MITIGATION OF AIRBORNE CONTAMINANTS IN MALAYSIAN OFFICES

JASPREET KAUR A/P MALKEET SINGH

FACULTY OF ENGINEERING
UNIVERSITI MALAYA
KUALA LUMPUR

2021

MITIGATION OF AIRBORNE CONTAMINANTS IN MALAYSIAN OFFICES

JASPREET KAUR A/P MALKEET SINGH

DISSERTATION SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SAFETY, HEALTH AND ENVIRONMENT ENGINEERING

FACULTY OF ENGINEERING
UNIVERSITI MALAYA
KUALA LUMPUR

2021

UNIVERSITI MALAYA

ORIGINAL LITERARY WORK DECLARATION

Name of Candidate: Jaspreet Kaur A/P Malkeet Singh
Matric No: 17201658
Name of Degree: Master of Safety, Health and Environment
Engineering Title of Project Paper/Research Report/Dissertation/Thesis ("this Work") Mitigation of Airborne Contaminants in Malaysian Offices
Field of Study: Indoor air contaminant

I do solemnly and sincerely declare that:

(1) I am the sole author/writer of this Work;
(2) This Work is original;
(3) Any use of any work in which copyright exists was done by way of fair dealing and for permitted purposes and any excerpt or extract from, or reference to or reproduction of any copyright work has been disclosed expressly and sufficiently and the title of the Work and its authorship have been acknowledged in this Work;
(4) I do not have any actual knowledge nor do I ought reasonably to know that the making of this work constitutes an infringement of any copyright work;
(5) I hereby assign all and every rights in the copyright to this Work to the University of Malaya ("UM"), who henceforth shall be owner of the copyright in this Work and that any reproduction or use in any form or by any means whatsoever is prohibited without the written consent of UM having been first had and obtained;
(6) I am fully aware that if in the course of making this Work I have infringed any copyright whether intentionally or otherwise, I may be subject to legal action or any other action as may be determined by UM.

Candidate's Signature Date: 28/09/2021

Subscribed and solemnly declared before,

Witness's Signature Date: 28/09/2021

Name: Ir Dr Jegalakshimi Jewaratnam

Designation: Senior Lecturer

MITIGATION OF AIRBORNE CONTAMINANTS IN MALAYSIAN OFFICES

ABSTRACT

Airborne contamination has been in the talk throughout the years. Research studies have shown that due to airborne contaminations such as volatile organic compound, particulate matter, asbestos, radon, nitrogen oxides, viruses, and ozone in office there is possible effects of indoor air quality (IAQ) on the office building and its work performance. The COVID-19 pandemic has promoted a renewed interest in the assessment of decline IAQ condition in closed space office. According to World Health Organization (WHO), it has been proven that one of the transmission routes of COVID-19 is through aerosols which open a possibility that an airborne transmission can occur, thus, higher chance of spreading in an indoor space with high occupancy, such as office building.

Thus, the study aims to develop a comprehensive checklist and guideline that is used to mitigate and prevent airborne contamination in office. As a result, a survey was conducted to determine the source of contaminant in office and its health impact on office occupants. Questionnaire forms were distributed among the office occupants to get their feedback on their satisfaction towards their office IAQ. A total of 102 office occupants have participated in this survey. The data collected were analysed using SPSS statistical software and based on the data analysed, most of the respondent experience sick building syndrome (SBS) symptoms analysed through four factor which are source of contamination in office, offices surrounding environment, office equipment and activities and ventilation.

Hence, based on the results. a checklist and guideline were developed to prevent or minimize indoor air contamination in office. This checklist and guideline were

established as a safety measure for office users, owner, employer, and employee to evaluate and mitigate the source of airborne contamination in closed space office. The checklist aims to identify the factors influencing the complaints, thus giving a general overview of the suspected source of pollutants and the guideline aims to provide awareness and steps to be taken to mitigate and reduce the presence of source of contaminant in the office. A total of nineteen new parameter were added in the checklist which are ventilation system, type of material, cleaning material, food and drink management, smoking management, waste management, toilet management, furniture, electronic equipment, office stationaries, personal and hygiene product, surrounding activities, maintenance operation include pest control, refreshers, office design, storage management, natural occurrence, plant-based contamination, and air conditioning system.

Keywords: office, Malaysia, indoor guideline, sick building syndrome, indoor checklist

MITIGASI KONTAMINASI UDARA DI PEJABAT MALAYSIA

ABSTRAK

Pencemaran udara telah menjadi bahan perbincangan selama bertahun-tahun. Penelitian kajian menunjukkan bahawa kerana pencemaran udara seperti sebatian organik yang tidak menentu, bahan zarah, asbestos, radon, nitrogen oksida, virus dan ozon di pejabat terdapat kemungkinan kesan kualiti udara dalaman (IAQ) pada bangunan pejabat dan prestasi kerjanya.. Pandemik COVID-19 telah mendorong minat baru dalam penilaian penurunan keadaan IAQ di pejabat ruang tertutup. Menurut Pertubuhan Kesihatan Sedunia (WHO), telah membukti bahawa salah satu laluan penularan COVID-19 adalah melalui aerosol yang membuka kemungkinan penularan melalui udara dapat terjadi, dengan demikian, peluang penyebaran lebih tinggi di ruangan dengan penghunian tinggi, seperti bangunan pejabat.

Oleh itu, kajian ini bertujuan untuk menyusun senarai semak dan garis panduan yang komprehensif yang digunakan untuk mengurangkan dan mencegah pencemaran udara di pejabat. Akibatnya, tinjauan dilakukan untuk menentukan sumber pencemaran di pejabat dan kesan kesihatannya terhadap penghuni pejabat. Borang soal selidik diedarkan di kalangan penghuni pejabat untuk mendapatkan maklum balas mengenai kepuasan mereka terhadap IAQ pejabat mereka. Seramai 102 penghuni pejabat telah mengambil bahagian dalam tinjauan ini. Data yang dikumpulkan dianalisis menggunakan perisian statistik SPSS dan berdasarkan data yang dianalisis, sebahagian besar gejala mengalami sindrom bangunan sakit (SBS) dianalisis melalui faktor berikut punca pencemaran di pejabat, persekitaran sekitar pejabat, peralatan dan aktiviti pejabat dan pengudaraan. .

Oleh itu, berdasarkan hasilnya. senarai semak dan garis panduan disediakan untuk mencegah atau mengurangkan pencemaran udara dalaman di pejabat. Senarai semak

dan garis panduan ini ditetapkan sebagai langkah keselamatan bagi pengguna pejabat, pemilik, majikan, dan pekerja untuk menilai dan mengurangkan sumber pencemaran udara di pejabat tertutup. Sebanyak sembilan belas parameter baru dimasukkan dalam senarai semak yang meliputi sistem pengudaraan, jenis bahan, bahan pembersih, pengurusan makanan dan minuman, pengurusan merokok, pengurusan sampah, pengurusan tandas, perabot, peralatan elektronik, alat tulis pejabat, produk kebersihan diri dan peribadi, kegiatan di sekitarnya, operasi pemeliharaan meliputi pengendalian hama, penyegar, desain kantor, pengurusan penyimpanan, kejadian alam, pencemaran nabati, dan sistem penyaman udara.

Keywords: pejabat, Malaysia, garis panduan untuk pejabat, sindrom bangunan sakit,senarai semak pejabat

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

DOSH	:	Department Of Occupational Safety and Health
WHO	:	World Health Organization
ICOP-IAQ	:	Industry Of Code of Practice on Indoor Air Quality
IAQ	:	Indoor Air Quality
PM	:	Particulate Matter
VOC	:	Volatile Organic Compounds
PCB	:	Polychlorinated Biphenyls
PAH	:	Polycyclic Aromatic Hydrocarbons
PCN	:	Polychlorinated Naphthalene
CO	:	Carbon Monoxide
UM	:	Urea-Formaldehyde
PF	:	Phenol-Formaldehyde
SVOCs	:	Semi Volatile Organic Compounds
ETS	:	Environment Tobacco Smoke
MS	:	Mainstream Smoke
SS	:	Side Stream Smoke
SBS	:	Sick Building Syndrome
HVAC	:	Heat, Ventilation, And Air Conditioning
OSHA	:	Occupational Safety and Health Act 1994
SPSS	:	Statistical Package for the Social Sciences
ASHRAE	:	American Society of Heating Refrigerating and Air -Conditioning Engineers

LIST OF APPENDICES

CHAPTER 1: INTRODUCTION

1.1 Background Study

In the end of year 2019, the world has been infected by a deadly virus name COVID-19 that have taken about 150,000 death and have affected 2.3 million people worldwide and the number keep increasing on daily basis(Azlan, Hamzah, Sern, Ayub, & Mohamad, 2020). With the rising cases of infection, there is urgent need to come out with ways to curb this virus spread and put a stop to this global pandemic. Hence, it is time to pay attention to the air we breathe indoors, as most of us spend 90% of our time indoors and almost 70 % of which is at home. As many countries implement stay at home or lockdown policies, it is vital to pay attention to the factors that cause indoor air quality to reduce and subsequently have severe effect on human health.

Air is such a vital component to our human existence. The average person breathes in 18 kg of air daily this is more than 1.2 kg of water and 1.3 kg of food that we consume on daily basis. According to a report done by the world health organization (WHO; World Health Organization. Office of & Health Literature, 1988) , state that 9 out of 10 people inhale air that surpasses the limits set by World Health Organization. WHO. Moreover, indoor air pollution is the leading risk factor for premature death and WHO have identified the death rate to be at 4.3 million. This is an alarming case and action must be taken to encounter the Indoor Air Quality problems.

Air contamination generated generally are in solid, liquid, or gaseous state. Air contaminants can come in many ranges relatively harmless to toxic dust, vapours, mist,

fumes, and gases that may be extremely dangerous. Air contaminant is major concern towards human health and environment. It was discovered that long term and short-term exposure to fine particle pollution can cause premature death, severe impact to cardiovascular system and respiratory disease such as asthma. Furthermore, in a closed space the contaminant can be generated from various source example from air condition, carpets, electrical equipment, lighting, appliances, used cleaning agents etc. This contamination is usually referred to "poor quality of indoor air". Since indoor environment is where people spend most of their time, to protect against this risk, the origin of the particles/contamination need to be understood (Morawska et al., 2017). A variety of gaseous contaminants in indoor air are emitted from indoor sources or brought into the building with outdoor which pose risk to health and may affect the indoor air condition. Certain health effects may appear shortly after a single exposure or after frequent exposures to a contaminant. Diseases such as asthma may appear up and deteriorated with the exposure to indoor air pollution.

In Malaysia, legislation was introduced in early 2005 when the Department of Occupational Safety and Health, DOSH under the Ministry of Human Resources launched a Code of Practice on Indoor air quality (2005) which was aimed to ensure that employers work voluntarily in accessing the risks in IAQ in the workplace. The Malaysian government have taken several ways to promote IAQ assessment to private companies. However, these procedures have not been fully applied and industries besides oil and gas, every so often do not take the IAQ seriously thus they often neglect to conduct IAQ assessment in their premises. Therefore, In August 2010, the DOSH in Malaysia have introduced a new and extensive legislation named the industry of code of practice on indoor air quality (ICOP-IAQ), which have been approved by the Minister

on 30th August 2010, which have replaced the 2005 version. This ICOP- IAQ addresses that it is the employer responsibilities to make sure the air quality of the indoors environment in up to requirement. This code of practice has been introduced mainly for provide guidance on improving the indoor air quality (IAQ) and to set minimum standard for selected parameters that will evade uneasiness and adverse health effect, however the response towards the usage of the code of practice have not been positive as well. Furthermore, with the burst of COVID-19 pandemic significantly have affected us in many aspects including working environment where now is ever so important to prevent and mitigate spreading air borne contamination.

Hence, it is necessary to produce a validated checklist for assessing risks of enclosed environments. Thus, this study aims to develop a comprehensive checklist and guideline for IAQ for office premises so that it can help to reduce the impact of unsatisfactory air quality in future.

1.2 Problem Statement

The current checklist published by Department of Safety and Health (DOSH) with primary aim to industrial area where it is stated that the building owner or employer is responsible to ensure safe working place for their employees or occupants. However, many employers only focus on major issue such as comfort and reduction of energy consumption instead of health-related issue that was cause by IAQ. Furthermore, with the rise of new contaminants from various new sources of pollutant may impact human health which have not been listed in the current available checklist, as well as with the current outbreak of COVID-19 pandemic, we are in the run to ensure our working environment to be safe as it has been reported by WHO, that the virus can be transmitted through aerosol which means it can be airborne transmitted in indoor

workplace such as offices. Therefore, there is a need of a comprehensive checklist and guideline to ensure office occupants and employer focus towards the health concern cause by indoor contamination.

1.3 Research Questions

1 What is the relation between source of contaminant and health effect.?

2 Does the surrounding environment effect the indoor air quality in office?

3 Do the office activity and items effect the health of office workers?

4 Does ventilation in office building have impact on the health of office workers?

1.4 Aims of Study

The study aims to develop a comprehensive checklist that can be used to identify and mitigate contamination in indoor office.

1.5 Objectives of Study

The objective of this study is:

1. To identify the source of contamination in closed space office and its health effect to the occupier

2. To develop a checklist and guideline to prevent or minimize and mitigate closed space air contamination in office buildings.

1.6 Scope of the study

The scope of this study is to identify the type of contamination present in office in Malaysia. Second is to investigate the current method to prevent, minimize and mitigate air borne contamination in office. Third is to conduct a survey on office users to evaluate on their office indoor air quality. The current questionnaire published by Department of Safety and Health (DOSH) will be used as guidance. As novelty of this research, a comprehensive checklist and guideline will be produced to assist office users to identify, minimize, mitigate, and prevent air-borne contamination in office.

1.7 Significance of the Study

The research is significant to the following:

The citizen: This will help them to determine the early cause of air contamination based on the checklist created. It will also help to determine what specific areas they would need to focus more and further improve the infected area by using the checklist as guideline.

The Employer: To meet with the Department of Safety and Health Code of practice, the updated checklist will be useful to them to analyse the indoor air quality. It will encourage them to ensure the indoor air quality at their premises. This will promote awareness to the importance of ensuring indoor air quality.

1.8 Thesis Outline

In nutshell, this study consist of 5 chapters as follows:

Chapter 1 – Introduction

This chapters introduce on the background of the research with a brief discussion on the current information on indoor contamination. Beside this, this chapter also discuss on the problem statement, aim and objectives of the study and the scope of the study.

Chapter 2 – Literature review

This chapter discuss on the current finding of enclosed office contamination and its sources. Besides that, this chapter discuss on the current procedures and steps taken to mitigate the indoor contamination. This chapter also discuss on the current indoor air quality checklist that is being used in Malaysia.

Chapter 3 – Research Methodology

This chapter explain on the techniques and methods used in gathering data and information which is related to this research. All information obtained are reviewed and studied using the Pearson chi square test through statistical package for the social sciences (SPSS) software.

Chapter 4 – Results and Discussion

This chapter involved in reviewing and analysing the data collected from the questionnaire and analysed using the statistical package for the social sciences (SPSS) tool. By this, a comprehensive checklist to identify and mitigate airborne contamination in office is produced. This chapter also assessed the initial objective where to see if the

objectives have been accomplished. Suggestion and recommendation for future studies is highlighted in a segment of this chapter.

Chapter 5 – Conclusion

In this chapter, the research is concluded, and the result is listed. Further recommendation has been provided.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

In Malaysia, indoor air quality (IAQ) issues are very challenging as the climate in Malaysia is high in humidity and temperature since it is located near the equator line which increase the discomfort among Malaysian (DOSH). Generally, a good quality IAQ is essential to ensure a comfortable and healthy working environment. Poor quality IAQ will lead to variety of health effect. (A. Syazwan, B. M. Rafee, J. Hafizan, et al., 2012). It was stated by the Occupational Safety and Health (OSHA) estimated that in the industrial building of different sector, 30 % of workers that are working in building are subjected to poor indoor air quality. Thus, the productivity and performance of the office occupants will be affected by IAQ. Most employee complaint related to sick building syndrome symptoms (SBS). The symptoms are commonly associated to time spent in the building and often the complaint decreased or disappear when workers leave the workplace. Thus, this chapter discuss on the possible air borne contamination in the office, its effect on health and state the source that produce the air borne contamination.

2.2 Air borne contamination in offices

The following are the possible airborne contamination that may be found in the office:

2.2.1 Particulate Matter

Particulate matter or PM is a complex mixture of particularly small particles and liquid droplets that is found in air. Some are large enough to be seen with the naked eye such as dust, soot, dirt, and some are so tiny that they only can be discovered by using an electron microscope. Particulate matter comes in various sizes and are often

classified in micrometres. There are particles less than 10 micrometres in diameter and fine particles that are less than 2.5 micrometres in diameter (Nezis, Biskos, Eleftheriadis, & Kalantzi, 2019). PM are commonly originated from outdoor which enter indoor environments through ventilation. Indoor PM is generated from combustion-based appliances likes ovens, heaters, tobacco smoke and fireplaces. PM can also be generated from reaction of ozone and some VOC like terpenes present in indoor environment (González-Martín, Kraakman, Pérez, Lebrero, & Muñoz, 2021). A study done by Nezis et al. (2019), that there is association between particulate matter and IAQ in office where the respondent response SBS-related symptoms (Mølhave, Kjaergaard, Sigsgaard, & Lebowitz, 2005; Niu, Guinot, Cao, Xu, & Sun, 2015) .

2.2.2 Volatile Organic Compounds

Volatile organic compounds (VOCs) are the main group of air pollutants in the outdoor and indoor environment. VOCs are discharged as gases from several solid or liquids materials. They are found in variety of chemicals, some of which may have long-term or short-term impact to health. There are many products that are discovered in the office environment that have the potential to release VOCs, such as sealants, coating, adhesives, paints, varnishes, wall coverings, cleaning agents, carpeting, vinyl flooring, fabric materials, air fresheners, etc (Girman, Hadwen, Burton, Womble, & McCarthy, 1999). The most common VOCs found are formaldehyde, ammonia, Polychlorinated biphenyls (PCB), Polycyclic Aromatic Hydrocarbons (PAH), Polychlorinated Naphthalene (PCN) (Al-Mudhaf, Abu-Shady, & Al-Khulaifi, 2020).

2.2.3 Carbon Dioxide

Carbon dioxide is a colourless, unscented, slightly acidic-tasting and a non-flammable gas. Carbon dioxide is a by-product of normal cell function and it's removed through exhaled air from the body. (Information, 2021). Normal outdoor level of Carbon dioxide is 250-350ppm. For indoor, with good air exchange the level of carbon dioxide is around 350-1000 ppm. For 1000-2000 ppm is level associated with complaints of drowsiness and poor air. For 2000-5000ppm is level associated with headaches, sleepiness, and stagnant, stale, and stuffy air. This level can also cause poor concentration and increased in heart rate. For more that 5000ppm, at this level toxicity or oxygen deprivation possibly will happen(Bonino, 2016; Hess-Kosa, 2018) . Therefore, office with poor ventilation, will increase the carbon dioxide level which can become harmful to human health.

2.2.4 Carbon Monoxide

Carbon monoxide (CO) is a toxic air pollutant produced mainly from vehicle emissions. It is an odourless and colourless gas. It is also released from tobacco smoke and act as secondary pollutant to non-smokers(Tsai, Lin, & Chan, 2012).

2.2.5 Ozone

Ozone is a gas composed of three atoms of oxygen. At ground level ozone is produced from reaction between oxides of nitrogen (NOx) and volatile organic compounds (VOC). In office, it can be found from printers, photocopiers as well as air cleaners. (Salonen, Salthammer, & Morawska, 2018)

2.2.6 Radon

Radon is a natural gas that is emitted naturally from ground. Especially when the soil contains excess uranium. Radon gets into the building through cracks or holes that are located closer to the ground, and they travel up the building. Radon is naturally occurring radioactive gas that can accumulate in an enclosed spaces such as houses, working offices and cinema halls (Jabarivasal, 2012). Radon can easily push through the cracks or any other openings in the foundation and build up. It can easily pass-through open doors and windows from outdoor environment to indoor environment. Radon is the result of the radioactive decay of radium in the soil and it is further decay to produce radioactive daughters which include polonium and lead (Turekian, Nozaki, & Benninger, 1977).

2.2.7 Flame Retardants

Flame retardants are basically chemicals that are applied on the any materials that will be used in building or offices. Its main function is to prevent the start or to slow down the growth of fire in case there is spreading out of fire nearby. They have been used in many consumers and industrial products such as doors, desk, shelves and even walls. A study conducted by Betts (2008), there have identified new undiscovered compound as ((2-ethylhexyl) tetrabromophthalate (TBPH) and verified the presence of 2-ethylhexyl 2,3,4,5-tetrabromobenzoate (TBB) that is found as active ingredient of flame retardant which is hazardous to human health.

2.2.8 Lead

In indoor area, walls that are painted with lead-containing pigment can release lead to the surrounding. Although, it is restricted, there have many buildings which are old and still have paintwork containing lead. This can pose health hazard(Horner, 2004).

Thus, based on the above there are many possible airborne contaminations in indoor office that may impact the human health of the office occupants. Thus, the following discuss on the source from where the air borne contamination may be generated.

2.3 Source of air borne contaminants in offices

2.3.1 Building Material

There are two types of pollution released from building material which are radioactive material and volatile toxic chemicals. Volatile toxic chemicals are found in many of decorating materials such as carpets, dyes used in items, paints and glues which will also cause cancer to human(Hodgson, Daisey, & Grot, 1991) which are often used in building or spaces. The chemical compound that are commonly found in this material are benzene, carbon monoxide, formaldehyde, and nitrogen dioxide. Furthermore, radon is also found in building material and decorative materials such as brick walks, stones, and concrete(Nero & Nazaroff, 1984). This radioactive pollution once enters human lungs and decays, will damage the DNA and causes lung cancer. Additionally, dry materials in office such as wood product, floor coating (vinyl, carpet), ceiling raw material (insulation, acoustic and subfloors) will emit different type of VOC(Liqun & Yanqun, 2011) which effects the human health.

2.3.2 Furniture

Furniture is another source of contamination in enclosed spaces. Furniture is made of various type of materials namely from wood, metals, plastics, marble, glass, fabrics. Wood is the most often material used for making furniture. During the process of making the furniture, the wood will undergo cutting, grinding, painted, gilded, and glued. The wood that is often being used are timber, veneer, carcass wood, plywood, laminated board, and hardboard for making different type of furniture and as finishing, varnish is often used as it gives a clear, glossy, and protective coat on the furniture(Pfister, 1993). Metal have been used since ancient time to make different type of furniture. Metal such as silver, bronze and iron are often used. However, the making of the furniture where material are used to attach the part of furniture and chemicals used to improve the appearance and quality are subtly poisoning the indoor occupants where chemicals are released from the furniture such as benzene, ethylene glycol and formaldehyde which are considered as “acute hazards” or irritants and can contribute to the development of infections, lung cancer and chronic lung diseases such as asthma (Pośniak, Kowalska, & Makhniashvili, 2005). Formaldehyde is found in particle board, hardwood, plywood, medium density fibre board used in shelving, furniture, and cabinets. There are two primary types of formaldehyde used in furniture which are urea-formaldehyde (UM) and phenol-formaldehyde (PF) (Iwakiri, Trianoski, Castro, Parchen, & Araújo, 2013). Product that has urea-formaldehyde emits more pollutant compared to phenol-formaldehyde. Flame retardants that are used in many types of furniture that to prevent catching fires are also source of pollutant. Exposure to flame retardants can cause cancer, reproductive issues and brain developments in humans and animals (Dodson et al., 2017). Also, the finishes, stains, varnish and topcoats that are applied during finishing process will release volatile organic compound. Chemical that

are released from these substances can react with air to form ground-level ozone which can lead to respiratory effects (Environmental Protection Agency, 2016).

2.3.3 Carpets

Decorative items such as carpets many source of pollutant namely contamination such as 1-ethyle---hexanol, nonanal,1-phenylcyclohexen, aromatic compounds (styrene, benzene, toluene, xylenes) as well biological contamination such as dust mites, moulds as carpets easily can trap dirt, dust and different type of contaminant existing in indoor spaces (Haines et al., 2020). Furthermore, when there is inadequate ventilation system toxic gases and contamination in enclosed spaces can easily settle and stick into carpets. These particles usually become air borne during cleaning activity or even daily activities such as walking on the carpet which will be inhaled by human and will further impact on the health.(Association, 2021). Additionally, chemical used in some new carpets as well adhesives used to install the carpet can cause serious problem to our health. It can serve as reservoirs for all type of allergens that can lead to health issue such as asthma, inflammation, coughing and shortness of breath (Becher et al., 2018) .

2.3.4 Asbestos

Asbestos is mineral fibre that naturally occurs in rocks and soil. Due to its resistance to heat, chemical, weathering, and biological break-down, it has been used for variety of commercial and industrial purpose. Asbestos can easily be discovered in the attics, flooring materials and as wall insulation product. They are used in making of vinyl floor tiles, adhesives, vinyl sheet flooring, roofing, in textured paint and patching compounds used on wall and ceilings (Camplin, 2003). Asbestos can also be found in walls and floors around wood-burning stoves and heat-resistant fabrics. It is often used

as an insulator as it can be mixed in cloth, paper, cement, and other material to make it stronger. Thus, asbestos is common and can be found in many of indoor closed space items or product. However, asbestos can cause serious impact to health as has been related to cause cancer due to asbestos dust. When home or any indoor space such as office undergoes maintenance or repairing of ceiling, floor or asbestos contain product, the asbestos in the product or material will divide into millions fine fibres known as asbestos dust which when inhaled can cause asbestosis which is a disease that cause scarring on lungs which will lead to breathing problems and heart illnesses. It can cause lung cancer such as mesothelioma, which is a rare cancer of the linings of the chest and abdomen (Vainio & Boffetta, 1994).

2.3.5 Electronic Equipment

Electronic equipment's are also source of indoor air contamination. In this era of technology, many technology devices such as computer, printers, copier machines and other equipment are being used in home and office spaces or any other enclosed space. Many research have been conducted that identified that office electronic equipment to be the source of indoor air contaminant such as ozone, particulate matter, volatile organic compounds (VOCs) and semi volatile organic compounds (SVOCs)(H. Destaillats, R. L. Maddalena, B. C. Singer, A. T. Hodgson, & T. E. McKone, 2008b; Salonen et al., 2018; A. Syazwan, B. M. Rafee, J. Hafizan, et al., 2012; A. Syazwan, B. M. Rafee, H. Juahir, et al., 2012). Also, from continuous usage of printer of copy machine, we are exposed to paper particles and to the toner where it releases toxic gases such as nitrogen dioxide and ozone, together with VOC (H. Destaillats, R. Maddalena, B. Singer, A. Hodgson, & T. McKone, 2008a; Elango, Kasi, Vembhu, & Poornima, 2013). Inhalation of toner dust have associated to causing respiratory

impairment, acetaldehyde and VOC are categories as toxic air contaminants (Pirela, Martin, Bello, & Demokritou, 2017).

2.3.6 Cleaning Agents

Cleaning agents or hard-surface cleaners are substances that usually comes in many forms such as in liquids, powder or granules which is used to remove dirt, including dust, stains, or foul smells. Office often use cleaning agents to clean the office equipment, furniture, floor, and ceiling. Table 1 shows the chemicals in the cleaning product that is commonly involved in causing respiratory symptoms such as sensitisers and irritation (Quirce & Barranco, 2010).

Table 1: Chemicals in Cleaning product that cause respiratory symptoms

	Sensitisers		Irritants
1	Aldehydes found in disinfectants	1	Ammonia
2	Terpenes in scent (eg, d-limonene, eugenol, pinene)	2	Hydrochloric acid
3	Formaldehyde (preservatives)	3	Monochloramine
4	Natural rubber latex	4	Mixing bleach with acid or alkali
5	Amine compound (eg, monoethanolamine)	5	Caustic soda
		6	Quaternary ammonium compounds
		7	Chloride (bleach)

This contamination can cause respiratory problems, allergic reaction, and headache (Cabaniss, 2018).

2.3.7 Environment Tobacco smoke

Environment tobacco smoke (ETS) which is a mixture of exhaled mainstream smoke (MS) and side stream smoke (SS) released from burning of tobacco product. ETS are complex mixture mixtures over 4000 compounds (Narkowicz, Polkowska, & Namieśnik, 2012). These includes more than 40 known or suspected human carcinogens such as nickel, benzene, Polycyclic aromatic hydrocarbons (PAH), ammonia, nitrogen oxides, sulphur dioxide, and various aldehydes and cardiovascular toxicants. Exposure to ETS can cause chronic diseases such as lung cancer and heart diseases, asthma, and cardiovascular diseases(Das, 2003; Pérez-Padilla, Schilmann, & Riojas-Rodriguez, 2010). Office users that are smokers are highly risk to exposure from ETS. According to WHO 2000, smoking and emission from cooking or burning of solid fuels is considered as one of the sources of indoor air pollution. Smoking of tobacco product especially second-hand tobacco can lead to rise of secondary pollutants such as particulate matter in enclosed spaces which can cause cardio-vascular and respiratory diseases (Braun, Koger, Klingelhöfer, Müller, & Groneberg, 2019; Kauneliene et al., 2019). Based on the survey conducted by the Ministry of Health, Malaysia, about 1017 per 100000 populations death was reported due to smoking-related diseases, making it primary cause of death(Lee & Tam, 2014)

2.3.8 Waste Collection

Waste that is generated from closed spaces, often create unpleasant odour which attracts a lot of insects and rodents (Biehler, 2013) when it is not properly manage. Every day waste is generated in office or any spaces from its users and if it is not properly managed it can lead to various diseases. Waste dumping and improper management of waste impact both long and short-term health effect. Short term effects

are stress, anxiety, headache, dizziness, and nausea. Long term health effect are chronic respiratory and cardiovascular diseases, cancer and even brain, nerves, liver, or kidney diseases. Solid waste also generates several harmful gases such as suspended sulphur dioxide, oxides of nitrogen, respirable particulate matter, and carbon monoxide(Triassi et al., 2015) which can impact to human health.

2.3.9 Pest Control

Pest Control are often used in households, offices, recreational building, halls and etc to remove pest, insect, fungi, mould, and rodent(Flint & Van den Bosch, 2012). Pest controls are done in office to keep away pest and insect growth in office. In pest control, chemical name insecticides is used to control insect, herbicides is used to control spreading of wildflower, fungicides are used for fungi and mould control and rodenticides used for rodent control. They can be easily obtained from hypermarkets or hardware shops. Pesticides are used to kill or harm pest; thus, its ingredients are poisonous and dangerous to human. It can cause acute poisoning, headache, nausea, vomiting, muscle weakness and difficulty in concentrating or remembering things (Md Meftaul, Venkateswarlu, Dharmarajan, Annamalai, & Megharaj, 2020).

2.3.10 Air Fresheners, deodorizing, and aromatising.

Home deodorizers such as scented candles, incenses deodorants and other volatile substance that releases elevated level of volatile organic compound such as formaldehyde, acetaldehyde, benzene, ethyl benzene in indoor. They can cause irritation to eyes, nose and throat as well as allergies (Kim, Hong, Bong, & Cho, 2015). Besides that, the contamination released by using this can react with constituents such as ozone which is already in the air to create secondary pollutant. Air fresheners have been

indicated as the primary source of volatile organic compound (VOC) (Steinemann, 2017). Furthermore, a lot of the ingredient in the air fresheners are legally allowed to not to be disclosed to the public as they are deemed to be trade secret, however the lack of disclosure on fragrance ingredient is a problem as most of them are associated with health impacts. Some office users, use air fresheners in office to give an aromatic feel in the office so that it is pleasant. A research paper done Steinemann (2017),by mention that when exposed to air fresheners or deodorizes it was recorded that 16.4% of the population have experience health problem where 9.1% experience respiratory problems, 6.2% experience mucosal symptoms, skin problem (4.8%) , asthma attack (4.5%) , migraine (4.2%) and neurological problem (2.2%).

2.3.11 Paints

Paints generally have the following ingredient which are pigments which are discovered in the resin and binder in the paint. Paint also has solvent that is used to ease paint application. There are many types of paint available in the market. Most common paint used are water-based pain known as latex. Furthermore, vinyl and acrylic paints that are used to seal or protect surface often includes plastic compounds which are harmful to human health (Stoye & Freitag, 2008). Most of us are unaware of the hazard propose by exposing ourselves to paint(Kanuka-Fuchs, 2001) even though they are often used in office, building and many spaces as decorative item to colour the walls or furniture(Bentley, 2001). Some paints include formaldehyde, arsenic, thinners and foamers where with persistent exposure to paint can cause headache, triggers allergies and asthmatic reaction. Paint releases volatile organic compound fumes which further react with the air to form ozone. There is also chemical added in paints which are propane sulfone which are classified as carcinogen leading to cancer when exposed.

The table 2 shows the contamination that can be found in indoor office and its possible source in indoor environment.

Table 2: List of Contamination

Contamination	**Name**	**Source in Indoor Area**	**Reference**
Volatile Organic Compound	Benzene, Toluene	Paint, Adhesives carpets, vinyl flooring, composite wood products, varnishes	(Heeley-Hill et al., 2021; Tran, Park, & Lee, 2020)
	Benzene, styrene, ethylbenzene, toluene, and xylene	Smoking, cooking, burning wood	
	Acetone, Ethanol, d-limonene, pinene and acetate	Air fresheners, cleaning products, cosmetics	
	Polychlorinated biphenyls (PCB)	1 Electrical equipment, 2 Capacitors 3 Transformers 4 Surface coatings, inks 5 Flame retardants, 6 Adhesives, 7 Paints 8 pesticides	(Andersen, Gunnarsen, Knudsen, & Frederiksen, 2020; Salthammer, 2020)
	Polycyclic Aromatic Hydrocarbons (PAH)	Cigarette smoking, heating source, Furniture,	(Ohura, Amagai, Fusaya, & Matsushita, 2004; Salthammer, 2020; Wang, Jia, Lee, Chow, & Fang, 2021)
	Polychlorinated	Rubber product, flame	(Agunbiade,

Contamination	Name	Source in Indoor Area	Reference
	Naphthalene (PCN)	retardants, paints, textile, paper, dye clothing, fungicides in wood, mothballs	Adeniji, Okoh, & Okoh, 2020; Salthammer, 2020)
	Formaldehyde	Air freshener, furniture, wooden product, plywood, insulating area, textiles, paints, wallpaper, glues, adhesives, varnishes, lacquers, detergents, disinfectants, softeners, shampoo, nail varnishes, electronic equipment, and paper product	(Kaden DA, 2010.)
Carbon Monoxide	-	Gas water heaters, cooking, or heating,	(Fazlzadeh, Rostami, Hazrati, & Rastgu, 2015)
Respirable particulates matter	-	1 From outdoor environment 2 cooking, combustion, moping,	(Patel et al., 2020)
Ozone	-	1 Outdoor ozone 2 Printers, photocopiers, 3 Cleaning chemicals 4 Electrostatic air filters 5 Electronic equipment, 6 Laser printing, 7 Ionizing type air	(Tian, Yi, Jin, & Wang, 2015)

Contamination	Name	Source in Indoor Area	Reference
		purifier	
Paraben	-	Personal health Care product, cosmetic ingredient, food, and beverages	(Hajizadeh, Pourzamani, Ebrahimpour, Chavoshani, & Rahimi, 2021; Salthammer, 2020)
Asbestos	Asbestos Fibre	Found in roof, floor ceiling, asbestos - cement, as insulator. The asbestos fibre is found during mechanical disturbance.	(Salthammer, 2020), (Vimercati et al., 2019)
Radon	-	Found in soil, building material	(Salthammer, 2020)
Flame Retardants	-	Doors, Furniture, walls, cabinets,	(Jia & Batterman, 2010)

Therefore, based on this research it is found that many of materials used in the office and indoor spaces emits indoor air contaminants. This contaminants in office building have been making us sick and effect our health. Thus, the following discuss on the effect of airborne contaminants to our health.

2.4 Health effects of airborne contaminants in offices

The common type of symptoms that early noticed due to poor indoor air quality is usually like headache, fatigue, shortness of breath, dryness or irritation of the eyes, nose, throat, and skin. If you have experience coughing, sneezing, dizziness and allergies which general symptoms that are often noticed when several hours are spend in work and will feel better once leaving the workplace building, then your facing sick

building syndrome symptoms. Raw, Health, and Executive (1992) has also summarized sick building syndrome symptoms into several categories as mentioned in Table 3.

Table 3: Symptoms and effects due to sick building syndrome

No	Organ Involved	Symptoms	Effects
1	Eyes	Irritated, dry/watering	Itch, fatigue, inflammation, burning
2	Nose	Irritated, runny/blocked	Congestion, nosebleeds, itchy or stuffy nose.
3	Throat	Dry or Sore	Rash or rasping symptoms, upper airway irritation or difficulties in eating
4	Skin	Dryness, itching or irritation	Rash, erythema, acne rosacea, nettle rash, pruritis,
5	Others	Headache	irritability, exhaustion, and poor focus

The source and effect of some common pollutants shown in Table 4. (Tran et al., 2020)

Table 4 : Common indoor pollutants and their effects on human health.

Contaminants	Sources	Health Impacts
Particulate Matter	Outdoor environment, cooking, combustion activities (burning of candles, use of fireplaces, heaters, stoves, cigarette smoking), cleaning actions	Premature death in people with heart or lung illness, nonfatal heart attacks, abnormal heartbeat, worsened asthma, declined lung function, heightened respiratory symptoms
Volatile Organic Compound	Paints, stains, wood preservatives, varnishes, pesticides, adhesives, waxes, polishes, cleansers, lubricants, sealants, dyes, air fresheners, perfumes, solvents, fuels, plastics, copy machines, printers, tobacco products, dry-cleaned clothing, building materials and furnishings	1 Eye, nose, and throat irritation 2 Headaches, loss of coordination skill and nausea 3 Damage to liver, kidney, and central nervous system 4 Cause cancer
Nitrogen Oxides	Gas-fuelled cooking and heating appliances	1 Enhanced asthmatic reactions 2 Respiratory damage leading to respiratory symptoms
Ozone	Photocopying, outdoor sources, air purifying, disinfecting devices	DNA damage, lung damage, asthma, decreased respiratory functions

Contaminants	Sources	Health Impacts
Sulphur dioxide	Cooking stoves, outdoor air	1 Weakening of respiratory function 2 Asthma, chronic obstructive pulmonary disease (COPD), and cardiovascular diseases
Carbon monoxide	Cooking stoves; tobacco smoking; fireplaces; generators and other gasoline powered equipment; outdoor air	Tiredness, chest pain, decreased vision, reduced brain function
Heavy metals (Pb, Cd, Zn, Cu, Cr, As, Ni, Hg, Mn, Fe)	Fuel-consumption products, enrage burning, smoking, , Outdoor sources and building materials,	1 Cancers, brain damage 2 Mutagenic and carcinogenic effects: respiratory illnesses, cardiovascular deaths
Aerosols	Building materials, tobacco smoke, incense burning, consumer products, cleaning, and cooking	Cardiovascular diseases, respiratory diseases, allergies, lung cancer, irritation, and discomfort
Radon (Rn)	Soil gas, building materials, tap water and outdoor air	Lung cancer
Pesticides	1 Termiticides, fungicides, insecticides, disinfectants, rodenticides, and herbicides 2 Building materials carpet,	Itchiness to eye, nose, and throat; Damage to central nervous system and kidney; Increased risk of cancer

Contaminants	Sources	Health Impacts
	textiles, and cushioned furniture	
	3 Outdoor environment	

In table 4 shows the type of pollutant that is found in office environment and its possible source. The table also discuss on the health impact caused by the indoor air contamination. Health effect in office building is detected based on the symptoms the occupant faces. These symptoms are called sick building syndrome.

2.5 Sick Building Syndrome

Sick building syndrome (SBS) is a condition where people leaving or working in a building suffer from symptoms of illness that appear to be related with the time spent in a building. WHO , have reported that up to 30% of new and remodelled buildings worldwide may been subjected to unsatisfactory indoor air quality in the building. Sick Building Syndrome is caused by source of indoor contamination such as contamination released from adhesives, flooring, furniture, industrial wood products, printers, pesticides, and cleaning agents that may emit volatile organic compound (VOC) and formaldehyde. Furthermore, ETS also caused SBS symptoms where it emits high levels of VOC and respirable particulate matter. Combustion products such as carbon monoxide, nitrogen dioxide that are from burning of fuel at fireplaces and gas stoves in a building also releases contaminant which leads to SBS symptoms. Another cause of sick building syndrome symptoms is inadequate ventilation, where the air exchange rate

is lower than the recommendation set by American Society of Heating, Refrigerating and Air- Conditioning Engineers (ASHRAE) where it has been stated that the air exchange rate needs to be 15 cfm per person. Sick Building syndrome is often detected when the occupants complain with acute discomfort like for example eye, nose, headache, or throat irritation, dry cough. Table 3 can be referred for SBS symptoms and table 4 can be referred to the possible contamination that causes SBS symptoms.

Thus, there are numerous sources and contaminants available in the office majority which are VOC, PM, Radon, and the level of exposure depends on the type of material present in office. This existing contaminant effect the health and symptoms can be identified as sick building symptoms. Furthermore, this source is also influence by external factor which are temperature, humidity, and ventilation.

2.6. Factors affect the air borne contamination

2.6.1 Temperature and Humidity

Temperature and Humidity have major impact on the air borne contamination effect in indoor environment. High temperature increases the risk of acute non-specific symptoms such as dry eyes and respiratory symptoms and low temperature increases the risk of cardiovascular and respiratory diseases (Wolkoff, Azuma, & Carrer, 2021). Therefore, to ensure the work and cognitive performance of office users at optimal the office temperature should be at between 22 °C and 24 °C(DOSH). Moreover, low indoor air humidity can cause common mucous membrane-related symptoms like tired and dry eyes. It is found that relative humidity between 40-60 % appears optimal for health(DOSH). At high humidity also favours the growth of dust mites.

2.6.2 Ventilation

A proper ventilation in an enclosed spaces are utmost important to ensure sufficient air exchange rate in the enclosed space which will indirectly minimize the exposure of contamination to humans. Air exchange rate is the measure of air volume replaced in a defined space by ventilation and infiltration. Many houses or office building experience infiltration. Infiltration is an accidental or unintentional movement of outside air into the building, mostly occur through cracks in the building or through doors for passage (Kubba, 2012). With lack of ventilation in an enclosed area, it gives negative impact to the occupants of enclosed spaces as its traps and concentrate the contamination such as dust, VOC, insecticides, paints, and contamination from cleaning supplier in enclosed spaces as there is no movement of the pollutant inside the enclosed area. Subsequently, the reaction among the indoor pollutants increases with decrease in ventilation rate which will results in immediate and long-term health consequence ranging from mild allergies to serious respiratory illnesses (CHARLES J. WESCHLER*, 2001; Stabile, Dell'Isola, Russi, Massimo, & Buonanno, 2017). Furthermore, inadequate ventilation effects the indoor humidity levels, if there is less humidity where the air becomes dry this can cause dry skin, itchy eyes, and sore throat. Some viruses are also known to be able to survive longer in drier air, thus making it easier for illnesses to be transmitted from one person to the other. However, when there is too much of humidity, will cause damp environment, this will promote the growth of mold and bacterial growth that can cause severe allergic reaction or trigger asthma attacks.(Kubba, 2012). Figure 1 shows the image of mould formation in damp building.

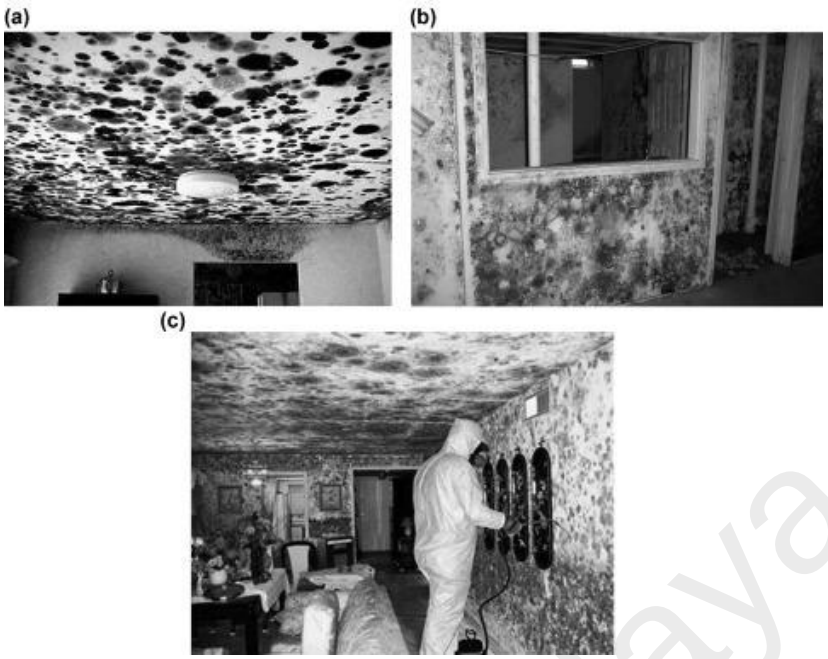

Figure 1: Mould Formation in damp building

The current indoor spaces are equipped with sufficient doors and windows to allow proper ventilation. However, there are still many enclosed spaces which does not have adequate doors or windows to allow high exchange rate of air. Despite the enhance in having outdoor-indoor ventilation, there is still energy loses related to air leakages and air exchange rate (Ficco, Dell'Isola, Vigo, & Celenza, 2015; Massimo, Dell, Isola, Frattolillo, & Ficco, 2014). Therefore, a proper designed of ventilating and air conditioning system is required which can reduce both indoor-generated contamination by increasing the air exchange rate (Rosbach et al., 2016; Toftum et al., 2015; van der Zee, Strak, Dijkema, Brunekreef, & Janssen, 2017).

Thus, based on the factor influencing the indoor air contamination. The following discuss on the cases of airborne contamination in Malaysia and Worldwide.

2.7 Cases of office airborne contamination in Malaysia.

There have been cases reported in Malaysia, in year 2014, the IHME Global Burden diseases have recorded that Malaysia have suffered death due to indoor air pollution where the number of deaths that was recorded is 487 deaths (Roser, 2014). Whereas, the President of Allergy and Immunology Association Malaysia, Dr. Amir Hamzah Abdul Latiff, have stated that about 30-40 % Malaysia suffers from sinusitis allergy which is greatly due to poor indoor air quality.

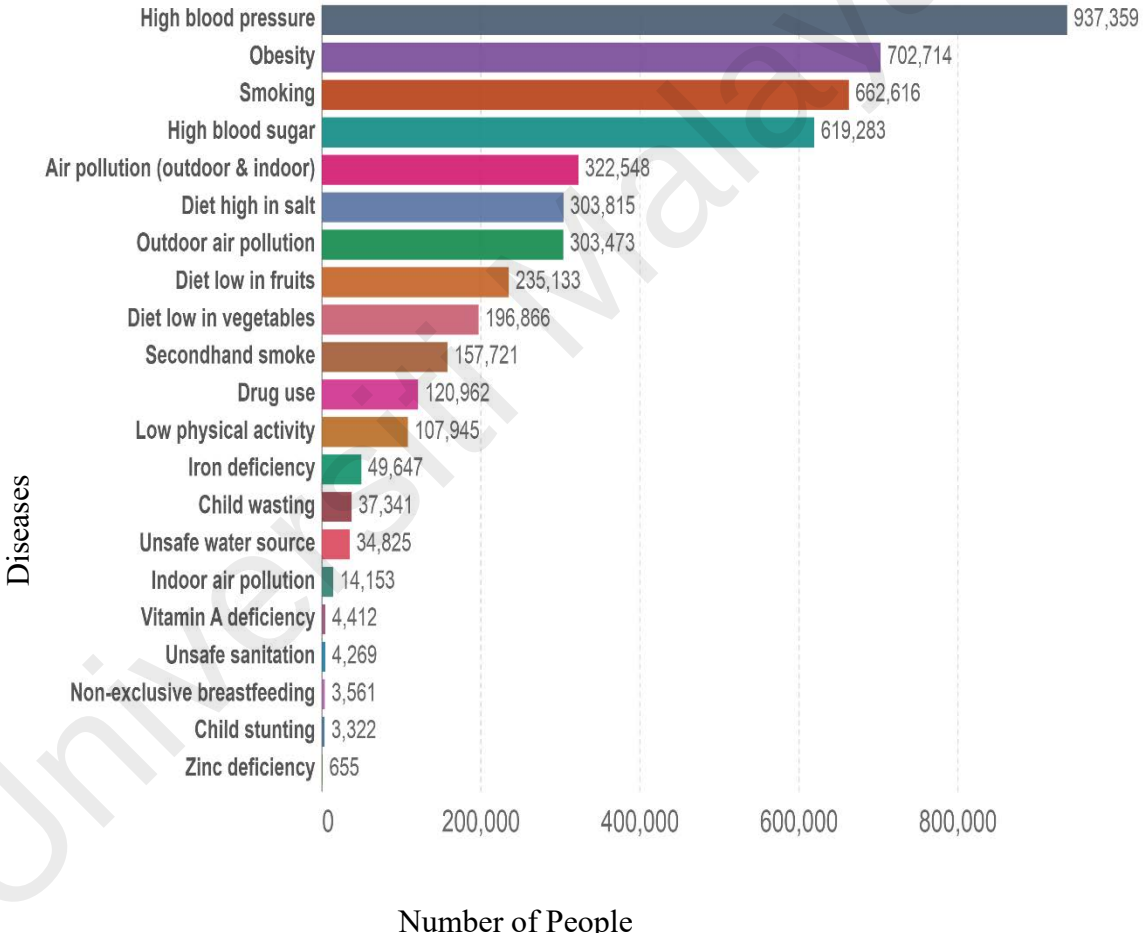

Figure 2: IHME_Global Burden of Disease (GBD) for Malaysia

2.8 Cases of office airborne contamination in Worldwide

The rise in death due to indoor air pollution have been a concern for the past two decades and it keeps increasing. Based on the Global Burden of Disease study, 1.6 million people have died prematurely in 2017 because of indoor air pollution which is four times the number of homicides. Whereas, based on research done by WHO it was estimated that 3.8 million deaths recorded in 2018 which indicated a triple rise in death.

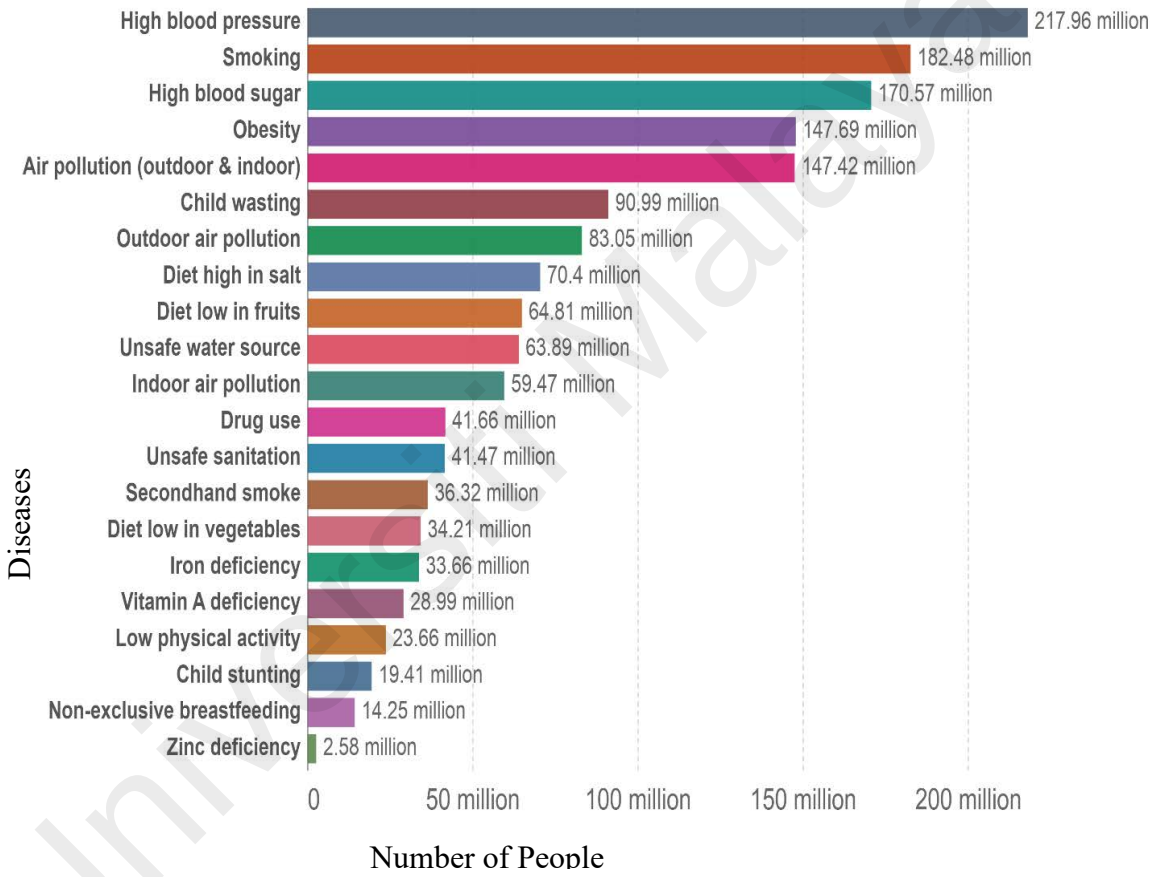

Figure 3: IHME_Global Burden of Disease (GBD) in World

Consequently, based on the data collected by the Global Burden Diseases shows that indoor air pollution is at high risk as many deaths have been recoded throughout the years. Therefore, it is very important to create awareness on the IAQ and its effect and ways to prevent the spreading of the contamination. Hence, the following discuss on the

general strategies to prevent airborne contamination in office that is currently being used.

2.9 General Strategies to prevent the airborne contamination in offices

Currently in Malaysia, the department of Safety and health have released a guideline Industry Code of Practice on Indoor Air Quality 2010 (ICOP IAQ 2010), where the initial strategies to prevent the airborne contamination is to conduct a survey or walkthrough inspection to detect any early-stage possibility of airborne contamination in the office.

First step to prevent the airborne contamination applies to the planning of general process that occur in office such as to ensure that hazardous substance is only used if necessary. If they need to be used, then the usage area, emission from the usage and the waste that will be generated have to be taken in consideration and should be minimized by considering the whole life of the process of the product. Therefore, the design of the workplace should be in a way that the hazardous exposure to air borne contamination is minimized(DOSH).

If no initial step is taken to reduce the contamination during planning stages, then an indoor air quality inspection is the safest way to obtain information, hypothesis formation and hypothesis testing on the IAQ in a place or building. A general walkthrough inspection will be conducted to identify the area that is problematic and the following four basic items which are the occupants in the office, the heat, ventilation, and air conditioning (HVAC) the possible pollutants pathway and possible contaminant source (Agle & Galbraith, 1991). This are the basic four factors that influence the indoor air quality.

Secondly, by identify the source of contamination, the elimination or modification is an effective way to overcome the indoor air quality problem if the control is feasible (Burroughs & Hansen, 2020). Some of the current strategies found are routine maintenance of the HVAC system, regular cleaning or replacement of air filters, replacement of water-stained ceiling and carpeting, venting contamination source emission to the outdoors and storage and use of paints, adhesives, solvents, and pesticides in well ventilated area.

Other steps that are taken, is increasing ventilation rates and air distribution in the indoor area. This is the most cost-effective means of reducing indoor pollutant levels as if air ventilation rate increases mean, more fresh air is brought in, and the contaminant are dispersed out of the building at a faster rate. This will decrease the exposure of contaminants in indoor area (Bearg, 2019). Thus, the HVAC system are designed, at a minimum to meet the ventilation standard set by DOSH.

Furthermore, education and communication among workers and building occupants on IAQ are important element in both corrective and prevention of indoor air quality management (Al horr et al., 2016). When the office occupants, administration and maintenance fully understand the causes and consequences of IAQ problems, they can work more efficiently together to prevent the problem from occurring from the source itself or solve it once detected.

Even though applying these strategies, without the enforcement of law and code of practice, there will always be a loophole in ensuring preventive action are taken place in office. Thus, the following section discuss on the regulation and guideline to prevent airborne contamination in Malaysian offices.

2.10 Regulations and guidelines to prevent airborne contamination in Malaysian offices

In Malaysia, currently there is Industry Code of Practice on Indoor Air Quality 2010 (ICOP IAQ 2010) that was introduced by the Department of Occupational Safety and Health. This code of practice has been introduced to ensure employees and occupants are protected from poor indoor air quality. It is, therefore, the general duties of employers and self-employed persons to their employees as stipulated under Section 15 of Occupational Safety and Health Act 1994 (OSHA).

There have been many studies taken place to improve and review the implementation of the guideline introduced by the DOSH. The following section discuss on the past studies done on airborne contamination.

2.11 Past studies on airborne contaminants in Malaysia

The following are the past studies done on IAQ in Malaysia:

Table 5: Past Studies on airborne contamination in Malaysia

No	Reference	Significant finding
1	(Ismail et al., 2012)	An IAQ checklist was produced to identify the risk elements for the assessment of Indoor air pollutants. The new checklist involves of seven core areas, nine technical areas and essential items.

No	Reference	Significant finding
2	(Ai Syazwan et al., 2012)	In this research, a semiquantitative assessment was conducted on the developed checklist for IAQ and the risk was graded from low to high based on the strength of the problem The checklist formed showed a promising result to be used as preliminary study to determine the IAQ.
3	(Zainal, Hashim, Jalaludin, Lee, & Hashim, 2019)	This research is done to investigate whether the office user experience SBS and does it affect their work performance. The result showed there is high occurrence of SBS symptoms among office users which does affect the workers performance.
4	(Lim et al., 2015)	This research investigates on the relation between SBS symptoms and office attributes and indoor office exposure among office workers from university in Malaysia. The results indicated there is strong relation between SBS symptoms and office workers due to house dust mite and high FeNo .
5	(Norhidayah, Chia-Kuang, Azhar, & Nurulwahida, 2013)	This research investigated on the association between IAQ parameters and SBS in three building in Malaysia. The

No	Reference	Significant finding
		results indicated there is strong indication of SBS symptoms in all three building. The CO concentration and fungal counts were not significantly different in the buildings. However, the studied CO2 concentration and climatic factors suggest that the reason of SBS might be due to ventilation and accumulation of contaminants within the indoor environment.
6	(Syazwan Aizat, Juliana, Norhafizalina, Azman, & Kamaruzaman, 2009)	This research investigated two building (old and new) that have same integrated air-conditioning unit and the office only have general ventilation. The results have indicated that almost 69 % of office workers in the old building suffers from SBS whereas, the new building recorded a lower value of 36 % suffer SBS symptoms even though the building is new.

Therefore, based on the literature reviewed that most of SBS complaint does not originate from one single cause, but multiple factors are assumed to identify occupant complaints. Hence, further investigation must be conducted to identify the multiple factors and its correlation with SBS symptoms so that to produce a comprehensive IAQ checklist and guideline.

2.12 Summary of literature review

A literature review is carried on the indoor air quality of offices in Malaysia. In this review, the possible air borne contamination in offices and the source generation of the air borne contamination in office is discussed. The health effect due to airborne contamination in office is also discussed in this chapter. Ventilation is one of the major reasons that effects the indoor air contamination, sick building syndrome and thermal comfort of office occupants. Temperature and humidity also play key role to ensure that the IAQ in offices is in good condition. From the literature review, it is found that IAQ is at high risk as many deaths have been recorded throughout the year and based on the previous study conducted in Malaysia it is shown that the building or offices occupants positively experience SBS symptoms even though the building are new or old. Thus, this indicated that there is lack of awareness among Malaysian office users on the risk possess by bad IAQ. Hence, a comprehensive guideline and checklist shall be produced to mitigate and prevent the airborne contamination in office.

In this dissertation, the main area of the research is to study on the objective of the research which are to find the correlation between the source of contamination, office activities and items, surrounding environment and ventilation effect towards the sick building symptoms. Thus, based on this investigation, a general checklist and guideline is developed and used to mitigate and prevent the indoor air contamination. Further details on this research work are discussed in the following chapters.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Overall research methodology

This chapter summarizes procedures and technique used to conduct the study. The data obtain in this study is from the Indoor air quality checklist published by the Department of Safety and Health (DOSH) on indoor air quality. The main methodology for this research is as per below:

1 Evaluate the type of contamination found in an office.

2 Conduct survey on contamination present in indoor spaces.

3 Develop an integrated checklist that can be used to evaluate the contamination in office.

The response from the survey has been analysed using the statistical package for the social science to be analyse. The case study will include 102 responses of office users (102 office building).

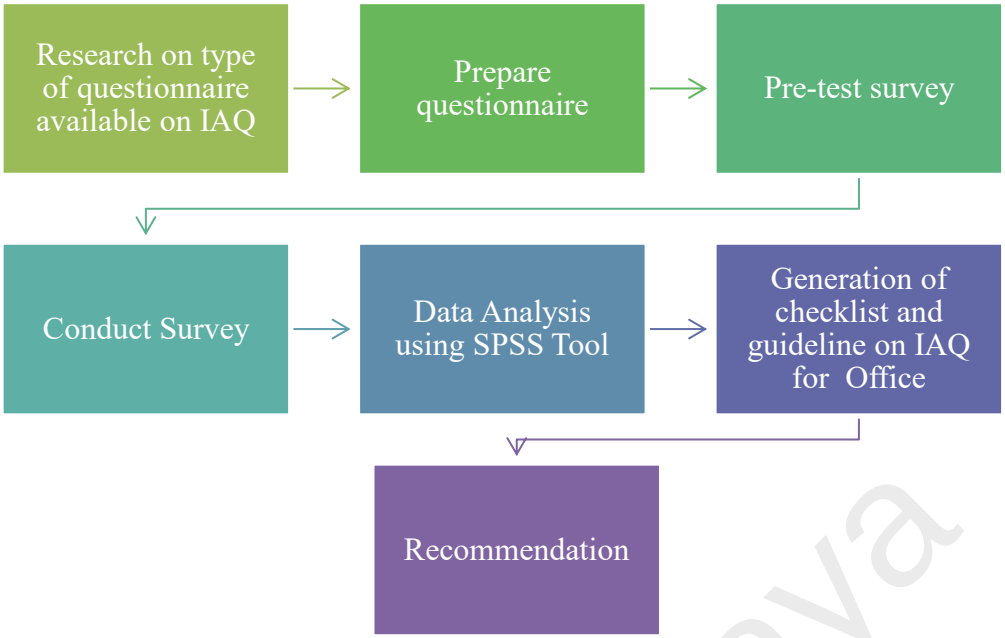

Figure 4: Methodology Flowchart

3.2 Data collection methods

The questionnaire was adapted from DOSH IAQ questionnaire were distributed in the form of survey and completed by the respondents voluntarily. The questionnaire was randomly and conveniently distributed to office workers through google survey to 102 participants.

3.3 Pre test

The questionnaire was pre -tested among 5 participants to identify any mistake or loophole. Comments from the participants was obtain and correction was made to the questionnaire before distributing through google survey.

3.4 Sampling methods

102 response samples were obtained. Sampling technique used is random. A total of 38 respondents are male and 64 respondents are female. The targeted sample of this study is office workers who are currently working in Malaysia.

3.5 Survey question

The survey question consists of four sections with total of 35 questions. Section A is to collect on the demographic data consist of information on age and gender. Section B is focus on possible source of contamination This section consists of 23 question which ask on the source of contamination in the office, the office item and activity used in the office, surrounding environment and ventilation effect in the office. Section C consist of participants response on the indoor air quality in their office. The total question was 3 questions. Section D consist of question that ask the participants whether they have experience sick building symptoms. There was total 7 question. The question is available in Appendix A.

3.6 Data analysis

Data was coded using the Statistical Package for Social Sciences (SPSS) Version 27.0. Data was cleaned and screened to identify any missing or significant outliners. The measurement of data is done using the adapted questionnaires. There is total of 7 items in Dependent variable which are the sick building symptoms and 14 independent variable question which are grouped to four different groups namely source of contamination, surrounding environment, office activities and items and ventilation effect were selected. Data is analysed as following:

Table 6 : Data Analysis

Variable	Section	Items	Likert Scale
Dependent Variable	Health Effect	Headache	Often =1 Sometimes =2 Never=3
		Feel like having a flue	
		Tiredness/reduce in energy	
		Irritating/swollen eyes	
		Dry/sore throat	
		Irritating cough	
Independent Variable	Source of contamination	Hazardous substance in the office	Yes = 1 No =2
		Usage of detergents, or any other chemicals in the office	
		Source of contaminants, such as painting, pesticide application in the office	
		Renovation or maintenance work in the office	

Variable	Section	Items	Likert Scale
		Renovation done during working hours	Yes = 1 No =2 Not Applicable=3
	Surrounding Environment	Construction work going on nearby your office	Yes = 1 No =2
		Designated room/area for smoking in office	
		Heavy industries located nearby the office	
	Office activities and items	Office is crowded with furniture	Yes=1 No=2
		Office equipment in the office	
		Large amount of paper stored or moved in the office	
		Paper shredding activity in the office	
	Ventilation Effect	Conditioning system installed in the office	Yes=1 No=2

Variable	Section	Items	Likert Scale
		Exhaust ventilation installed in the office	

3.7 Descriptive analysis

In this study, a Pearson's Chi-Square correlation used to identify the significant strength and direction of the relationship between the proposed independent variable and dependent variable. There is total four analysis done to meet the objective of the research where the chi-square test was used to analyse the source of contamination, surrounding Environment, office activities and items and ventilation effect with the sick building symptoms (health effect). The statistic test was found to be significant or correlated if p-value obtain is less than 0.05.

3.8 Confidentially of the study

The survey conducted is anonymously through google survey. However, the author has approached the respondent personally, but the respondent input is kept as anonymously. Thus, the confidentiality of the respondent will be protected.

3.9 The checklist and guideline evaluation

Based on the office occupants complains about the general IAQ condition in their office workplace, a checklist and guideline are produced to help the nonindustrial setting such as office area to predetermine the condition of IAQ which they can further analyse for airborne pollutants through detailed quantitative analysis. The checklist aims to identify the factors influencing the complaints, thus giving a general overview of the

suspected source of pollutants and the guideline aims to provide awareness and steps to be taken to mitigate and reduce the presence of source of contaminant in the office.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Introduction

The survey conducted among 102 office users selected randomly, fulfilled the study criteria of age range from 20 to more than 40 years old. The respondent consists of 64 (62.7%) Female and 38 (37.3%) Male. The survey was randomly distributed among office users by using the online platform of goggle survey. The survey is aimed to obtain the opinion of the office users regarding the current office environment and on the IAQ. The survey also assessed personal wellbeing to identify the occupant's health condition in the office.

4.2 Factors that contributed to Sick Building Syndrome

4.2.1 Type of contaminants

There are numerous sources of contaminants available in indoor office. The contaminant can be originated from the usage of chemicals in office, usage of pesticides in office Thus, the following are the analysis on the question related to of source contaminant which has been correlated with health effect: There are total of five survey question asked which are to see if there is presence of hazardous substance in the office, to see if there is usage of detergents or any chemicals in office, is there source of contaminants originated from painting or pesticides application in the office, is there renovation work conducted in the office and is there renovation work conducted in office but during office hours. The response towards this question was analysed where the participant refers their preference whether the often, sometimes, or never experience

any of the sick building symptoms which are headache, feel like having a flue, tiredness, swollen eyes, sore throat, irritating cough, and rashness on face.

Table 7:Source of contaminants VS Health effect

Questions	Test	Headache	Feel Like Having Flue	Tiredness/reduce in energy	Irritating /swollen eyes	Dry sore throat	Irritating cough	Rashness on hand/face
Hazardous substance in the office	P-value	0.103	0.779	0.098	0.098	0.012	0.094	0.094
	X^2	4.759	0.499	4.648	4.637	8.793	4.736	4.733
Usage of detergents or any other chemicals in the office	P-value	0.045	0.883	0.010	0.234	0.047	0.011	0.148
	X^2	6.218	0.250	9.296	2.908	6.106	9.046	3.815
Source of contaminants, such as painting, pesticide application in the office	P-value	0.001	0.468	0.000	0.010	0.000	0.000	0.267
	X^2	13.981	1.517	19.785	9.277	17.178	18.847	2.641
Renovation or maintenance work in the office	P-value	0.001	0.009	0.000	0.005	0.000	0.000	0.004
	X^2	13.134	9.371	16.315	10.480	15.539	19.941	10.963
Renovation done during working hours	P-value	0.001	0.039	0.000	0.000	0.000	0.000	0.11
	X^2	18.096	10.068	31.134	25.856	20.636	26.332	13.011

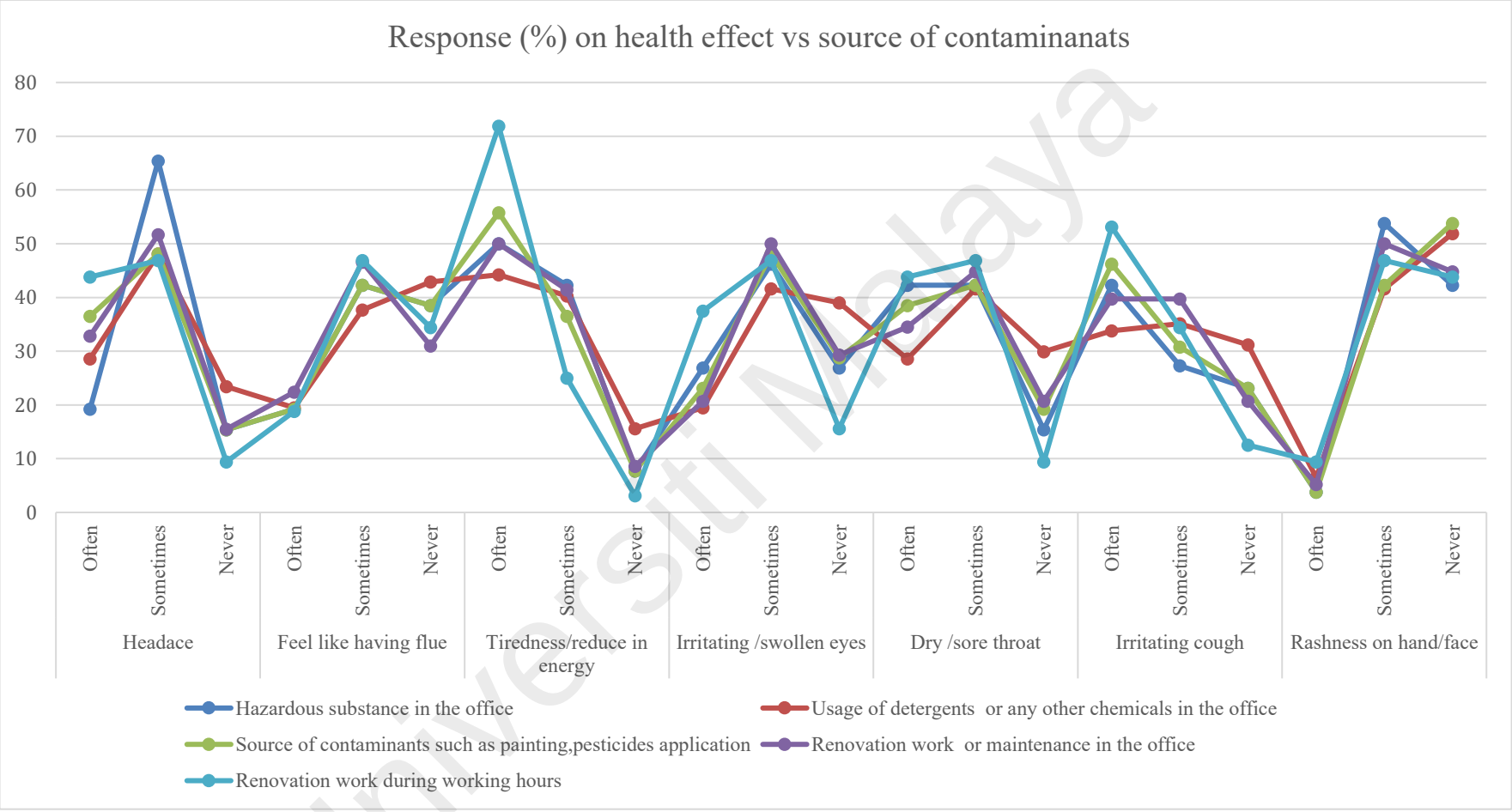

Figure 5: Response (%) on Health Effect VS Source of Contaminants

Table 7 shows the p-value obtain through chi square test conducted through analysis using SPSS Tool. The analysis shown that all the five-source of contaminant have shown strong positive impact on the health effect where one of the health symptoms indicated p value <0.05. Among the seven health effect, the respondent experienced dry sore throat the most where the highest value were indicated by renovation during office hours showed p-value of 0.000, P<0.05 followed by presence of source of contamination such as during painting and pesticides application activity indicated p-value at 0.000, p<0.05, renovation and maintenance work in office where p-value indicated 0.000, p<0.005, hazardous substance in office also indicated p-value at 0.012, p<0.05; and lastly the usage of detergents or any other chemicals indicate at p-value of 0.047, P<0.05. The respondent has also experienced headache, tiredness/reduce in energy and irritating cough indicated p-value < 0.05 for four of the sources of contaminants except presence of hazardous substance in the office. For all the three symptoms that the respondent experience, the data strongly suggest there is significant relation when renovation was done during office hours where the chi square test indicated 18.096, 31.134 and 26.332 respectively.

Besides, the most respondent experience irritating/swollen eyes which was contributed by three of the sources where renovation done during working hours indicated high chi-square value at 25.855, p value ,0.05. The two source that was found to be insignificant to the respondent experiencing swollen eyes were contaminant presence from hazardous substance and usage of detergents, or any other chemicals which indicated p-value >0.05. Furthermore, the response towards feels like having flue and rashness on hand/face have the least response where the respondent feels this symptom only when there is renovation work and maintenance work done in office and renovation done during office hours where recorded p-value <0.0 for both where the

strongest was shown to be when renovation done during office hours, X^2=13.011.

In Figure 5 shows the response of participant exposed to the source of contaminant and the SBS symptoms they experience due to the exposure to the source of contaminant. Based on majority response related to SBS symptoms, 65.4% of the respondent response that sometimes experience headache due to exposure to hazardous substance in the office, 46.9 % have response they sometimes experience feel like having flue due to renovation work in office, 71.9 % have response that they often experience tiredness/reduce in energy, 50% have response that they sometimes experience irritating/swollen eyes due to renovation work, 46.9 % have response that they sometimes experience dry and sore throat due to the renovation work in office during office hours, 46.2 % have response that they often experience irritating cough due to existing source of contaminants such as paints and pesticides application and 53.8 % have sometimes experience rashness on hand or face when exposed to hazardous substance in the office. .

It is identified that the current condition of the indoor air quality in respective 102 office building are at concern level as majority of the occupant's mention they experience several sick building symptoms. It is found there is correlation between present source of contamination in office and sick building symptoms where, office that have source of contamination such as painting activity, renovation work in office and especially renovation during office hours and usage of chemicals, detergents and pesticides have most IAQ problem. Renovation activity does create a possible link between health and comfort which suggest that work permits, and prior hazard identification analysis must be conducted.(Ai Syazwan et al., 2012) It also have strong positive complaints of hazardous substance and usage of pesticides, detergents, and other chemicals. This is highly due to usage of chemicals and hazardous substance that

have potent chemical structure that is hazardous to human health. Thus, office users, building and office owners should be aware of the chemicals used in the office for all purpose. If the usage of such chemicals is needed proper mitigation must be implemented when using the chemicals through health risk assessment monitoring.(Jendritzky, Havenith, Weihs, & Batchvarova, 2005; Ai Syazwan et al., 2012) . Furthermore, training should be provided to the cleaners before using the cleaning chemicals. (Baharuddin, Sahid, Noor, Sulaiman, & Othman, 2011).

4.2.2 The effect of office surrounding environment on the occupant's health

The analysis focus on the impact of surrounding environment to human health. Three surrounding environment aspects were asked to 102 office users which was if there is any construction work going on nearby their office, whether their office have any designated room/area for smoking activity and lastly if their office is surrounded by heavy industries. The relation of surrounding environment is investigated with the sick building symptoms experience by the participants namely headache, feel like having flue, tiredness/reduce in energy, irritating/swollen eyes, dry sore throat, irritating cough, and rashness on face is recorded in Table 8.

Based on the data recorded only heavy industries located nearby have shown significant p-value to be <0.05 for where the respondent experience SBS symptoms which are headache, tiredness/reduce in energy, irritating/swollen eyes, dry sore throat, and irritating cough. The respondent experience irritating cough the most when their office is surrounded by heavy industries where the chi square recorded was 26.090 The other surrounding environment have not shown insignificant value where p-value is more than 0.05. This may be due to the response size that agree on experiencing the surrounding environment criteria is small compared to those who respondent no to

experiencing the survey question on surrounding environment.

In Figure 6 shows the respondent who agree on facing the relevant surrounding environment with the sick building symptoms. Based on the data collected, for sick building symptoms of headache, majority of the respondent which was 50% of respondent who answered they have heavy industries surrounding their office sometimes experience headache, whereas 53.6% of respondent who have heavy industries nearby sometimes experience having irritation or swollen eyes, and 46.4% of respondent feels like having a flue due to having heavy industries nearby. For sick building symptoms of where the respondent often experiences tiredness, dry or sore throat and irritating cough, 67.9 %, 50% and 64.3 % of respondent respectively they often experience the respective SBS due to having heavy industries surrounding their office area. However, for symptoms of rashness on hand/face the respondent have respondent the least where majority have stated never this SBS Symptoms when their office is surrounded by heavy industries and construction work. On the positive side, it was also found that with the implementation of having an designated room for smoking activity majority of the respondent agree that they never experience the following SBS symptoms which are headache (43.3% response), feel like having a flue (50% response), swollen eyes(50% response), dry sore throat(46.7% response), irritating cough (43.3% response) or rashness on hand(63.3% response) but they do sometimes experience tiredness (46.7% response).

For this research, relation of surrounding environment, had strong positive response of complaint on SBS symptoms when the office is surrounded by heavy industries. Therefore, to mitigate the contamination from outdoor environment a proper management on ventilation system must be implemented where the efficiency in removing the outdoor pollutants is upheld at a high level. (A. Syazwan, B. M. Rafee, J.

Hafizan, et al., 2012; Turiel et al., 1983). However, it was found that an insignificant chi-square test was recorded for having a designated room for smoking activity in the office. This shows that many of office doesn't have a proper designated room for smoking area, but the data strongly indicated that the SBS symptoms are significantly reduced with the presence of a special design room for smoking activity with proper ventilation in the office. Thus, a strong implementation of smoke free policy must be established and must be administered by the local authority and Ministry of Health (Zainal et al., 2019).

.

Table 8 : Surrounding Environment VS Health Effect

Questions	**Test**	**Headache**	**Feel Like Having Flue**	**Tiredness/reduce in energy**	**Irritating /swollen eyes**	**Dry sore throat**	**Irritating cough**	**Rashness on hand/face**
Construction work going on nearby your office	P-value	0.116	0.281	0.087	0.076	0.539	0.245	0.439
	X^2	4.307	2.537	4.893	5.146	1.235	2.810	1.648
Designated room/area for smoking in office	P-value	0.096	0.614	0.350	0.644	0.301	0.221	0.553
	X^2	4.689	0.977	2.102	0.879	2.402	3.021	1.186
Heavy industries located nearby the office	P-value	0.002	0.472	0.000	0.005	0.000	0.000	0.362
	X^2	12.310	1.502	15.878	10.717	15.496	26.090	2.034

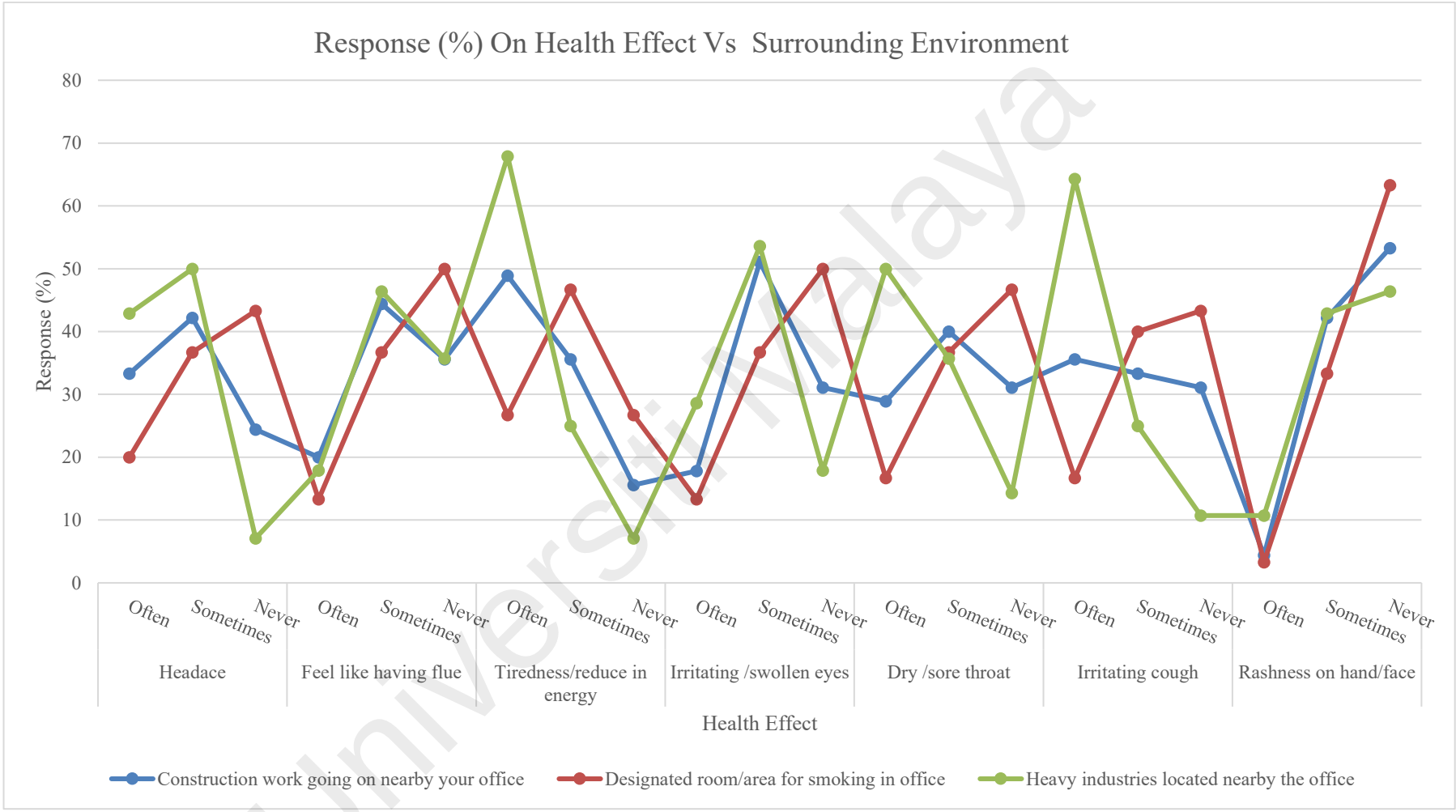

Figure 6: Response (%) on Health Effect VS Surrounding Environment

4.2.3 Office activities and equipment

The analysis focus on the impact of contamination generated from office activities and equipment to human health. Four office activities and equipment aspects were asked to 102 office users which was is whether do they feel their office is crowded, presence of office equipment such as printer, photocopies, fax machine and etc, do they store large amount of paper in their office and lastly do they conduct paper shredding activity in their office. The relation of office equipment and activities is investigated with the sick building symptoms experience by the participants namely headache, feel like having flue, tiredness/reduce in energy, irritating/swollen eyes, dry sore throat, irritating cough, and rashness on face is recorded in Table 9.

Table 9 shows the p-value of chi square test for office activity and equipment correlation with sick building symptoms. Based on the data obtain, the results show significant value where the p-value is < 0.05 for all sick building symptoms except feel like having a flue when the respondent feels that their office is crowded and when there is office equipment in the office. The respondent experience irritating cough symptoms the strongest when their office is crowded with furniture where the X^2 recorded was 23.694 and the respondent experience both dry sore throat and irritating cough the strongest when there is office equipment such as printers and copy machine where the X^2 recorded was 20.054 and 20.691.

Whereas, having large paper stored in office also significantly impact the health where significantly four out of seven SBS symptoms have recorded p-value <0.05 which were headache, tiredness, sore throat, and irritating cough. The results indicated that the respondent feel tired or reduce in energy the most where X^2 is 21.12 followed by irritating cough, $X^2 = 16.636$ and dry sore throat, $X^2 = 18.597$. However, conducting

paper shredding activity significantly impact the health where the respondent strongly feels tired, X^2 at 7.113, $p < 0.05$. and followed by feeling irritating cough, X^2 at 6.565, $p < 0.05$.

In Figure 7 shows the response of respondent having the office activities and equipment in their respective offices and its correlation with the health effect. This figure indicates that majority of the office occupants (55% of response) sometimes experience headache when their office is crowded with items like furniture or cabinets. Majority, 43.1 % of the office occupants experience feel like having flue due to office equipment, 52.9% of office occupants often experience tiredness due to when their office is crowded, 56.9 % of office occupants sometimes experience swollen eyes due to crowded office, 51 % of office occupants sometimes experience dry sore throat due to overcrowding in office, 54.1 % of office occupants experience irritating cough also due to overcrowding of office and lastly 51 % of office occupants also sometimes experience rashness on hand/face due to crowded office.

For this research, the relation of office equipment and activity have shown strong response on complaint mainly due to overcrowding of office, followed by presence and usage of office equipment, keeping of large amount of paper and paper shredding activity in the office. Complaint on overcrowding is due to poor management at office. Usage of printers, fax machine and photocopies, paper storage and paper shredding activity must be placed in a separate room as there have been study shown that they cause potential source of indoor air contaminants namely, volatile organic compound, ozone, and particulate matter. Paper dust also can cause health related issue on upper respiratory system. (Morawska et al., 2017) . It was also mention in study by ,when the printers are not isolated to another area away from the work area, the

emission of particle from the printer create the main source of indoor air pollution(Zainal et al., 2019).

Table 9: Office Activities and Items VS Health Effect

Questions	Test	Headache	Feel Like Having Flue	Tiredness/reduce in energy	Irritating /swollen eyes	Dry sore throat	Irritating cough	Rashness on hand/face
Office is crowded with furniture	p-value	0.000	0.106	0.000	0.000	0.000	0.000	0.002
	X^2	19.448	4.848	18.373	16.669	18.759	23.694	12.953
Office equipment in the office	p-value	0.002	0.231	0.000	0.011	0.000	0.000	0.022
	X^2	12.186	2.932	18.794	9.006	20.054	20.691	7.603
Large amount of paper stored or moved in the office	p-value	0.023	0.413	0.000	0.077	0.000	0.000	0.132
	X^2	7.577	1.768	21.12	5.120	18.597	18.636	4.045
Paper shredding activity in the office	p-value	0.072	0.927	0.029	0.200	0.225	0.038	0.723
	X^2	5.261	0.152	7.113	3.219	2.980	6.564	0.650

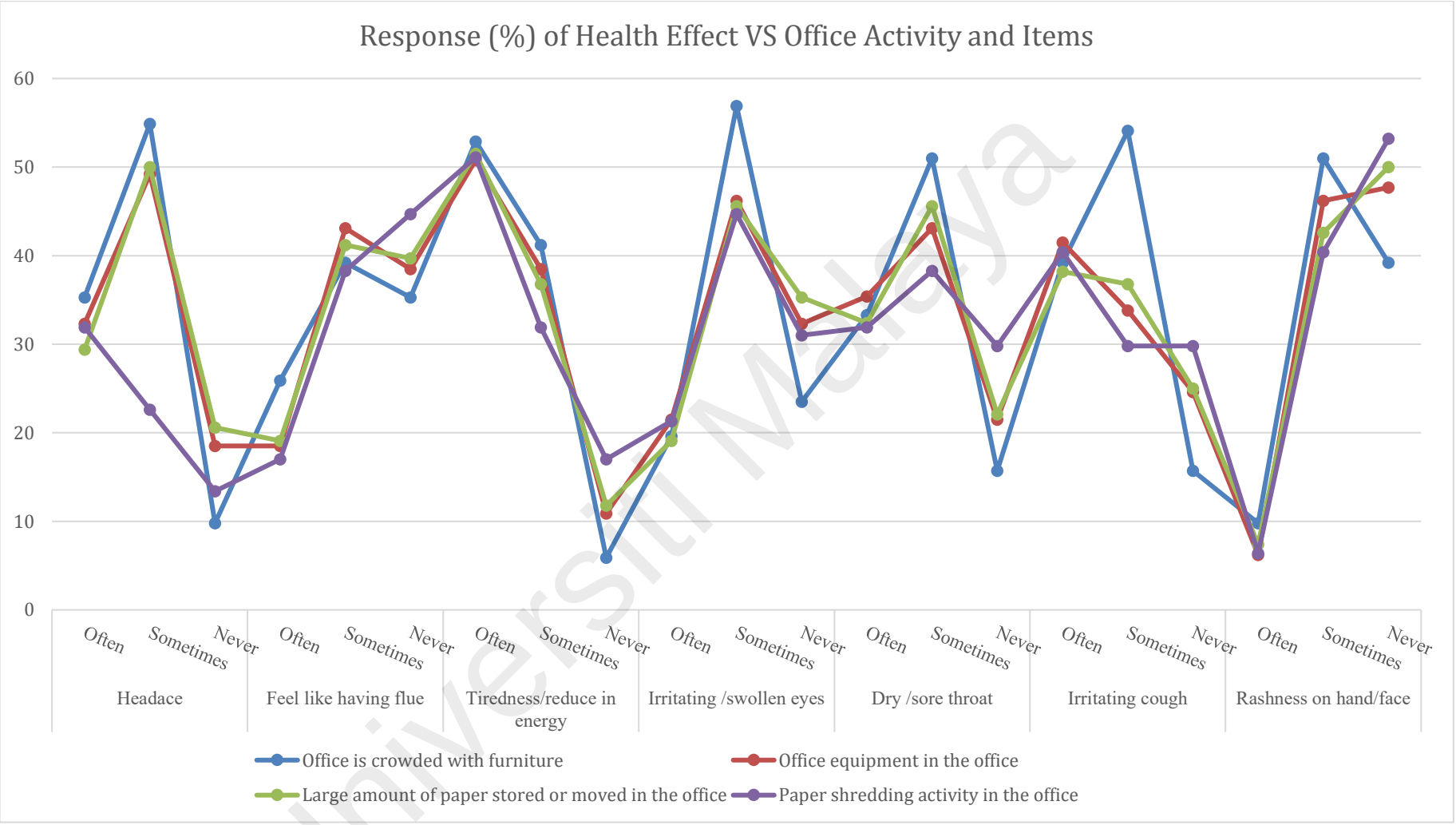

Figure 7: Response (%) of Health Effect VS Office Activity and Item

.

4.2.4 The effect of ventilation on the occupant's health

The analysis focus on the factors affecting the indoor contamination which are the ventilation aspect and its correlation to human health. Two office ventilation effect were asked to 102 office users which was is whether do they have an air conditioning system in the office and do they have exhaust system installed in the office. The relation ventilation factor is investigated with the possible sick building symptoms experience by the participants namely headache, feel like having flue, tiredness/reduce in energy, irritating/swollen eyes, dry sore throat, irritating cough, and rashness on face is recorded in Table 10.

Table 10 shows the p-value of chi square test on ventilation effect with sick building symptoms. Based on the results, it was found that when the participants have air conditioning system installed in their office, they experience SBS symptoms which where the strongly feel headache where the X^2 is 7337, p value, 0.05, followed by rashness on hand or face giving X^2 as 6.995, p-value < 0.05 and lastly they feel like having flue given X^2=6.554 where p-value < 0.05. , whereas for ventilation system, the results shows that the health effect experienced by the respondent was not influenced when the respondent office have an exhaust ventilation system as the p-value indicated >0.05. Therefore, we can conclude that the source of contaminant from only having conditioning system in the office significantly influences the health but with an exhaust ventilation system the SBS symptoms are significantly reduced.

In Figure 8 shows the response of office user experiencing health effect due to type of ventilation system existing in their office. Majority of them have sometimes experienced headache where 50 % of respondent mention due to having air conditioning

system, 42.6 % of office occupants mention they experience tiredness due to air conditioning system and 33.0 % occupants have mention they have sometimes experience rashness on hand or face due to air conditioning system.

Based on ventilation system of an office, an air conditioning system solely is not a proper ventilation system. It recycled back the air into the building by changing its physical attribute such as temperature or humidity. The office must be supported by an exhaust ventilation system that will introduce fresh air into the office. Therefore, a poorly ventilated room may be worse as the pollutants are not removed and tend to accumulate in the whole building. This indicate that limited understanding of the IAQ and Air handling Unit (AHU) or ventilation system as the main source of fresh and clean air which lead them to being exposed to major source of pollutant s(Turiel et al., 1983)..Based on the results indicate there is no association on the source of contaminants from using exhaust ventilation installed in the office and all the seven-health effect. This is to say that, based on the survey respondent who have exhaust ventilation in their office have no correlation indicated with SBS symptoms. Thus, this also reflect that many offices in Malaysia don't have a proper ventilation unit install in their building which may be due to poor understanding of IAQ concept and application.(A. Syazwan, B. M. Rafee, J. Hafizan, et al., 2012)..

Table 10: Ventilation Effect VS Health Effect

Question	Test	Headache	Feel Like Having Flue	Tiredness/reduce in energy	Irritating /swollen eyes	Dry sore throat	Irritating cough	Rashness on hand/face
Conditioning system installed in the office	p-value	0.026	0.038	0.306	0.100	0.106	0.215	0.030
	X^2	7.337	6.554	2.368	4.595	3.660	3.071	6.995
Exhaust ventilation installed in the office	p-value	0.862	0.830	0.295	0.258	0.263	0.160	0.295
	X^2	0.296	0.372	2.438	2.710	2.674	3.665	2.438

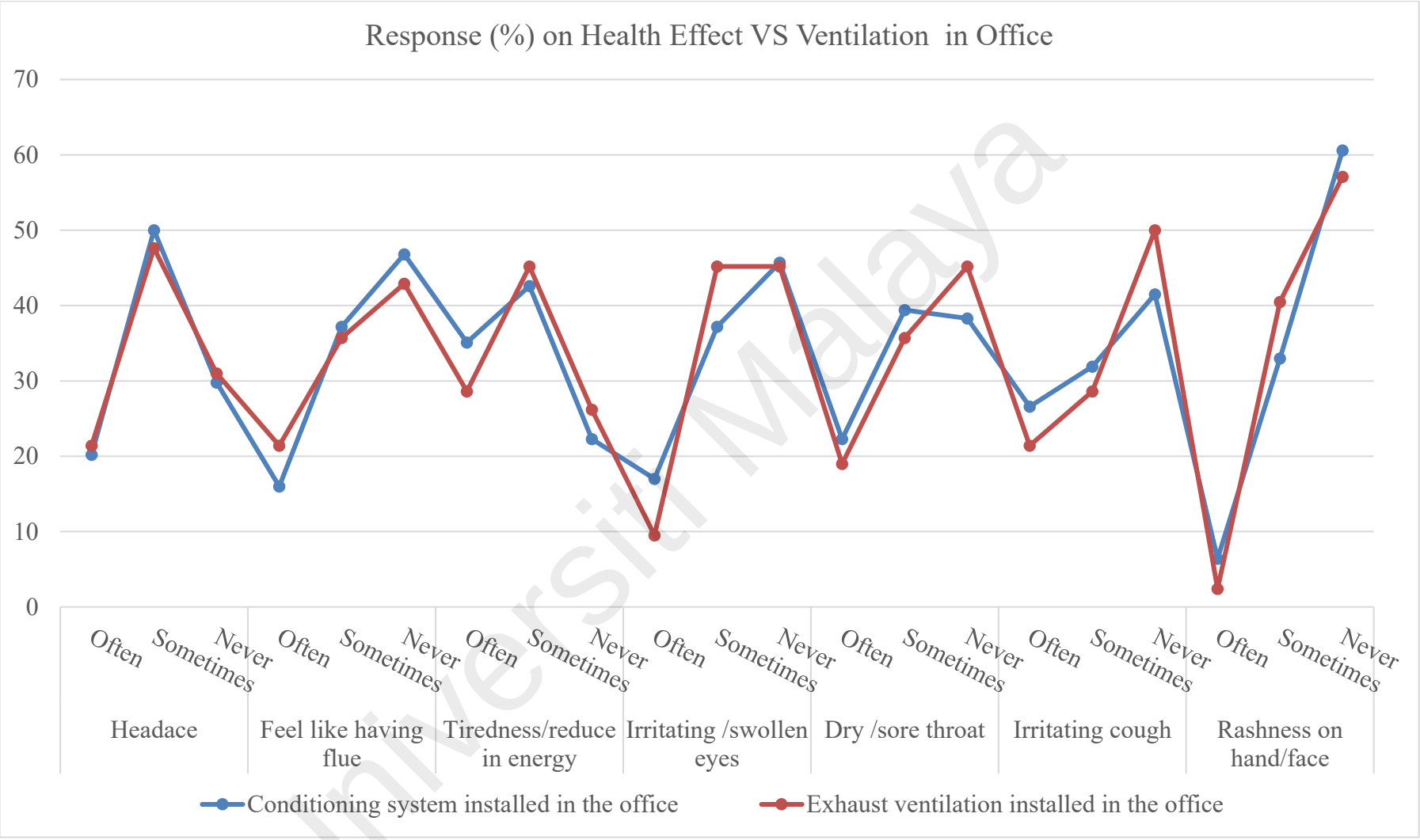

Figure 8: Response (%) on Health Effect VS Ventilation in Office

Therefore, based on the above discussion a comprehensive checklist and guideline is formed consisting of total 19 new criteria to be listed to mitigate and prevent indoor air contamination in office.

4.3 Checklist to prevent office indoor contamination

In this section, the checklist to mitigate and prevent the indoor air contamination focusing on indoor office environment have been generated. The purpose of creating the checklist was due to the indication of SBS symptoms experience by the 102 office occupants in the survey. Therefore, based on the above results, nineteen parameters were discovered and highlighted in the checklist for the IAQ assessment. The nineteen parameters were ventilation system, type of material, cleaning material, food and drink management, smoking management, waste management, toilet management, furniture, electronic equipment, office stationaries, personal and hygiene product, surrounding activities, maintenance operation include pest control, refreshers, office design, storage management, natural occurrence, plant-based contamination, and air conditioning system.

These nineteen parameters were selected to cater the many sources of indoor air pollutants which are commonly found in an enclosed office building. This checklist was generated to protect the occupants from poor indoor air quality that can adversely affect their health and wellbeing which will indirectly reduce their working performance. These nineteen parameters were selected as all these nineteen parameters have potential to create or generated the indoor air contamination or enhance the contamination concentration. The two parameters are the main contributor in reducing the concentration of indoor air contamination which are air ventilation system and air

conditioning system. The other seventeen parameter are sources that may generate air contamination which can lead to health effects.

No	Criteria	Checklist	Yes	No
1	Ventilation System	1 Check for any evidence deviation in air movement?		
		2 Inspect the overall state of the installed ventilation, its parts and instrument.		
		3 Are the ventilation system parts in good condition?		
		4 Inspect the temperature and thermostat?		
		5 Is there thermostat installed?		
		6 Is the cooling system in operation?		
		7 Inspect the electrical connections and components.		
		8 Check if there is any loose connection in electrical connection		
		9 Inspect safety/controls measure		
		10 Is the safety/control measure in good operating condition?		
		11 Inspect fan pressure, is it according to the design?		
		12 Inspect air filter, is it cleaned?		

No	Criteria		Checklist	Yes	No
		13	Is there insufficient ventilation hoods at area needed?		
		14	Being in a space for 10 minutes, do you feel hot and suffocated?		
		15	Is a crowded room properly ventilated?		
2	Type of Material	1	Are the paint or adhesive used as water-based?		
		2	Are adhesives or coating selected emits less contamination?		
		3	Does the material emit odour?		
		4	Is the selected material easy to clean and maintain?		
		5	Is the material selected able to withstand humidity?		
		6	Is the cooling system in operation?		
		7	Inspect the electrical connections and components.		
		8	Is the cleaning procedure of the material used known? Such as carpets, binders, resilient flooring.		
		9	Is the material used “Green Label” by the carpet and rug institute that determine the level of VOC?		
		10	Was the selection of building material		

No	Criteria	Checklist	Yes	No
		based on low VOC ?		
		11 Is the material in office regularly cleaned?		
		12 Is there a schedule cleaning for carpets, flooring, windows and etc?		
		13 Are the materials selected easily be cleaned without using further toxic chemical for cleaning purpose?		
		14 Are the paints and coating selected are low or no VOC emitting?		
		15 Are PPE selected and worn not harmful?		
		16 Is everyone in office wearing PPE for COVID 19?		
		17 Is the indoor relative humidity measured?		
		18 Is it within the range of 40-60%?		
		19 Are there usage of evaporative humidifiers?		
3	Cleaning Material	1 Check the type of cleaning material used in office. Is it chemical based?		
		2 Check the type of cleaning material used in office. Is it organic based?		
		3 Is the cleaning of office done during office hours.?		

No	Criteria	Checklist	Yes	No
		4 Are the cleaning material storage in air ventilated cabinet/room		
		5 Are the rugs/clothes used in the office cleaned every time after usage?		
		6 Is the cleaning of office done when workers are not inside/near the working place?		
		7 Is there procedure on control if there is spillage of cleaning material in office?		
		8 Do you have perfume in your cleaning material?		
		9 Is the water changed when mopping the floor?		
		10 Do you have the cleaning chemicals safety data sheet?		
		11 Is sanitizer used less irritant?		
		12 Is there soap place in the washroom?		
		13 Is the soap selected less harmful?		
4	Food and Drink Management	1. Is your office refrigerator regularly cleaned?		
		2. Is food stored properly in the pantry?		
		3. Is there a microwave in the office?		
		4. Is there schedule cleaning done in the pantry?		

No	Criteria	Checklist	Yes	No
		5. Is there proper garbage disposal service in the office?		
		6. Is there garbage disposal unit placed in the pantry?		
		7. Is the microwave regularly cleaned in the office?		
		8. Is the fridge temperature at its optimum temperature?		
		9. Is Refrigerator temperature = < 4deg C?		
		10. Is Freezer temperature = 0 deg C?		
		11. Are there food and drink policy in office to avoid		
		12. Is the water cooler/water storage cleaned regularly?		
5	Smoking management	1 Is there an established smoking policies in the company?		
		2 Is the designated /room of smoking area properly ventilated?		
		3 Do you personally, notice odour from smoking activity nearby the smoking area?		
		4 Is there a smoke-free policy in the office?		

No	Criteria		Checklist	Yes	No
		5	Is smoking taking place anywhere in the building?		
		6	Is the outside air intake located near the smoking area of the building?		
6	Waste Management	1	Is a waste collection done every day in office?		
		2	Is there a person/body in charge to ensure no overflow of waste in office?		
		3	Is there a recycling policy in office?		
		4	Is the dustbin properly covered throughout the working time?		
		5	Is there a ventilation spot above each dustbin area?		
		6	Are the workers undergone waste management training?		
		7	Is the different waste bin for used mask or potential contaminated materials due to COVID 19?		
7	Toilet Management	1	Is there any water leaking activity noticed?		
		2	Is there a schedule cleaning service?		
		3	Is there a proper waste disposal management?		
		4	Is the dustbin monitored throughout the		

No	Criteria		Checklist	Yes	No
			working time?		
		5	Is there an operating fan in the toilet or window?		
		6	Are damp or wet materials that could promote growth of biological agents repaired?		
		7	Do the toilets have automatic flush system?		
		8	Are the cleaning agents using less toxic and green label?		
		9	Is the toilet air pressure slightly negative relative to building?		
		10	Are the fan exhaust grilles cleaned?		
		11	Are there make-up path or supply air exists in the toilet?		
		12	Does the floor drain trap wet?		
		13	Are there separate disposable bin for used mask?		
8	Furniture	1	Is there sufficient space around the office to walk?		
		2	Is the furniture giving a dull experience?		
		3	Does the furniture emit odours?		
		4	Is the furniture regularly dusted?		
		5	Is the furniture regularly cleaned?		

No	Criteria		Checklist	Yes	No
		6	Is the furniture checked for dust mite?		
		7	Is the furniture placed under a ventilation vent area?		
		8	Are there broken/torn furniture in the office?		
9	Electronic equipment	1	Is there a smart system where the electronic equipment will be switched off when not in use?		
		2	Are the electronic equipment places in a proper ventilated area?		
		3	Is the cleaning process on the electronic equipment done during office hours?		
		4	Is the electrical equipment placed in the separate room of the workers?		
		5	Are the printer used wet based ink?		
10	Office Stationaries	1	Are the office stationaries kept in a well-ventilated area?		
		2	Are the stationaries kept in order?		
		3	Are the stationaries kept in damp, wet area?		
		4	Is the ink, toners kept in anti-spill compartment?		
		5	Do you notice the spoiling of office stationaries?		

No	Criteria		Checklist	Yes	No
11	Personal and Hygiene Product	1	Does your office have strong scent from perfume usage?		
		2	Does your work require you to do vigorous activity such as climbing, repairing and etc which makes you sweat?		
		3	Do your office have a bathroom?		
12	Surrounding Area Activities	1	Is your office located nearby a construction area?		
		2	Is your office located near a dumpster area?		
		3	Is your office in a congested traffic area?		
13	Maintenance operations include pest control	1	Is the maintenance activity done through proper?		
		2	Is the pest treatment done under control environment?		
		3	Are the pesticides activity done during office hours?		
		4	Will the pesticide activity have done nearby the company working area/table?		
		5	Is the maintenance work done in office during office hours?		
		6	Are there a proper barrier created during maintenance work to not allow the		

No	Criteria		Checklist	Yes	No
			contaminants to be exposed to other area in the office?		
14	Air Fresheners	1	Are the fresheners in the office on automated timing schedule?		
		2	Are the fresheners used have toxic chemicals?		
		3	Is volatile chemical used in fresheners?		
		4	What's is the condition of fresheners? (Mould, dusty, dirty)		
		5	Are the current fresheners in use have already meet the expiry date?		
		6	Are the fresheners located at above area in the office?		
		7	Are the fresheners located at below area in the office?		
			Are the fresheners used aerosol based?		
15	Office design	1	Do your office layout have changed throughout the years?		
		2	Is there an odd room located in your office?		
		3	Is there blockage on exhaust air vents?		
		4	Is there blockage on clean air inlet vents?		
		5	Are there office compartments in the		

No	Criteria		Checklist	Yes	No
			office?		
		6	Are the office compartment in the office have ventilation vents?		
16	Storage Management	1	Is the storage area properly vented?		
		2	Is the room congested?		
		3	Are there items in storage room installed properly?		
		4	Is carpet used for flooring in storage room?		
		5	Is the room often checked to avoid mould formation?		
		6	Is the room away from wet or mould walls?		
		7	Do you notice decolourization on the wall?		
17	Natural occurrence	1	Check if there is any crack on the office wall?		
		2	Check if there is any crack on the floor?		
		3	Check if there is a lot of insects crawling in the office?		
		4	Does the office locate at ground level?		
		5	If yes for No.4, then is there any mould formation at the ground level of the office?		

No	Criteria		Checklist	Yes	No
		6	Are the office windows often open?		
		7	Do dusty air travel into the office through open		
		8	Do your office have windows?		
18	Plant based contamination	1	Is there fertilizer used in the plants?		
		2	Is the fertilizer used toxic?		
		3	Do you often see water deposit at the bottom of the plant vase?		
		4	Does your plant often get dusty?		
		5	Do you often notice your plant spoils or plant witted?		
19	Air conditioning system	1	Do your air condition release warm air?		
		2	Does your air condition make loud noise?		
		3	Is there leaking notice from the air conditioning?		
		4	Do you smell foul or unpleasant smell from the air condition?		
		5	Does your office air condition undergo a schedule service?		
		6	Is the electrical equipment in proper function for your air condition?		

4.4 Guideline to Prevent Office Indoor Contamination

In this section, the to support the checklist to mitigate and prevent the indoor air contamination focusing on indoor office a corresponding guideline is generated. The purpose of creating the guideline is to provide the requirement that an office building needed to ensure that there are initially steps taken to prevention and mitigation air borne contamination that may worsen the indoor air quality in an office. Therefore, based on the above, for each of the nineteen parameters that were discovered and highlighted in the checklist for the IAQ assessment, a guideline for the office occupants were given in this section. The nineteen parameters are ventilation system, type of material, cleaning material, food and drink management, smoking management, waste management, toilet management, furniture, electronic equipment, office stationaries, personal and hygiene product, surrounding activities, maintenance operation include pest control, refreshers, office design, storage management, natural occurrence, plant-based contamination, and air conditioning system.

These nineteen parameters were selected to cater the many sources of indoor air pollutants which are commonly found in an enclosed office building. This guideline was generated to protect the occupants from poor indoor air quality that can adversely affect their health and wellbeing which will indirectly reduce their working performance. The purpose of this guidance is also to create awareness among the office occupants on the nineteen possible factors that can affect the IAQ in their office.

1. Ventilation System

The main way to prevent indoor contamination is to have a proper designated ventilation system in office. The main aspect in designing a proper ventilation, the room size, the number of occupants, the type of activities should be considered when designing the ventilation design in the office. In a space there should be fresh air supply and dirty or contaminated air being exhaust from the building. Thus, a ventilation system is where the used and 'dirty' indoor air is removed and is replaced with a new, fresh and oxygen rich air whereas, air conditioning unit means that the indoor air is recycled, and its recycled air quality is changed like for example the temperature or its removing moisture. (A. Syazwan, B. M. Rafee, J. Hafizan, et al., 2012)It doesn't bring fresh air into the office building. Therefore, it is important to have and maintained the ventilation system in office, both ventilation and air conditioning system is needed in an office where air is circulated through ventilation system and cooled through air conditioning system. During the COVID-19 outbreak it is important to have a good ventilation to ensure high air exchange rate in the office. The following are the steps and control measure to be taken:

1 For ensuring the office have a proper ventilation, its best to always have the ventilation system timely checked and maintained.

2 A schedule maintenance shall be followed strictly to avoid faulty performance of the ventilation system.

3 In addition to the ventilation test, air cleaners can be used as additional source of preventing indoor air pollution. As air cleaners are designed to

filter air throughout the area.

4 Increasing the outside air to increase the air change rate in the office.

5 Control the pressure relationship especially at the area where pollutant is generated.

6 When existing spaces in office have been redesigned for changes, thus, the air flow should also be redesigned to ensure adequate airflow. Flow system rebalancing may be necessary.

7 Relative humidity in office should be kept around 40 to 60% as its optimal to help reduce COVID-19 as COVID 19 favours dry and cold conditions.

2. Type of Material

Material selection is important when constructing an office building as well as its interior design. Selection must be based on its quality and type of raw material used to make the material. This selection process should consider the installation and maintenance requirements as well as how the material or furnishing will be done on the materials and how will it impact during its service life. It is, therefore, important to select material that emits low or least hazardous pollutant(Liqun & Yanqun, 2011). Type of material selection are prone to introduce the following air contamination in indoor office spaces such as radon, VOC, particulate matter, and heavy metals. The following steps, and control measure shall be taken:

1 Installation or renovation should be done possible after office hours. If this can't be avoided, a proper separation should be placed to avoid the spread of air pollution due to the installation or renovation work.

2 New office shall only be occupied after a certain period to allow the off gas

released by the new material used in office have been dispersed and reduce in contaminants in indoor office.

3 Removing or reduce the source by selection of materials or product that emits lower level of contamination emission.

4 Off gassing the material and product before any installation work.

5 Increasing the flow of outside air during the occupied and non-occupied hours.

6 Controlling source and the air distribution relationship by relocating occupants in the office to avoid contact with contamination.

7 Material that can generate aerosols should be avoided.

A holistic approach of building design should be combined with IAQ professional and industrial hygienist before any installation work

3. Cleaning Material

Cleaning materials must be selected where the contamination level is low(Quirce & Barranco, 2010). They should be placed in area where there are no occupants and must be placed where if there are any leakages it can be control immediately (preferably kept in leak control containers). Cleaning materials are the source of contamination such as VOC, particulate matter, ozone and etc which can lead to diseases such cancer, respiratory problem, and heart diseases. The following are the steps and control measure to be taken:

1 Removing or reducing the source such as removing the materials, by selecting proper or less contaminated cleaning material that are producing contamination

to a better-ventilated space.

2 Increasing the air flow of outdoor air.

3 Cleaning activity should be done when there is no occupants in the office.

4 Ensure training done to office users, cleaners and relevant individuals who will deal with chemicals in office.

5 Materials used to sanitize the office building should be less toxic and stored properly.

6 Cleaning material that can transformed to aerosols should be avoided.

4. Food and Drink Management

Food and drink management is extremely important as bad food and drink management can attract pest and rodent in the office which can cause sickness. Food and drink can lead to foul smells and attract pest which lead to usage of pesticides. Thus, the following are the steps and control measure to be taken:

1 The pantry or food storage area should be properly ventilated.

2 In the office, cooking activity should be avoided.

3 Any electrical equipment used should be kept clean and dry, thus, avoiding formation of mould and germs.

4 Store food properly as food attract pests.

5 Schedule inspection shall be implemented to avoid any spoil, rotting food and drink left unattended in the office.

5. Smoking management

Smoking policy should be implemented in office as this is major cause of ETS which can lead to cancerous disease (Das, 2003). Therefore, companies should ensure as the following:

1. Outside air intake vents shall be located away from polluted area such as smoking area, car park area or traffic area.
2. Filters should be installed in outdoor air intake vents.
3. Avoid recirculation of air that contains contaminants.
4. Ensure the designated/room for smoking doesn't pollute the indoor office area
5. ASHRAE-62-1999 required 60 cfm per person of makeup air intake
6. The smoking room should be design under negative pressure to prevent the smoke from environmental tobacco entering to non-designated room or area.

6. Waste Management

Waste management is essential in office environment as when it is badly managed can cause foul smell, attracts insects, and indirectly cause sickness(Slack, 2007). Therefore, an organized waste management policy should be implemented in office. The following are the steps and control measure to be taken:

1. Have a schedule waste cleaning service in office
2. Have a ventilation vent above the dustbin area to avoid unpleasant smell.
3. Ensure there is proper training on the waste management.
4. Ensure there is personal in charge to manage the waste

5 Each office occupants should have the responsibility to ensure the waste generated are properly disposed

6 Training on the effect of the poor waste management should be given to the building occupants.

7 Masked (used) need to be disposed and avoid contact when handling. Mask can be kept under the sun or hot temperature to kill the virus before disposal.

7. Toilet Management

Toilet management is required to mitigate the IAQ contaminants as toilet is the area where germs and insects can produce which can cause contamination such as fungus, particulate matter, and pathogen shedding. Thus, the following are the steps and control measure to be taken:

1 Schedule cleaning is necessary to keep the toilets clean. Timing and frequency of cleaning should be adequate.

2 Cleaning of toilet should use which are green label and less toxic.

3 Use hand dryer when possible.

4 Litter shall be disposed into the bins.

5 Negative pressure in toilet is to prevent the odours from migrating to adjacent occupied building.

6 Exhaust fan will be reduced if makeup air is not supplied

7 Training on toilet management should be provided to building occupants

8 Every occupant should be responsible to ensure the toilet has been clean and

flushed after usage.

8. Furniture

Selection of furniture is important to reduce the IAQ contaminant in office. Furniture in office should be chosen that emits less contaminants(Pfister, 1993). Furniture is main source of VOC, particulate matter, flame retardants, some may have radon and asbestos. That is why, selection of furniture is extremely important. Thus, the following are the steps and control measure to be taken:

1 Cleaning service on all existing furniture in the office to be done everyday

2 Furniture that are discoloration, broken, release smelly odour should be send for repairing or thrown away.

3 New furniture needs to be kept in a ventilated area to allow off gassing activity.

4 Furniture in office should be kept in a well-ventilated area

5 Selecting furniture that uses low toxic releasing material and have green label. This info can be obtained from the supplier.

9. Electronic equipment

As the current era, many of work activity is highly dependent on electronic equipment and technology. Thus, we cannot stop using them, but we can take the action to mitigate or reduce the exposure of contaminants that's radiating from the electronic equipment. Arrangement of electronic equipment is necessary in office as the equipment emits VOCs and ozone (Destaillats et al., 2008b). Thus, the following are the steps and control measure to be taken:

1 Have regular service of the electrical equipment such as photocopiers, fax

machine, printer

2 Use dry printing printer compared to wet printing printer

3 Adequate ventilation and properly design ventilation shall be placed near electrical equipment

4 Ensure that an ozone filter is fitted to photocopiers and printers that emit ozone.

5 Have a limited time on exposer to electrical equipment.

6 Changing of toner for printers should be done by professional and worn personal protective equipment e.g mask, gloves.

7 Have a separated room specially organized for the usage of office equipment.

10. Office Stationaries

Office stationaries are also source of contamination as when kept in bulk or when there is spillage can release the airborne contamination. Office stationaries can cause VOC and particulate matter. Thus, the following are the steps and control measure to be taken:

1 The room where the office stationeries are kept must be well vented and dry.

2 Ink, toners, wet stationaries are kept in a compartment that can trap the chemical if there is spillage.

3 Usage of office stationaries should be in moderate.

11. Personal and Hygiene product

Personal and hygiene product are also source of contamination as many of recent or previous product have ingredients that can be harmful to human health (Wolkoff et al., 2021). Personal and hygiene product can cause the main contamination of VOC and

particulate matter. Therefore, the following are the steps and control measure to be taken:

1 Upgrade the ventilation in the office

2 Use a diffuser to reduce the scent from perfume or other personal product.

3 A diffuser should not be harmful to the environment and to people.

4 Have a policy on usage of personal and hygiene product

5 Office occupants shall be considerate on the type of personal and hygiene product used

6 Ensure the air exchange rate is high to avoid the accumulation of contamination released from this product.

12. Surrounding area activities

There are always changes in surrounding environment of an office area as there may be development or construction that can generate contamination from outdoor to indoor. Outdoor air is the causes contamination such as radon, particulate matter, sulphur dioxide, nitrogen monoxide and heavy metals. Thus, this criterion should be noted as well when conducting IAQ assessment. Thus, the following are the steps and control measure to be taken:

1 Office that are located near a dense polluted area, will need to install air filters to their indoor air intake vents.

2 Filters need to be checked and cleaned regularly.

3 Maintenance shall be done on the HVAC system consistently.

4 Preventive maintenance shall be incorporated into HVAC System

5 Avoid opening of windows if the surrounding area causes odour or dusty environment.

13. Maintenance operation include pest control

This guideline is for the office that conduct maintenance operation and pest control activity(Al horr et al., 2016). Thus, the following are the steps and control measure to be taken:

1 Maintenance should be done during the time when there are least people working in the office.

2 Pest activity should be done at the specific location, and not during office hours. This is to avoid contamination reaction with office workers

3 Possible to use pesticides that are less harmful and less toxic.

4 A separate compartment should be created when there is maintenance activity to avoid distribution of contaminant

14. Air Fresheners

This guideline is for the office that uses fresheners or aromatizes. Air fresheners contribute to aerosols, VOC, particulate matter, and some can produce secondary ozone. Thus, the following are the steps and control measure to be taken:

1 Ensure the fresheners used in office are non-toxic and not harmful in the office.

2 Avoid using time orientated fresheners in the office

3 Ensure cleaning of refreshers containers

15. Office design

This guideline is for office design This step are best to taken when the office is newly design, however, existing office shall meet this guideline as best practice so that the air borne contamination in the office can be prevented. Thus, the following are the steps and control measure to be taken:

1. Do not block air vents or grilles
2. Space in the office must be planned accordingly to the HVAC system where is properly planned to avoid unsteady air flow.
3. If the space doesn't have adequate openable windows that can meet natural ventilation requirements, the building should be provided with a mechanical ventilation system that can be used when indoor air need to be purged from the space, as in addition to the air-conditioning system.
4. Windows are only used as backup plan as there may be contamination outdoor air. This, best is to have a ventilation system with air filter in indoor air intake vent.

16. Storage Management

Storage management is necessary to reduce the IAQ contamination. As when all sources of contamination are places in one area will generate high amount of contamination. Therefore, the following are the steps and control measure to be taken:

1. An adequate ventilation shall be installed in the storage area.
2. Materials in store should store in such way they don't react with each other that can cause contamination.

3 Liquid material should store in anti-spill compartment.

4 Chemicals and cleaning material shall be stored separate from other material such as paper etc

17. Natural occurrence

Natural occurrence cannot be avoided; however, steps can be taken to mitigate and reduce or prevented in earlier stage. Natural occurrences are related to exposure to a radioactive material called radon that is emitted from the ground. Thus, if the building has cracks or holes it can easily pass through the building to the office environment. Thus, the following are the steps and control measure to be taken:

1 Cracks on walls, flooring, ceiling should be covered to stop movement of natural decay and insects.

2 A protective layer can be placed at the lowest level of the building to prevent the rise of natural decay throughout the building.

3 Have an adequate ventilation system

18. Plant based contamination

Many offices have a policy to go green, where plants are kept in office to provide a serene office environment. However, this is one of the sources of indoor air contamination if it is not properly maintained such as particulate matter and nitrogen oxides release from the usage of fertilizer. Thus, the following are the steps and control measure to be taken:

1 Real plants are difficult to manage, however they do give out fresh oxygen. The plant must be water and fertilized to ensure it stay fresh. Therefore, when watering the plant, must make sure no spillage of water. The fertilizer used must

be non-toxic.

2 Real plant should be trimmed and kept clean.

3 Fake plant needs to be cleaned regularly, to remove dust accumulations.

4 Plants must be checked to keep away from pests

19. Air conditioning system

Air conditioning system is installed in almost all office building(Jung, Wu, Tseng, & Su, 2015). However, they can be source of contamination if it is not properly maintained. Thus, the following are the steps and control measure to be taken:

1 A periodic maintenance shall be conducted on the air conditioning in the office.

2 Air conditioning is not a ventilation service as same air is recirculated; no fresh air is introduced in the area. Therefore, a supply air vent is necessary.

3 Selection of air conditioning system can be enhanced with proper filters to filter out virus and contaminant such as Hepa filter.

4 Usage of evaporative humidifiers on additional following the ASHRAE limits can protect from being affected by COVID-19.

Therefore, based on the research done through survey, where questionnaire was distributed to 102 office occupants, it has been found that most of the office users experience SBS symptoms. Thus, a checklist and its corresponding guideline have been developed with nineteen parameter which are ventilation system, type of material, cleaning material, food and drink management, smoking management, waste management, toilet management, furniture, electronic equipment, office stationaries, personal and hygiene product, surrounding activities, maintenance operation include pest control, refreshers, office design, storage management, natural occurrence, plant-based contamination, and air conditioning system. This checklist and guideline can be used as safety measure to reduce the impact of many office items, activity, surrounding environment on the indoor air quality in an office. Thus, the following legal and recommendation can be further applied to improve the checklist and guideline for IAQ in office.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In conclusion, this research was done to identify the possible source of contamination in a closed space office and the effect it caused on the occupier of the closed space office. This was done through an analysis based on a distributed questionnaire survey with 102 respondents from office occupants. The analysis was performed through the usage of the statistical package for the social sciences (SPSS) tool. The factors that were analysed were the possible source of contamination in office which consisted of five questions, second was to analyse the surrounding environment of the office which consisted of three questions, third was to analyse the office equipment and activity which consisted of four question and lastly the ventilation in the office which consisted of two questions. There four factors were correlated with the sick building symptoms which were, headache, feel like having a flue, tiredness, swollen eyes, sore throat, irritating cough and rashness on face or hand. The data was interpreted, and it was found that for the first factor, all five question have shown significant p-value in relation with at least one of the SBS symptoms where most of the office occupants experience SBS symptoms when there is renovation work done in the office. For the second factor one out of the 3 question have shown significant data with the SBS symptoms where most of the office occupants experience SBS Symptoms when there is heavy industrial area nearby the office. For the third factor, all four question have shown significant p-value in relation with at least one of the SBS symptoms where most of the office occupants experience SBS symptoms when their office is crowded and have office equipment and the last factor, one out of the two

questions have shown significant data with the SBS symptoms where most of the office occupants experience SBS Symptoms when there is air conditioning system in the office. Thus, based on this analysis it can be concluded that the current office environment still requires steps and control measure to counter the indoor air quality contamination. Hence, a comprehensive checklist and guideline have been developed which consist of nineteen parameters. The parameters are ventilation system, type of material, cleaning material, food and drink management, smoking management, waste management, toilet management, furniture, electronic equipment, office stationaries, personal and hygiene product, surrounding activities, maintenance operation include pest control, refreshers, office design, storage management, natural occurrence, plant-based contamination, and air conditioning system. This checklist and guideline were proposed for the closed space office building to be used by the office occupants, building owner, work employer and work employee. The checklist and guideline can be used as safety measure to reduce the impact of many office items, activity, surrounding environment which indirectly can help to improve the indoor air quality in an office.

To sum up, with the current pandemic, COVID-19 that have taken the world by surprise, we must come up with new ways and strategies to stay together with COVID-19 virus for the economic, business and market to function in linearity with the pandemic. Thus, importance must be placed on the management of Indoor Air Quality in an office environment where we spend the most amount of time.

5.2 Recommendation for future research:

1. Further analysis should be conducted with to represent these 19 parameters in IAQ issue. The checklist can be further investigated together with the current published indoor air quality checklist to evaluate its effectiveness.
2. Conduct a scoring method on the produce checklist
3. Conduct future analysis with large number of samples to show that early indicators on IAQ can be detected by using this 19 items which are ventilation system, type of material, cleaning material, food and drink management, smoking management, waste management, toilet management, furniture, electronic equipment, office stationaries, personal and hygiene product, surrounding activities, maintenance operation include pest control, refreshers, office design, storage management, natural occurrence, plant-based contamination, and air conditioning system
4. Conduct an interview survey to get response from selected office building and survey on site condition and the causes of contamination which can lead to health effect.

REFERENCE

Agle, E., & Galbraith, S. (1991). *Building air quality: A guide for building owners and facility managers*: US Government Printing Office.

Agunbiade, I. V., Adeniji, A. O., Okoh, A. I., & Okoh, O. O. (2020). A review on occurrence and analytical procedures for the evaluation of polychlorinated naphthalenes in human and environmental matrices. *Environmental Pollutants and Bioavailability, 32*(1), 154-174. doi:10.1080/26395940.2020.1829992

Al-Mudhaf, H. F., Abu-Shady, A.-S. I., & Al-Khulaifi, N. M. (2020). Indoor and Outdoor Volatile Organic Compounds at Office Buildings in Kuwait. *Air, Soil and Water Research, 6*(1).

Al horr, Y., Arif, M., Katafygiotou, M., Mazroei, A., Kaushik, A., & Elsarrag, E. (2016). Impact of indoor environmental quality on occupant well-being and comfort: A review of the literature. *International Journal of Sustainable Built Environment, 5*(1), 1-11. doi:https://doi.org/10.1016/j.ijsbe.2016.03.006

Andersen, H. V., Gunnarsen, L., Knudsen, L. E., & Frederiksen, M. (2020). PCB in air, dust and surface wipes in 73 Danish homes. *International Journal of Hygiene and Environmental Health, 229*, 113429. doi:https://doi.org/10.1016/j.ijheh.2019.113429

Association, A. L. (2021). Indoor Air Pollutants and Health.

Azlan, A. A., Hamzah, M. R., Sern, T. J., Ayub, S. H., & Mohamad, E. (2020). Public knowledge, attitudes and practices towards COVID-19: A cross-sectional study in Malaysia. *PLOS ONE, 15*(5), e0233668. doi:10.1371/journal.pone.0233668

Baharuddin, M. R., Sahid, I. B., Noor, M. A., Sulaiman, N., & Othman, F. (2011). Pesticide risk assessment: A study on inhalation and dermal exposure to 2,4-D

and paraquat among Malaysian paddy farmers. *J Environ Sci Health B, 46*(7), 600-607. doi:10.1080/03601234.2011.589309

Bearg, D. W. (2019). *Indoor air quality and HVAC systems*: Routledge.

Becher, R., Øvrevik, J., Schwarze, P. E., Nilsen, S., Hongslo, J. K., & Bakke, J. V. (2018). Do carpets impair indoor air quality and cause adverse health outcomes: a review. *International journal of environmental research and public health, 15*(2), 184.

Bentley, J. (2001). Composition, manufacture and use of paint *Forensic Examination of Glass and Paint* (pp. 135-154): CRC Press.

Betts, K. (2008). New flame retardants detected in indoor and outdoor environments. *Environmental Science & Technology, 42*(18), 6778-6778. doi:10.1021/es802145r

Biehler, D. D. (2013). *Pests in the city: Flies, bedbugs, cockroaches, and rats*: University of Washington Press.

Bonino, S. (2016). Carbon Dioxide Detection and Indoor Air Quality Control. *Occupational Health and Safety, 85*, 46-48.

Braun, M., Koger, F., Klingelhöfer, D., Müller, R., & Groneberg, D. A. (2019). Particulate Matter Emissions of Four Different Cigarette Types of One Popular Brand: Influence of Tobacco Strength and Additives. *International journal of environmental research and public health, 16*(2), 263. doi:10.3390/ijerph16020263

Burroughs, H., & Hansen, S. J. (2020). *Managing indoor air quality*: River Publishers.

Cabaniss, A. D. (2018). *Handbook on household hazardous waste*: Rowman & Littlefield.

Camplin, J. C. (2003). Asbestos. *Professional Safety, 48*(8), 32-39.

CHARLES J. WESCHLER*, H. C. S. (2001). The Influence of Ventilation on Reactions Among Indoor Pollutants: Modeling and Experimental Observations. *Munksgoard 2000*(2000).

Das, S. K. (2003). Harmful health effects of cigarette smoking. *Molecular and cellular biochemistry, 253*(1), 159-165.

Destaillats, H., Maddalena, R., Singer, B., Hodgson, A., & McKone, T. (2008a). Indoor pollutants emitted by office equipment: A review of reported data and information needs. *Atmospheric Environment, 42*, 1371-1388.

Destaillats, H., Maddalena, R. L., Singer, B. C., Hodgson, A. T., & McKone, T. E. (2008b). Indoor pollutants emitted by office equipment: A review of reported data and information needs. *Atmospheric Environment, 42*(7), 1371-1388. doi:https://doi.org/10.1016/j.atmosenv.2007.10.080

Dodson, R. E., Rodgers, K. M., Carey, G., Cedeno Laurent, J. G., Covaci, A., Poma, G., . . . Allen, J. G. (2017). Flame retardant chemicals in college dormitories: flammability standards influence dust concentrations. *Environmental Science & Technology, 51*(9), 4860-4869.

DOSH. Code of practice on indoor air quality. 2005. *JKKP GP (1) 05/2005. ISBN 983-2014-51-41.* Retrieved from https://www.dosh.gov.my/index.php/legislation/codes-of-practice/chemical-management

Elango, N., Kasi, V., Vembhu, B., & Poornima, J. (2013). Chronic exposure to emissions from photocopiers in copy shops causes oxidative stress and systematic inflammation among photocopier operators in India. *Environmental health : a global access science source, 12*, 78. doi:10.1186/1476-069X-12-78

Environmental Protection Agency, E. (2016). Outdoor Air - Industry, Business, and Home: Wood Furniture Operations - Additional Information.

Fazlzadeh, M., Rostami, R., Hazrati, S., & Rastgu, A. (2015). Concentrations of carbon monoxide in indoor and outdoor air of Ghalyun cafes. *Atmospheric Pollution Research, 6*(4), 550-555. doi:https://doi.org/10.5094/APR.2015.061

Ficco, G., Dell'Isola, M., Vigo, P., & Celenza, L. (2015). Uncertainty analysis of energy measurements in natural gas transmission networks. *Flow Measurement and Instrumentation, 42*, 58-68. doi:https://doi.org/10.1016/j.flowmeasinst.2015.01.006

Flint, M. L., & Van den Bosch, R. (2012). *Introduction to integrated pest management*: Springer Science & Business Media.

Girman, J., Hadwen, G., Burton, L., Womble, S., & McCarthy, J. (1999). Individual volatile organic compound prevalence and concentrations in 56 buildings of the building assessment survey and evaluation (BASE) study. *Indoor air, 99*, 460-465.

González-Martín, J., Kraakman, N. J. R., Pérez, C., Lebrero, R., & Muñoz, R. (2021). A state–of–the-art review on indoor air pollution and strategies for indoor air pollution control. *Chemosphere, 262*, 128376. doi:https://doi.org/10.1016/j.chemosphere.2020.128376

Haines, S. R., Adams, R. I., Boor, B. E., Bruton, T. A., Downey, J., Ferro, A. R., . . . Dannemiller, K. C. (2020). Ten questions concerning the implications of carpet on indoor chemistry and microbiology. *Building and Environment, 170*, 106589. doi:https://doi.org/10.1016/j.buildenv.2019.106589

Hajizadeh, Y., Pourzamani, H., Ebrahimpour, K., Chavoshani, A., & Rahimi, B. (2021). Monitoring of paraben compounds in indoor and outdoor air of a populated city. *Atmospheric Pollution Research, 12*. doi:10.1016/j.apr.2021.02.012

Heeley-Hill, A. C., Grange, S. K., Ward, M. W., Lewis, A. C., Owen, N., Jordan, C., . . . Adamson, G. (2021). Frequency of use of household products containing VOCs and indoor atmospheric concentrations in homes. *Environmental Science: Processes & Impacts, 23*(5), 699-713. doi:10.1039/D0EM00504E

Hess-Kosa, K. (2018). *Indoor Air Quality: The Latest Sampling and Analytical Methods, Third Edition*: CRC Press.

Hodgson, A. T., Daisey, J. M., & Grot, R. A. (1991). Sources and Source Strengths of Volatile Organic Compounds in a New Office Building. *Journal of the Air & Waste Management Association, 41*(11), 1461-1468. doi:10.1080/10473289.1991.10466944

Horner, J. M. (2004). Lead in house paints–Still a health risk that should not be overlooked. *PROFESSIONAL EVALUATION, 3*(1), 1.

Information, N. C. f. B. (2021). Carbon dioxide. Retrieved September 1, 2021, from PubChem Compound Summary for CID 280 https://pubchem.ncbi.nlm.nih.gov/compound/Carbon-dioxide.

Ismail, S., Baharudin, M. R., Juahir, H., Azman, A. Z. F., Nizar, A., Zulkapri, I., . . . Othman, J. (2012). Development of an indoor air quality checklist for risk assessment of indoor air pollutants by semiquantitative score in nonindustrial workplaces. *Risk Manag Healthc Policy, 5*, 17-23. doi:10.2147/RMHP.S26567

Iwakiri, S., Trianoski, R., Castro, V. G., Parchen, C. F. A., & Araújo, R. D. (2013). Quality of plywoods obtained from melia azedarach combined with pinus taeda,

produced with urea-formaldehyde and phenol-formaldehyde resins. *Floresta, 44*(1), 93-100.

Jabarivasal, N. (2012). *Indoor atmospheric radon in Hamadan, Iran. Atmospheric radon indoors and around Hamadan city in Iran.* Retrieved from http://hdl.handle.net/10454/5452

Jendritzky, G., Havenith, G., Weihs, P., & Batchvarova, E. (2005). *COST Action 730 on the Universal Thermal Climate Index UTCI*: Selbstverlag des Deutschen Wetterdienstes, Offenbach am Main (Germany);.

Jia, C., & Batterman, S. (2010). A Critical Review of Naphthalene Sources and Exposures Relevant to Indoor and Outdoor Air. *International journal of environmental research and public health, 7*, 2903-2939. doi:10.3390/ijerph7072903

Jung, C.-C., Wu, P.-C., Tseng, C.-H., & Su, H.-J. (2015). Indoor air quality varies with ventilation types and working areas in hospitals. *Building and Environment, 85*, 190-195. doi:https://doi.org/10.1016/j.buildenv.2014.11.026

Kaden DA, M. C., Nielsen GD, et al. F. (2010.). ormaldehyde. In: WHO Guidelines for Indoor Air Quality: Selected Pollutants. Geneva: World Health Organization; . *3*.

Kanuka-Fuchs, R. (2001). *Healthy Home and Healthy Office*: Harald W. Tietze.

Kauneliene, V., Meisutovic-Akhtarieva, M., Prasauskas, T., Ciuzas, D., Krugly, E., Keraitytė, K., & Martuzevicius, D. (2019). Impact of Using a Tobacco Heating System (THS) on Indoor Air Quality in a Nightclub. *Aerosol and Air Quality Research, 19*. doi:10.4209/aaqr.2019.04.0211

Kim, S., Hong, S.-H., Bong, C.-K., & Cho, M.-H. (2015). Characterization of air freshener emission: the potential health effects. *The Journal of toxicological sciences, 40*(5), 535-550.

Kubba, S. (2012). Indoor Environmental Quality. *Handbook of Green Building Design and Construction*, 313-360. doi:10.1016/B978-0-12-385128-4.00007-X

Lee, M. Y., & Tam, C. L. (2014). Smoking and burden of ill health: a review of the Malaysian context. *International Journal of Collaborative Research on Internal Medicine & Public Health, 6*(7), 190.

Lim, F. L., Hashim, Z., Md Said, S., Than, L. T., Hashim, J. H., & Norbäck, D. (2015). Sick building syndrome (SBS) among office workers in a Malaysian university--Associations with atopy, fractional exhaled nitric oxide (FeNO) and the office environment. *Sci Total Environ, 536*, 353-361. doi:10.1016/j.scitotenv.2015.06.137

Liqun, G., & Yanqun, G. (2011). Study on Building Materials and Indoor Pollution. *Procedia Engineering, 21*, 789-794. doi:https://doi.org/10.1016/j.proeng.2011.11.2079

Massimo, A., Dell, Isola, M., Frattolillo, A., & Ficco, G. (2014). Development of a Geographical Information System (GIS) for the Integration of Solar Energy in the Energy Planning of a Wide Area. *Sustainability, 6*(9). doi:10.3390/su6095730

Md Meftaul, I., Venkateswarlu, K., Dharmarajan, R., Annamalai, P., & Megharaj, M. (2020). Pesticides in the urban environment: A potential threat that knocks at the door. *Science of The Total Environment, 711*, 134612. doi:https://doi.org/10.1016/j.scitotenv.2019.134612

Mølhave, L., Kjaergaard, S. K., Sigsgaard, T., & Lebowitz, M. (2005). Interaction between ozone and airborne particulate matter in office air. *Indoor air, 15*(6), 383-392. doi:10.1111/j.1600-0668.2005.00366.x

Morawska, L., Ayoko, G. A., Bae, G. N., Buonanno, G., Chao, C. Y. H., Clifford, S., . . . Wierzbicka, A. (2017). Airborne particles in indoor environment of homes, schools, offices and aged care facilities: The main routes of exposure. *Environment International, 108*, 75-83. doi:https://doi.org/10.1016/j.envint.2017.07.025

Narkowicz, S., Polkowska, Ż., & Namieśnik, J. (2012). Analysis of markers of exposure to constituents of environmental tobacco smoke (ETS). *Critical Reviews in Analytical Chemistry, 42*(1), 16-37.

Nero, A. V., & Nazaroff, W. (1984). Characterising the source of radon indoors. *Radiation Protection Dosimetry, 7*(1-4), 23-39.

Nezis, I., Biskos, G., Eleftheriadis, K., & Kalantzi, O.-I. (2019). Particulate matter and health effects in offices - A review. *Building and Environment, 156*, 62-73. doi:https://doi.org/10.1016/j.buildenv.2019.03.042

Niu, X., Guinot, B., Cao, J., Xu, H., & Sun, J. (2015). Particle size distribution and air pollution patterns in three urban environments in Xi'an, China. *Environ Geochem Health, 37*(5), 801-812. doi:10.1007/s10653-014-9661-0

Norhidayah, A., Chia-Kuang, L., Azhar, M., & Nurulwahida, S. (2013). Indoor air quality and sick building syndrome in three selected buildings. *Procedia Engineering, 53*, 93-98.

Ohura, T., Amagai, T., Fusaya, M., & Matsushita, H. (2004). Polycyclic Aromatic Hydrocarbons in Indoor and Outdoor Environments and Factors Affecting Their

Concentrations. *Environmental Science & Technology, 38*(1), 77-83. doi:10.1021/es030512o

Patel, S., Sankhyan, S., Boedicker, E. K., DeCarlo, P. F., Farmer, D. K., Goldstein, A. H., . . . Vance, M. E. (2020). Indoor Particulate Matter during HOMEChem: Concentrations, Size Distributions, and Exposures. *Environmental Science & Technology, 54*(12), 7107-7116. doi:10.1021/acs.est.0c00740

Pérez-Padilla, R., Schilmann, A., & Riojas-Rodriguez, H. (2010). Respiratory health effects of indoor air pollution. *The International Journal of Tuberculosis and Lung Disease, 14*(9), 1079-1086.

Pfister, M. (1993). Finishes for furniture (1993).

Pirela, S. V., Martin, J., Bello, D., & Demokritou, P. (2017). Nanoparticle exposures from nano-enabled toner-based printing equipment and human health: state of science and future research needs. *Critical reviews in toxicology, 47*(8), 678-704. doi:10.1080/10408444.2017.1318354

Pośniak, M., Kowalska, J., & Makhniashvili, I. (2005). Exposure to hazardous chemical substances in furniture industry. *Medycyna pracy, 56*(6), 461-465.

Quirce, S., & Barranco, P. (2010). Cleaning agents and asthma. *J Investig Allergol Clin Immunol, 20*(7), 542-550; quiz 542p following 550.

Raw, G. J., Health, G. B., & Executive, S. (1992). *Sick Building Syndrome: A Review of the Evidence on Causes and Solutions*: H.M. Stationery Office.

Rosbach, J., Krop, E., Vonk, M., van Ginkel, J., Meliefste, C., de Wind, S., . . . Brunekreef, B. (2016). Classroom ventilation and indoor air quality-results from the FRESH intervention study. *Indoor air, 26*(4), 538-545. doi:10.1111/ina.12231

Roser, H. R. M. (2014). Indoor Air Pollution

Salonen, H., Salthammer, T., & Morawska, L. (2018). Human exposure to ozone in school and office indoor environments. *Environ Int, 119*, 503-514. doi:10.1016/j.envint.2018.07.012

Salthammer, T. (2020). Emerging indoor pollutants. *International Journal of Hygiene and Environmental Health, 224*, 113423. doi:https://doi.org/10.1016/j.ijheh.2019.113423

Slack, R. J. (2007). Household hazardous waste: disposal to landfill as a pathway for environmental pollution.

Stabile, L., Dell'Isola, M., Russi, A., Massimo, A., & Buonanno, G. (2017). The effect of natural ventilation strategy on indoor air quality in schools. *Science of The Total Environment, 595*, 894-902. doi:https://doi.org/10.1016/j.scitotenv.2017.03.048

Steinemann, A. (2017). Ten questions concerning air fresheners and indoor built environments. *Building and Environment, 111*, 279-284. doi:https://doi.org/10.1016/j.buildenv.2016.11.009

Stoye, D., & Freitag, W. (2008). *Paints, coatings and solvents*: John Wiley & Sons.

Syazwan, A., Rafee, B. M., Hafizan, J., Azman, A., Nizar, A., Izwyn, Z., . . . Othman, J. (2012). Development of an indoor air quality checklist for risk assessment of indoor air pollutants by semiquantitative score in nonindustrial workplaces. *Risk Manag Healthc Policy, 5*, 17-23. doi:10.2147/rmhp.s26567

Syazwan, A., Rafee, B. M., Juahir, H., Azman, A., Nizar, A., Izwyn, Z., . . . Kamarul, F. (2012). Analysis of indoor air pollutants checklist using environmetric technique for health risk assessment of sick building complaint in nonindustrial workplace. *Drug, healthcare and patient safety, 4*, 107-126. doi:10.2147/dhps.s33400

Syazwan, A., Rafee, B. M., Juahir, H., Azman, A., Nizar, A., Izwyn, Z., . . . Kamarul, F. (2012). Analysis of indoor air pollutants checklist using environmetric technique for health risk assessment of sick building complaint in nonindustrial workplace. *Drug, healthcare and patient safety, 4*, 107-126. doi:10.2147/DHPS.S33400

Syazwan Aizat, I., Juliana, J., Norhafizalina, O., Azman, Z., & Kamaruzaman, J. (2009). Indoor air quality and sick building syndrome in Malaysian buildings. *Glob J Health Sci, 1*(2), 126-136.

Tian, X., Yi, Z., Jin, T., & Wang, X. (2015). *Indoor Ozone Pollution and the Purification Technologies.* Paper presented at the ICIEA 2015.

Toftum, J., Kjeldsen, B. U., Wargocki, P., Menå, H. R., Hansen, E. M. N., & Clausen, G. (2015). Association between classroom ventilation mode and learning outcome in Danish schools. *Building and Environment, 92*, 494-503. doi:https://doi.org/10.1016/j.buildenv.2015.05.017

Tran, V. V., Park, D., & Lee, Y.-C. (2020). Indoor Air Pollution, Related Human Diseases, and Recent Trends in the Control and Improvement of Indoor Air Quality. *International journal of environmental research and public health, 17*(8), 2927. doi:10.3390/ijerph17082927

Triassi, M., Alfano, R., Illario, M., Nardone, A., Caporale, O., & Montuori, P. (2015). Environmental pollution from illegal waste disposal and health effects: a review on the "triangle of death". *International journal of environmental research and public health, 12*(2), 1216-1236. doi:10.3390/ijerph120201216

Tsai, D. H., Lin, J. S., & Chan, C. C. (2012). Office workers' sick building syndrome and indoor carbon dioxide concentrations. *J Occup Environ Hyg, 9*(5), 345-351. doi:10.1080/15459624.2012.675291

Turekian, K. K., Nozaki, Y., & Benninger, L. K. (1977). Geochemistry of atmospheric radon and radon products. *Annual Review of Earth and Planetary Sciences, 5*(1), 227-255.

Turiel, I., Hollowell, C. D., Miksch, R. R., Rudy, J. V., Young, R. A., & Coye, M. J. (1983). The effects of reduced ventilation on indoor air quality in an office building. *Atmospheric Environment (1967), 17*(1), 51-64. doi:https://doi.org/10.1016/0004-6981(83)90007-0

Vainio, H., & Boffetta, P. (1994). Mechanisms of the combined effect of asbestos and smoking in the etiology of lung cancer. *Scandinavian journal of work, environment & health*, 235-242.

van der Zee, S. C., Strak, M., Dijkema, M. B., Brunekreef, B., & Janssen, N. A. (2017). The impact of particle filtration on indoor air quality in a classroom near a highway. *Indoor air, 27*(2), 291-302.

Vimercati, L., Cavone, D., Mansi, F., Cannone, E. S. S., De Maria, L., Caputi, A., . . . Serio, G. (2019). Health impact of exposure to asbestos in polluted area of Southern Italy. *Journal of preventive medicine and hygiene, 60*(4), E407-E418. doi:10.15167/2421-4248/jpmh2019.60.4.1330

Wang, M., Jia, S., Lee, S. H., Chow, A., & Fang, M. (2021). Polycyclic aromatic hydrocarbons (PAHs) in indoor environments are still imposing carcinogenic risk. *Journal of Hazardous Materials, 409*, 124531. doi:https://doi.org/10.1016/j.jhazmat.2020.124531

WHO. World Health Organization. Retrieved from https://www.who.int/health-topics/air-pollution#tab=tab_2

Wolkoff, P., Azuma, K., & Carrer, P. (2021). Health, work performance, and risk of infection in office-like environments: The role of indoor temperature, air

humidity, and ventilation. *Int J Hyg Environ Health, 233*, 113709. doi:10.1016/j.ijheh.2021.113709

World Health Organization. Office of, L., & Health Literature, S. (1988). Styles for bibliographic citations : guidelines for WHO-produced bibliographies (2nd ed ed.). Geneva: World Health Organization.

Zainal, Z. A., Hashim, Z., Jalaludin, J., Lee, L. F., & Hashim, J. H. (2019). Sick Building Syndrome among Office Workers in relation to Office Environment and Indoor Air Pollutant at an Academic Institution, Malaysia. *Malaysian Journal of Medicine and Health Sciences, 15*(3).