Accessed 10 March 2012]. Available at http://www.ilaqh.qut.edu.au/Misc/BIOLOGICAL%20AGENTS%202009.pdf.

New Zealand Department of Labour. (2007). *Health bulletin-physical hazards fact sheet – thermal comfort project* [online]. [Accessed 10 March 2012]. Available at http://www.osh.govt.nz/publications/series/hb-21-thermalcomfort.html.

Nicol, F. (1993). *Thermal comfort—a handbook for field studies toward an adaptive model.* London: University of East London.

Nicol, J.F. & Raja, I.A. (1996). *Thermal comfort, time and posture: exploratory studies in the nature of adaptive thermal comfort*. England: Oxford Brookes University, School of Architecture.

Ozkaynak . H., Xue, J., Spengler, J., Wallace, L., Pellizzari, E . & Jenkins, P. (1996). Personal exposure to airborne particles and metals : results from the Particle TEAM study in Riverslde, California. *Journal of Exposure Analysis and Environmental Epidemiology*. Vol. (6), pp. 57-78.

Perry, M. J., Campbell, F. W. & Rothwell, S. E. (1987). A physiological phenomenon and its implications for lighting design. *Lighting Research and Technology*. Vol. (19), pp. 1-5.

Plotnik R & Kouyoumdjian, H. (2011). *Introduction to psychology*. California: Pacific Grove.

Preserve Articles (2012). *What are the main causes of noise pollution?* [online]. [Accessed 3 March 2012]. Available at http://www.preservearticles.com/2012011320628/what-are-the-main-causes-of-noise-pollution.html.

Prianto, E. & Depecker, P. (2001). Characteristic of airflow as the effect of balcony, opening design and internal division on indoor velocity a case study of traditional dwelling in urban living quarter in tropical humid region. *Energy and Buildings* (34), pp. 401-409.

Qi, Q. & Deng, S. (2009).Multivariable control of indoor air temperature and humidity in a direct expansion (dx) air conditioning (a/c) system. *Building and Environment* (44), pp. 1659–1667.

Redman, T., Hamilton, P., Malloch, H. & Kleymann, B. (2011). Working here makes me sick! The consequences of sick building syndrome. *Human Resource Management Journal* (21), pp. 14-27.

Rosen, K.G. & Richardson, G. (1999). Would removing indoor air particulates in children's environments reduce rate of absenteeism a hypothesis. *Science of the Total Environment* (234), pp. 87-93.

Saade, J.J. & Ramadan, A.H. (2008). Control of thermal-visual comfort and air quality in indoor environments through a fuzzy inference-based approach. *International Journal of Mathematical Models and Methods in Applied Sciences*. Vol. (2).

Saadeh, D. (2007). *Environment key challenge for booming Dubai*. [online] [Accessed 19 February 2012]. Available at http://www.reuters.com/article/2007/05/03/environment-emirates-recycle-env-dc-idUSL0353057620070503.

Schneider, M. (2002). *Do school facilities affect academic outcomes? National clearing house for educational facilities* [online]. [Accessed 10 April 2012]. Available at http://www.ncef.org/pubs/outcomes.pdf.

Seltzer, J. (1994).Biological contaminants*. Journal of Allergy and Clinical Immunology*. Vol. 94 (2), pp. 318-326.

Seppanen, O., Fisk, W.J. & Lei, Q.H. (2006). Room temperature and productivity in office work. *Lawrence Berkeley National Laboratory* [online]. [Accessed 10 April 2012]. Available at http://escholarship.org/uc/item/9bw3n707#page-3.

Sekhar, C. (2009). IAQ and sustainability—a balancing act. *HVAC&R Research*. Vol. 15(6), pp. 987-989.

Shendell, D., Barnett, C. & Boese, S. (2004). Science-based recommendations to prevent or reduce potential exposures to biological, chemical, and physical agents in schools. *Journal of School Health*. Vol. 74 (10), pp. 390-396.

Spengler, J.D., Dockery, D .W., Turner, W.A., Wolfson, J .M . & Ferris, B.G. (1981). Long-term measurements of respirable sulfates and particles inside and outside homes. *Atmospheric Environment*. Vol. 15, pp. 23-30.

Tanabe, S., Arens, Edward A., Bauman, F., Fred, Zhang, H. & Madsen, T. (1994). Evaluating thermal environments by using a thermal manikin with controlled skin surface temperature. *Center for the Built Environment UC Berkeley*. Vol. 100 (1), pp. 39-48.

Todorova, V. (2009). 850 deaths each year linked to air pollution. *The National* [online] 4 October, p.1. [Accessed 19 February 2012]. Available at: http://www.thenational.ae/news/uae-news/health/850-deaths-each-year-linked-to-air-pollution#full.

Tulen, J.H.M., Kumar, A. & Jurriins, A.A. (1986). Psycho physiological acoustics of indoor sound due to traffic noise during sleep. *Journal of Sound and Vibration* (110), pp. 129-141.

Veitch, J. A., Hine, D. W. & Gifford, R. (1993). End users' knowledge, preferences, and beliefs for lighting. *Journal of Interior Design*. Vol. 19 (2), pp. 15-26.

Veitch, J. A. & Newsham, G. R. (1995). *Quantifying lighting quality based on experimental investigations of end user performance and preference* [online]. [Accessed 10 March 2012]. Available at http://130.203.133.150/showciting;jsessionid=BE89E7911B8E581EFF50776DF19196AE?cid=5913139.

Veitch, J. A., Miller, N., Mckay, H. & Jones C. C. (1996). *Lighting system effects on judged lighting quality and facial appearance*. [online]. [Accessed 10 March 2012]. Available at http://www.lrc.rpi.edu/resources/pdf/51-1996.pdf.

Veitch, J. A. & Newsham, G. R. (1996). *Determinants of lighting quality II: research and recommendations*. [online]. [Accessed 10 March 2012]. Available at http://citeseerx.ist.psu.edu/viewdoc/similar;jsessionid=D1DEBCFCA775366AE1C6403EC3A8D967?doi=10.1.1.4.4116andtype=ab.

Veitch, J. A. (2001). Psychological processes influencing lighting quality. *Journal of the Illuminating Engineering Society*. Vol. *30*(1), pp. 124-140.

Vermeer, W. P. & Passchier, W.F. (2000). Noise exposure and public health. *Environmental Health Perspectives*. Vol. (108), pp. 123- 131.

Wikipedia (2013). *Sick building syndrome*. [online]. [Accessed 10 March 2012]. Available at http://en.wikipedia.org/wiki/Sick_building_syndrome.

Wikipedia (2013). *ANOVA*. [online]. [Accessed 10 March 2012]. Available at https://en.wikipedia.org/wiki/Analysis_of_variance

Wikipedia (2013). *T-Test*. [online]. [Accessed 10 March 2012]. Available at https://en.wikipedia.org/wiki/T-test

Wienold, J. (2007). *Dynamic simulation of blind control strategies for visual comfort and energy balance analysis* [online]. [Accessed 10 March 2012]. Available at http://www.ibpsa.org/proceedings/BS2007/p231_final.pdf.

Wohlwill, J. F. (1975). Children's responses to meaningful pictures varying in diversity: exploration time vs. preference. *Journal of Experimental Child Psychology*. Vol. (20), pp.341-351.

Wolkoff, P. & Kjærgaard, S.J. (2007). The dichotomy of relative humidity on indoor air quality. *Environment International* (33), pp. 850–857.

World Health Organization (1946). *The definition of health.* [online].Vol. (2), pp. 100. [Accessed 10 March 2012]. Available at http://www.who.int/about/definition/en/print.html.

World Health Organization (2002). The preamble to the constitution of world health organization. *PubMed*. Vol. 80(12), pp. 981-984.

Wyon, D.P., Andersen, I. & Lundqvist, G.R. (1972). Spontaneous magnitude estimation of thermal discomfort during changes in the ambient temperature. *The Journal of Hygiene*. Vol. 70 (2), pp. 203-221.

LIST OF APPENDICES

APPENDIX A

RESIDENTIAL SURVEY FORMAT

Residential Indoor Environmental Survey | Date/Time:

1. Demographic Information

1.1 Sex
Male ☐ Female ☐

1.2 Age
20 -30 ☐ 31-40 ☐ 41-50 ☐ 51-60 ☐ 61-70 ☐ 71-80 ☐

1.3 Country Of Origin
Asian ☐ American ☐ European ☐ Arab ☐ African ☐

1.4 Length of stay in U.A.E: _____

2. Environmental Conditions

2.1 Number of people residing with you? _____

2.2 Type of residential building:
Villa ☐ Apartment ☐ Hotel Apartment ☐

2.3 No. of Rooms in your residential building
Studio ☐ 1BR ☐ 2BR ☐ 3BR ☐ 4BR ☐ 5BR+ ☐

2.4 How is your area Air-Conditioned?
Window Unit ☐ Split Unit ☐ Central Unit ☐

2.5 How many hours is the Air-conditioner operational in your house? _____

2.6 What is the main type of lighting in your home?
Fluorescent Lighting ☐ Non Fluorescent Lighting ☐

2.7 Please indicate if you sit mostly near the following equipment at home:

Computer/Laptop	Everyday ☐	2-3 times weekly ☐	Never ☐
Printers	Everyday ☐	2-3 times weekly ☐	Never ☐
Television	Everyday ☐	2-3 times weekly ☐	Never ☐
Telephones/Fax	Everyday ☐	2-3 times weekly ☐	Never ☐

2.8 Do you have to put on extra clothing for comfort?
Regularly ☐ Sometimes ☐ Never ☐

2.10 Do you have smoking members in the family? YES ☐ NO ☐
If YES, do they smoke indoors YES ☐ NO ☐

2.11 No. of hours spent per day at your home? _____

2.12 Is your Kitchen: Open ☐ OR Closed ☐

2.13 Does the kitchen area consist of an exhaust?

YES ☐ NO ☐

2.12 Please rate the level of satisfaction in your home, in the past 1-4 weeks;

	Highly dissatisfied			*Neutral*			*Highly satisfied*
	-3	-2	-1	0	+1	+2	+3
Noise							
Humidity							
Lighting							
Indoor Air Quality							
Thermal Comfort							

3. Health Complaints

3.1 Please indicate your experience of the following symptoms at home during the past month:

Headache	Everyday ☐	2-3 times weekly ☐	Never ☐
Lethargy	Everyday ☐	2-3 times weekly ☐	Never ☐
Drowsiness	Everyday ☐	2-3 times weekly ☐	Never ☐
Dizziness	Everyday ☐	2-3 times weekly ☐	Never ☐
Nausea/vomiting	Everyday ☐	2-3 times weekly ☐	Never ☐
Shortness of breath	Everyday ☐	2-3 times weekly ☐	Never ☐
Stuffy nose	Everyday ☐	2-3 times weekly ☐	Never ☐
Dry Throat	Everyday ☐	2-3 times weekly ☐	Never ☐
Skin rash/itchiness	Everyday ☐	2-3 times weekly ☐	Never ☐
Eye irritation	Everyday ☐	2-3 times weekly ☐	Never ☐

3.2 No. of days in the past one month that you had to take off work because of these complaints? _____

3.3 When do these complaints occur? Mornings ☐ Afternoons ☐ No noticeable trend ☐

3.4 When do you experience relief from these complaints?
After I leave my home ☐ After I enter my home ☐ Never ☐

3.5 Please Indicate if you have any of these medical conditions:

Asthma?	Yes, on medication ☐	Yes, not on medication ☐	No ☐
Allergy?	Yes, on medication ☐	Yes, not on medication ☐	No ☐
Sinus?	Yes, on medication ☐	Yes, not on medication ☐	No ☐
Migraine?	Yes, on medication ☐	Yes, not on medication ☐	No ☐
Any Other?	_____		

3.6 What do you think is affecting your productivity at home?
Environmental Conditions ☐ Work Stress ☐

APPENDIX B

COMMERCIAL SURVEY FORMAT

Commercial Indoor Environmental Survey | Date/Time:

1. Demographic Information

1.1 Sex
Male ☐ Female ☐

1.2 Age
20 -30 ☐ 31-40 ☐ 41-50 ☐ 51-60 ☐ 61-70 ☐ 71-80 ☐

1.3 Country Of Origin
Asian ☐ American ☐ European ☐ Arab ☐ African ☐

1.4 Length of stay in U.A.E: _____

2. Environmental Conditions

2.1 What is your job category?
Managerial ☐ Professional ☐ Secretarial ☐ Clerical ☐ Other ☐
(If other Please Specify): _____

2.2 Type of workstation
Enclosed room ☐ Open concept ☐

2.3 Number of people who share your work station _____

2.4 How is your area Air-Conditioned?
Window Unit ☐ Split Unit ☐ Central Unit ☐

2.5 How is your workstation lighted?
Fluorescent Lighting ☐ Non Fluorescent Lighting ☐

2.6 Please indicate if you work with or near the following equipment:

Computer/Laptop	Everyday ☐	2-3 times weekly ☐	Never ☐
Printers	Everyday ☐	2-3 times weekly ☐	Never ☐
Photocopier	Everyday ☐	2-3 times weekly ☐	Never ☐
Fax Machine	Everyday ☐	2-3 times weekly ☐	Never ☐

2.7 Do you have to put on extra clothing for comfort?
Regularly ☐ Sometimes ☐ Never ☐

2.8 Does the office air have an unpleasant odor?
Regularly ☐ Sometimes ☐ Never ☐

2.9 Does the office air feel unventilated?
Regularly ☐ Sometimes ☐ Never ☐

2.10 Are there colleagues in your office often taking a smoke break? YES ☐ NO ☐

2.11 What do you think is affecting your productivity?
Environmental Conditions ☐ Work Stress ☐

2.11 Please rate the level of satisfaction in your office area, in the past 1-4 weeks;

	Highly dissatisfied -3	-2	-1	*Neutral* 0	+1	+2	*Highly satisfied* +3
Noise *(Speech privacy, sound vibration, reverberation, etc.)*							
Lighting *(Glare, integration of artificial light and daylight, occupancy factors and controls, etc.)*							
Indoor Air Quality *(Smell of gases, vapour, fumes, smoke, fresh air; dust; bacteria, mold; occupancy factors and control; etc.)*							
Thermal Comfort *(Air temperature, radiant temperature, humidity, air speed, occupancy factors and controls, etc.)*							

3. Nature of Occupation

3.1 No. of hours spent per day at your main workstation _____

3.2 Please rate how you find the stress in your working conditions:

Physical stress experience: Low ☐ Moderate ☐ High ☐
Mental stress experience: Low ☐ Moderate ☐ High ☐
Climate of cooperation at work: Low ☐ Moderate ☐ High ☐

4. Health Complaints

4.1 Please indicate your experience of the following symptoms at work during the past month:

Headache	Everyday ☐	2-3 times weekly ☐	Never ☐
Lethargy	Everyday ☐	2-3 times weekly ☐	Never ☐
Drowsiness	Everyday ☐	2-3 times weekly ☐	Never ☐
Dizziness	Everyday ☐	2-3 times weekly ☐	Never ☐
Nausea/vomiting	Everyday ☐	2-3 times weekly ☐	Never ☐
Shortness of breath	Everyday ☐	2-3 times weekly ☐	Never ☐
Stuffy nose	Everyday ☐	2-3 times weekly ☐	Never ☐
Dry Throat	Everyday ☐	2-3 times weekly ☐	Never ☐
Skin rash/itchiness	Everyday ☐	2-3 times weekly ☐	Never ☐
Eye irritation	Everyday ☐	2-3 times weekly ☐	Never ☐

4.2 No. of days in the past one month that you had to take off work because of these complaints? _____

4.3 When do these complaints occur? Mornings ☐ Afternoons ☐ No noticeable trend ☐

4.4 When do you experience relief from these complaints?
After I leave my workstation ☐ After I leave the building ☐ Never ☐

4.5 Please indicate if you have any of these medical conditions:

Asthma?	Yes, on medication ☐	Yes, not on medication ☐	No ☐
Allergy?	Yes, on medication ☐	Yes, not on medication ☐	No ☐
Sinus?	Yes, on medication ☐	Yes, not on medication ☐	No ☐
Migraine?	Yes, on medication ☐	Yes, not on medication ☐	No ☐

APPENDIX C

RESPONDED SURVEY SAMPLE

Residential Indoor Environmental Survey | Date/Time:

1. Demographic Information

1.1 Sex
Male ☐ Female ☑

1.2 Age
20 -30 ☑ 31-40 ☐ 41-50 ☐ 51-60 ☐ 61-70 ☐ 71-80 ☐

1.3 Country Of Origin
Asian ☑ American ☐ European ☐ Arab ☐ African ☐

1.4 Length of stay in U.A.E: 10years

2. Environmental Conditions

2.1 Number of people residing with you? 3

2.2 Type of residential building:
Villa ☐ Apartment ☑ Hotel Apartment ☐

2.3 No. of rooms in your residential space
Studio ☐ 1BR ☐ 2BR ☐ 3BR ☑ 4BR ☐ 5BR+ ☐

2.4 How is your area Air-Conditioned?
Window Unit ☐ Split Unit ☑ Central Unit ☐

2.5 How many hours is the Air-conditioner operational in your house? 24/7.

2.6 What is the main type of lighting in your home?
Fluorescent Lighting ☐ Non Fluorescent Lighting ☑

2.7 Please indicate if you sit mostly near the following equipment at home:

Computer/Laptop	Everyday ☐	2-3 times weekly ☐	Never ☐
Printers	Everyday ☐	2-3 times weekly ☐	Never ☐
Television	Everyday ☐	2-3 times weekly ☐	Never ☐
Telephones/Fax	Everyday ☐	2-3 times weekly ☐	Never ☐

2.8 Do you have to put on extra clothing for comfort?
Regularly ☐ Sometimes ☑ Never ☐

2.10 Do you have smoking members in the family? YES ☐ NO ☑
If YES, do they smoke indoors YES ☐ NO ☐

2.11 No. of hours spent per day at your home? 7-8 hrs.

2.12 Is your Kitchen: Open ☐ OR Closed ☑

2.13 Does the kitchen area consist of an exhaust?

YES ☑ NO ☐

2.14 Please rate the level of satisfaction in your home, in the past 1-4 weeks;

	Highly dissatisfied -3	-2	-1	*Neutral* 0	+1	+2	*Highly satisfied* +3
Noise *(Speech privacy, sound vibration, reverberation, etc.)*					✓		
Lighting *(Glare, integration of artificial light and daylight, occupancy factors and controls, etc.)*				✓			
Indoor Air Quality *(Smell of gases, vapour, fumes, smoke, fresh air; dust; bacteria, mold; occupancy factors and control; etc.)*	✓						
Thermal Comfort *(Air temperature, radiant temperature, humidity, air speed, occupancy factors and controls, etc.)*				✓			

3. Health Complaints

3.1 Please indicate your experience of the following symptoms at home during the past month:

Headache	Everyday ☐	2-3 times weekly ☐	Never ☑
Lethargy	Everyday ☐	2-3 times weekly ☐	Never ☑
Drowsiness	Everyday ☐	2-3 times weekly ☐	Never ☑
Dizziness	Everyday ☐	2-3 times weekly ☑	Never ☐
Nausea/vomiting	Everyday ☐	2-3 times weekly ☐	Never ☑
Shortness of breath	Everyday ☐	2-3 times weekly ☐	Never ☑
Stuffy nose	Everyday ☐	2-3 times weekly ☑	Never ☐
Dry Throat	Everyday ☐	2-3 times weekly ☑	Never ☐
Skin rash/itchiness	Everyday ☐	2-3 times weekly ☐	Never ☑
Eye irritation	Everyday ☐	2-3 times weekly ☑	Never ☐

3.2 No. of days in the past one month that you had to take off work because of these complaints? 2-3days

3.3 When do these complaints occur? Mornings ☐ Afternoons ☐ Evenings ☑ No noticeable trend ☐

3.4 When do you experience relief from these complaints?
After I leave my home ☐ After I enter my home ☐ Never ☑

3.5 Please Indicate if you have any of these medical conditions:

Asthma?	Yes, on medication ☐	Yes, not on medication ☐	No ☑
Allergy?	Yes, on medication ☐	Yes, not on medication ☐	No ☑
Sinus?	Yes, on medication ☐	Yes, not on medication ☐	No ☑
Migraine?	Yes, on medication ☐	Yes, not on medication ☐	No ☑
Any Other?	_____		

3.6 What do you think is affecting your productivity at home?
Environmental Conditions ☑ Work Stress ☐

APPENDIX D

RESIDENTIAL SURVEY RESULTS

APPENDIX E

COMMERCIAL SURVEY RESULTS