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A SYSTEMATIC LITERATURE REVIEW (SLR) OF INDOOR AIR QUALITY (IAQ) ON OCCUPANTS' HEALTH AND WELL-BEING IN RESIDENTIAL BUILDING

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Abstract

Air pollution is a major disturbance nowadays. It occurs in not only one country, but even throughout the whole world. Besides, air pollution involves not only one gas, but also a variety of gases that can give an impact on human health and flora and fauna. Hence, this paper aims to review the previous research related to indoor air quality (IAQ) conducted worldwide. A Systematic Literature Review (SLR) was employed in this study to identify, critically appraise, and summarise the previous research findings related to the IAQ. This paper concludes that particulate matter, nitrogen dioxide, and carbon monoxide were the problems that are commonly associated with IAQ as addressed by other researchers. These findings are beneficial to new researchers who intended to conduct a study on the aspect of IAQ.

Keywords: *air pollution; indoor air quality (IAQ); systematic literature review (SLR)*

1.0 INTRODUCTION

Developed countries not only own their magnificent development, but also extensive transport systems to cater for the nation's density wthout realising that such systems cause health problems to the citizens. As a result of developmental activities, air pollution is prevalent to most developed countries. To date, air pollution has become the subject of research and discussions of the world as air pollution affects the health of the people. According to the World Health Organizati (2019), recorded urban air pollution (outdoor and indoor) contributed to over seven millions premature deaths (WHO, 2019) with higher impacts in developing nations such as Indonesia, China, and India (Chin et al., 2019). Besides, countries such as Bangladesh, India, Pakistan, USA, and Saudi Arabia have among the highest national air pollution readings in the world. The readings of air quality in countries are always updated daily (IQAir, 2019). This is because, the symptoms or results that are adverse to human well-being are closely connected to contaminated environments, which consequently deteriorate the satisfaction of life.

Similar to other emerging countries, Malaysia has seen rapid economic and urban growth and has been aspiring to become a developed country by 2020. As a result of rapid growth in the evolving state of Malaysia, Malaysia could not avoid extreme air pollution, which affects human health (Chin et al., 2019). According to The World Air Quality ranking, Malaysia ranked the 50th in the world, while in Asia, Malaysia is the 7th among nine Asian nations (IQAir, 2019).

2.0 LITERATURE REVIEW

2.1 Outdoor Air Quality

Air pollution is one of the world's significant challenges and threatens the indoor environment of residential homes, which leads to various health threats (Leung, 2015). Outdoor air pollutants mainly consist of a lot of harmful gases which are; nitrogen oxide (NOx), sulphur oxide (SOx), ozone (O3), lead (Pb), sulphur dioxide (SO2), particulate matter (PM), carbon dioxide (CO2), carbon monoxide (CO), methane (CH4), and many more (Leung, 2015; WHO, 2019). It is understood that these contaminants are often produced in urban areas. These contaminants are released from on-road and off-road vehicles (70-75%) (Chin et al., 2019). However, there are also contributions from power plants, industrial factories, open combustion, and so on. All these activities depend on the location of the site and the existing wind (Leung, 2015).

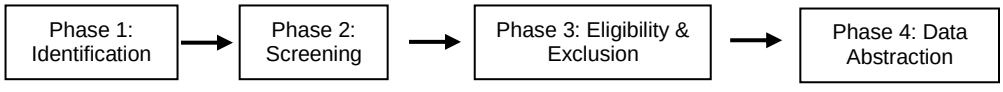
2.2 Indoor Air Quality

Due to the rise of the amount of time spent in different spaces such as home and offices, IAQ is a vital concern in recent years. IAQ has been reported as having many air contaminants, including VOC, radon, microorganisms, O3, CO, and many more. Some of these pollutants are prevalent in both indoor and outdoor environments, and some may originate from outdoor environments (Leung, 2015). It has been proven that some air pollution gases from outdoor activities affect IAQ (Sun et al., 2018). As such, outdoor and indoor pollution influence the population's health at an instant rate such as respiratory systems (e.g., coughing, difficulty in breathing, tightness of chest, and many more). The residents will feel uncomfortable even when they are in a building (Leung, 2015).

In Malaysia, air pollution is typically caused by three (3) factors, namely combustion, industry, and vehicles. According to the Department of Environment (DOE) (2019), air quality should be monitored continuously and manually to identify any change in air quality early so it does not threaten human health and the environment. The air pollution index (API) is a medium used to track average readings of gas such as O3, SO2, CO, CO2, PM, and so on. Rampant air pollution can lead to respiratory and lung disorders (Shafii et al., 2018).

3.0 RESEARCH METHODOLOGY

The extensive study covers issues related to outdoor and indoor air for the well-being and health of residents. This identification was carried out in the form of a query to allow a systematic search. For the systematic literature search, the researcher used two groups of the database, which were lead database and supported database. Web of Science (WoS) and PubMed were chosen to be the lead database. WoS was selected to cover publications on natural sciences while PubMed covered sciences and biomedical topics. At this phase, related published papers were searched using keywords such as "air pollution and health risk", "association of air pollutants and health", and "air pollution and perceived health".



The search string as follows;

Web of Science	"air pollution" OR "air contamination" AND "health risk" OR "well-being" AND "residential" OR "occupants"	47
PubMed	"air pollution" OR "air contamination" AND "health risk" OR "well-being" AND "residential" OR "occupants"	101

From the database, only full texts, review papers, and papers with years of publication which were available for the authors were considered. After that, the next group was considerd, which is a supporting group database consisting of Google Scholar, Scopus.

Google Scholar	"air pollution" OR "air contamination" OR "urban contamination" AND "impact on health" OR "health risk" AND "residential" AND "low-cost housing" OR "economical housing" OR "low budget" AND "Malaysia" OR "Kuala Lumpur" (2014-2020)	28
Scopus	"air pollution" OR "air contamination" OR "urban contamination" AND "impact" OR "effect" AND "health" AND "residential" OR "occupants" AND "low-cost" AND "economical"	30

The next step is screening after the recognition process of the analysis. In this phase, the research described is consistent with the context needed, such as air quality, health effects, air pollution in urban areas as well as excluding the type of document. The literature focused on studies conducted in the last six years back, from 2014 to 2020. To allow the comparisons, the concept of literature searching is limited to studies performed in larger cities from any region—afterwards, the eligibility and exclusion stage. The total number of studies mentioned above were checked on a rough basis by looking at the abstract. At this stage, 27 literature were selected for the SLR. The systematic literature review was tabulated with List of Pollutants, Authors, Year of Publication and Type of Documents at the next stage.

4.0 ANALYSIS & DISCUSSION: SYSTEMATIC LITERATURE REVIEW

Table 1 shows a list of air pollutants found worldwide via research. Using the Systematic Literature Review methods, researchers found that there are 16 types of air pollutants frequently found by researchers around the world.

Table 1: Type of air pollutants

Type of Air Pollutant	Lazovic	Leung (2015)	Vardoulakis et al. (2015)	Ji & Zhao,	Jiang et al., (2016)	Maharana et al.,(2018)	Castell et al., (2018)	Sun et al.,	Sharma et al (2018)	Ndong Ba et al., (2019)	Dandotiya (2019)	Houdouin & Dubus, 2019)	Chin et al.,	Sharpe et al., (2020)	Frequency
D/Type	P	R	R	D	R	D	D	D	D	D	R	R	D	R	*f*
NO2	/	/	/		/	/	/	/		/		/		/	10
CH4															0
Hydrocarbon		/				/									2
NOx					/					/	/				3
SOx					/						/				2
Pb					/									/	2
O3		/	/		/						/	/		/	6
SO2		/			/	/		/						/	5
PM	/	/	/	/	/	/		/	/	/	/	/	/	/	13
CO		/	/		/	/				/	/		/	/	8
CO2	/					/				/	/				4
VOC		/	/		/	/				/	/			/	7
Mercury															0
Microorganisms		/				/								/	3
Rado		/	/		/									/	4

n														
Asbestos													/	1

According to the schedule provided, from all of the types of air pollutants, the researcher found particulate matter (*f*=12) is a type of air pollutant that was frequently reviewed almost every year—followed by nitrogen dioxide (*f*=9), and carbon monoxide (*f*=8).

Table 2: Type of outdoor air pollutants

Type of outdoor air pollutants	Lazovic (2014)	Leung, (2015)	Ji & Zhao, (2015)	Castell et al. (2018)	Sun et al. (2018)	Sharma et al. (2018)	Ndong Ba et al. (2019)	Dandotiya (2019)	Houdouin & Dubus, 2019)	Chin et al., 2019)	Frequency
D/Type	P	R	D	D	D	D	D	R	R	D	*f*
NO2	/	/		/	/		/		/		6
PM	/	/	/		/	/	/	/	/	/	9
CO		/					/	/		/	4

From the types of air pollutants in Table 1, the researcher highlighted the top three outdoor air pollutants that were constantly being reviewed by researchers. As displayed in Table 2, researchers found that the most commonly found outdoor air pollutants were particulate matter (*f*=9), followed by nitrogen dioxide (*f*=6), and carbon monoxide (*f*=4).

Table 3: Type of Indoor Air Pollutants

Type of indoor air pollutants	Lazovic (2014)	Leung (2015)	Vardoulakis et al. (2015)	Ji & Zhao (2015)	Jiang et al. (2016)	Maharana et al. (2018)	Ndong Ba et al. (2019)	Dandotiya (2019)	Sharpe et al., (2020)	Frequency
D/Type	P	R	R	D	R	D	D	R	R	*f*
NO2	/	/	/		/	/	/		/	7
PM	/	/	/	/	/	/	/	/	/	9
CO2		/	/		/	/	/	/	/	7
VOC		/	/		/	/	/	/	/	7

The researcher highlighted the top four indoor air pollutants that are mostly reviewed by researchers out of all types of air pollutants in Table 3. The pollutants were PM (*f*=9), followed by NO2 (*f*=7), CO (*f*=7), and VOC (*f*=7).

4.1 Particulate Matter (PM)

Particulate matter is a mixture of airborne particles and liquid drops such as dust, smoke (cigarettes, kitchen stove) that may be seen through naked eyes. However, a small particle (PM 2.5) can only be seen under the microscope. Generally, PM includes PM 2.5 and PM 10. Leung (2015) and Sharpe et al., (2020) said this PM could affect human health such as cardiovascular disease and respiratory system problems (Table 4).

4.2 Nitrogen Dioxide (NO2)

Nitrogen dioxide is a series of gases formed by the process of combustion. It is a combination of combustion process gases (e.g. vehicles, industrials, commercials) and oxygen in the air. This gas could lead to health problems such as coughing and shortness of

breath/asthma (Leung, 2015). If it is not treated/reduced, it can lead to worse health problems such as lung cancer (Table 4).

4.3 Carbon Monoxide (CO)

Carbon monoxide is an invisible, odourless gas, but when released for a long time, its effects on humans are highly harmful and can cause death (Leung, 2015). CO gas is produced by incomplete fossil fuel (e.g. coal, woods, motor vehicles, natural gas, and kerosene). Many recommendations have been made after being reviewed by many experts (Table 4) (Sharpe et al., 2020).

4.4 Volatile Organic Compound (VOC)

Volatile organic compound (VOC), is a large collection of chemicals that humans often use in the house. VOC gas may or may not carry a scent. Among the examples of VOC in the house are; paints, adhesives, composite wood products, air fresheners, cosmetics, fuel oil, gasoline, carpets, and various products of the same properties (Table 4). VOC in the house can cause respiratory system disruption if it is frequently used and is not controlled. Furthermore, a longer exposure to it can cause lung cancer, and liver and kidney damage (Leung, 2015).

In addition to the health risks involved, Table 4 displays some recommendations with regards to the air pollutants highlighted by previous research.

Table 4: Possibility of health risk and recommendations by the researchers

Type of Pollutants (Outdoor and Indoor)	Possibility of Health Risk	The Recommendation by Researchers
Carbon Monoxide Particulate Matter (PM 2.5 & PM 10) Nitrogen Dioxide Volatile Organic Compound (VOC)	● Acute Severe Difficulties in breathing Nausea Dizziness Headaches Coughing Shortness of breath Asthma Vomiting Confusions ● Long-term severe lung cancer Stroke Liver & kidney damage	1. Reduce the number of vehicle usage 2. Reduce the time facing the cooking stoves according to the standard given. 3. Use a suitable ventilation air system in the house 4. Buy a low VOC product 5. Store the VOC product in a space where fewer people spend time at 6. Dispose unused VOC product 7. Maintain a suitable temperature and humidity in the house 8. All recommendations must be in accordance with the guideline in the table below.

Table 5: Standard of ambient air quality

Pollutants	Averaging Time	Ambient Air Quality Standard
PM 2.5	24 hours	35 µg/m³
PM 10	24 hours	100 µg/m³
NO2	24 hours	70 µg/m³
CO	8 hours	10 µg/m³

Source: Department of Environment Malaysia, 2020)

5.0 CONCLUSION

The pollutants stated are often studied as the indoor air quality issue has always been an issue every year but not the solution to resolve the issue. After the Systematic Literature Review (SLR) process, the researcher found that particulate matter, nitrogen dioxide, and carbon monoxide were the main problems that were commonly addressed by other researchers so far. This form of air pollution has a significant effect on the well-being of local people. However, experts studying the impact of this type of pollution or other emissions proposed a few reasonable suggestions to reduce the effects of poor air quality on the health and well-being of the public.

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