Sick Building Syndrome in Ageing Vertical Developments: A Sustainable Remediation Framework High-Rise Assets-The Case of KOMTAR Tower, Penang, Malaysia

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ABSTRACT

Sick Building Syndrome (SBS) has become a significant environmental health concern in contemporary workplaces. It is characterized by a range of non-specific symptoms experienced by occupants while inside a building, which typically diminish once they leave the premises. This study examines the factors contributing to SBS and its effects on the health, comfort, and work performance of office employees from Majlis Bandaraya Pulau Pinang (MBPP) occupying Levels 11 to 17 of the KOMTAR building in Penang. The research was motivated by concerns that aging infrastructure and centralized ventilation systems in older government buildings may heighten the risk of SBS. The primary objectives were to identify key contributing factors, evaluate the impacts on occupants, and propose appropriate preventive measures and a remediation framework. Adopting a quantitative research design, data were gathered through a structured digital questionnaire distributed via purposive sampling, resulting in 70 valid responses. The data were analyzed using Jamovi software, with emphasis on descriptive statistical analysis. The findings indicate that dust accumulation, noise disturbance, and temperature instability were the most prominent environmental contributors to SBS. In terms of health effects, respondents frequently reported symptoms such as headaches, fatigue, and eye irritation, which were significantly associated with perceived reductions in work productivity and psychological well-being. Additionally, occupants prioritized the installation of high-efficiency air purifiers, regular maintenance of ventilation ducts, and the use of non-toxic building materials as key preventive strategies. The study concludes that a substantial relationship exists between indoor environmental quality within the KOMTAR building and the prevalence of SBS symptoms among MBPP staff. It is therefore recommended that building management strengthen preventive maintenance practices and implement targeted improvements to enhance indoor environmental conditions implementing sustainable remediation framework

Keywords: Sick Building Syndrome, Productive Indoor Environment, Remediation SBS Framework.

INTRODUCTION

Sick Building Syndrome (SBS) has become a growing academic and professional concern at the time of growing awareness of the adverse health outcomes of bad indoor environmental conditions. With buildings becoming complicated, closed-up spaces, usually with mechanical ventilation and electrical lighting, there is a growing possibility of the poorly managed indoor spaces negatively influencing the health, comfort, and productivity of building users. Sick Building Syndrome (SBS) is a term that has been used over recent decades to describe a range of non-specific illnesses experienced by occupants while inside a particular building or within a specific area of the indoor environment. These symptoms commonly disappear within hours, or in some cases days, after the occupant leaves the enclosed space, indicating a direct link between the indoor environment and individual health (Wang et al, 2022).

The World Health Organization (WHO) proposed SBS in 1983 and it refers to a group of vague symptoms that are triggered by the exposure to dangerous substances at the workplace. These causes have such symptoms as headache, fatigue, mucosal and skin irritation, and respiratory issues, which lead to poor health and the productivity of occupants (Wang et al, 2022). A spatiotemporal nature is one of the most important peculiarities

of SBS, as the symptoms come on following extended contact with a building and subside automatically once the individual leaves the setting (Wang et al, 2022).

This study aims to identify the remediation the Sick Building Syndrome (SBS) Framework in Ageing Vertical Developments. A Sustainable Remediation Framework for Legacy High-Rise Assets for building occupants and assess its potential impact on their health, with particular attention to indoor environmental quality factors in selected Malaysian building remediations of the HVAC system and adopt holistic air quality management protocols to ensure a healthy and productive indoor environment.

Problem Statement

Sick Building Syndrome (SBS) is one situation that is rising in the field of modern-day work environment bringing with it numerous health symptoms (Bello, 2024). SBS has a considerable effect on the health, comfort, and productivity of the occupants of offices, houses, as well as schools (Nduka et al, 2021).

The typical ones are breathing and eye problems, headaches, and weakness (Bello, 2024). The health-related building-related illnesses are mainly due to indoor air quality (IAQ), where a low ventilation rate of people occupying the building raises the chances of developing symptoms and reduces productivity. SBS is also associated with physical and chemical contaminants and personal and sociodemographic factors (Aziz et al., 2023).

Research points to lack of the awareness and appropriate monitoring of Sick Building Syndrome (SBS) by the managers of office buildings and facility operators. SBS relates to the low quality of indoor air and poor ventilation which cause different health symptoms that normally resolve themselves without the person having to come out of the building (Awang, 2023). The research on the knowledge and attitude toward individual preventative measures towards SBS is scarce (Nduka, 2021). Green building techniques and enhancing indoor air quality by maintaining good ventilation and preventing sources will aid in alleviating symptoms of SBS and the development of healthier workplaces (Awang. 2023).

Sick Building Syndrome (SBS) is a term which implies that people experience health problems and feel uncomfortable in the building offices (Bello, 2024). Researchers have indicated that SBS may contribute to poor well-being of the employees, higher rate of employee absenteeism and an overall decline in productivity (Bello, 2024)). SBS symptoms may have a high prevalence, and one research found that they reached 74.4 percent and 68.5 percent among women and men, respectively (Suzuki et al., 2021). Some of the long-term effects of unmanaged SBS can be work impairments, poor relationships, and economic wastage through poor attendance and low productivity (Bello, 2024)

Recent studies by Awang (2023) highlight the urgency of investigating SBS in high-rise office buildings. Their work underlines the importance of rigorous maintenance and monitoring systems as a means of improving health outcomes for occupants in aging facilities.

Therefore, those knowledge gaps should be filled by further research and effective prevention strategies should be implemented. This research is significant as it aims to enhance understanding of the factors contributing to Sick Building Syndrome (SBS) and its impact on building occupants particularly within office and institutional environments. This research can guide the stakeholders of the construction and property management sector as well as the building owners and facility managers because it highlights the cause and effects of SBS. The results of the present study will lead to formulation of efficient strategies and protocols to reduce the threat related to SBS and eventually result in healthy and comfortable indoor settings. Moreover, this study can be used as a source of future research regarding building performances, indoor air quality, and occupants' wellbeing. It also promotes the overall objectives of a healthy and sustainable building designing and maintenance procedures.

Objectives

This study synthesizes finding from the research

1. To identify the indoor building condition of KOMTAR building, Penang.

2. To assess the impact of indoor building condition on the health, comfort, and work performance related to Sick Building Syndrome (SBS) among office occupants.

3. To propose remedial preventive measures framework to improve indoor building condition in order to minimize the occurrence of Sick Building Syndrome (SBS) in the high-rise office building.

LITERATURE REVIEW

Definition of Sick Building Syndrome (SBS)

Sick Building Syndrome (SBS) is a complex of sick occupants, discomfort and health challenges by occupants of particular buildings with regard to the time spent there (Bello, 2024). The usual effects involve eye, respiratory, and skin disorders, headaches, exhaustion and deficient attention (Bello, 2024). According to a research, workers found that at work, they had irritated nostrils, headache, inability to concentrate as well as sneezing. Most frequently reported SBS symptom among the staff, in most cases included the headache, but other studies reported that other SBS symptoms included lethargy and dizzy as the most common ones. The predominant SBS symptoms such as headache and tiredness were always reported (Aziz et al, 2023).

Generally, the ones who appeared frequently were headache, fatigue, inability to concentrate or breathe, being sleepy, and chest tightness, as most of the office staff complained. Complaints of headaches and irritation of the eyes after an entire day on the job were frequent in the respondents. On the one hand, other studies still claimed that the irritation of the nose and throat belonged to the most widespread symptoms; on the other hand, nose irritation proved to be the least reported of all. Seasonal difference was also involved, fatigue, irritation, nervousness, tired eyes being experienced more during summer than during winter (Aziz et al, 2023).

Indoor Air Quality (IAQ) and Its Contribution to Sick Building Syndrome.

Building Factors

Factors associated with building have a direct and critical bearing on the possibility of Sick Building Syndrome (SBS) occurrence among occupants. The most important factors include indoor air quality (IAQ), indoor temperature and humidity, ventilation rate, and the quality of mechanical systems maintenance. Aziz et al, (2023) note that SBS symptoms are closely related to such physical and environmental factors as ventilation efficiency, temperature control, indoor dampness, and airborne contaminants. Their results emphasize that the combination of these parameters brings about the complex indoor environments and SBS is a multifactorial and not a single-causality condition.

Ventilation Rate

As a systematized review, Aziz et al, (2023) found that ventilation rate is one of the primary environmental predictors of SBS. Through a series of studies, they found that low ventilation rates had a significant relationship with reports of mucosal, dermal and general symptoms by occupants especially in office and residential buildings. This shows that ensuring that the ventilation is vital in ensuring that the IAQ levels remain acceptable. Similarly, Iwayama et al, (2025) discovered that the larger the ventilation volumes, the less the general SBS symptom in Japanese modern houses. Nevertheless, they also noted that the connection between high ventilation rate and greater mucosal irritation existed under certain occasions where the pollutants were disseminated by the ventilation system itself and thus, they are not linearly connected.

Temperature

Such findings have been corroborated in the recent research in the different climatic zones. Indicatively, Abu Mansor et al. (2024) indicated that high room temperatures were significantly linked to such symptoms in administration office workers as headaches, dizziness, and skin irritation in Malaysia, which implies that an effect of thermal conditions directly influences SBS symptomatology. Similarly, Sovero et al, (2024) stated that

the sudden temperature change and the thermal loads increase are also known to affect the physiological response of the occupants, that is, the elevation in the body temperature and heart rate, which, in turn, leads to the emergence of perceived discomfort and SBS-related symptoms.

Zubir et al, (2022) demonstrated that high concentrations of indoor temperature and humidity worsened the discomfort and poorer air quality perception of occupants of hot and humid environments and aggravated the SBS symptoms.

Humidity

One of the most influential environmental parameters that affect indoor air quality and prevalence of the Sick Building Syndrome (SBS) is humidity. Outdoor climatic condition is important in determining the level of indoor humidity, which determines the level of comfort and health outcomes among the occupants. Nevertheless, humidification with the objective of reaching satisfactory indoor air quality has not always improved the SBS symptoms. As a matter of fact, there have been studies to indicate that the association between the application of humidifiers in air-conditioning systems and the enhancement of SBS-related symptoms may be higher than the other way round. The recent systematic reviews indicate that humidity, ventilation, and temperature are the most important indoor environmental factors that contribute to the SBS risk (Aziz et al, 2023).

Freshness of the Ambien Air

Freshness of ambient air is an important source of indoor air quality as well as one of the key factors which may cause Sick Building Syndrome (SBS). Air freshness is the perceived purity and comfort of occupants and depends upon the rate of ventilation, the air flow and the level of indoor air pollutants: Carbon Dioxide (CO2), volatile organic compounds (VOCs), and particulate matter. Poor air exchange or ineffective ventilation results in the buildup of these contaminants that contribute to negative health outcomes that include headaches, eye and throat swelling, fatigue, and difficulties with concentration (Nimlyat and Inusa, 2023).

The occupant well-being and productivity mainly depend on the freshness of ambient air. Proper ventilation, frequent air movement and proper temperature regulation are key factors that ensure that air remains fresh hence minimizing the occurrence of Sick Building Syndrome particularly in office buildings that have high density like KOMTAR in Penang.

Bacterial and Fungal

The microbial growth is usually observed in the damp or gaseous surroundings of a building, HVAC (Heating, Ventilation, and Air Conditioning), carpets, ceilings and wall materials that might have been damaged by condensation or water. In this scenario, bacteria and fungi may multiply, discharge bioaerosols, such as spores, endotoxins, and microbial volatile organic compounds (MVOCs) that deteriorate the quality of indoor air and have a negative impact on human health (Taheri Sarvtin, 2023).

Malaysian-based research also confirmed that bacterial and fungal taxa detected in indoor dust samples showed a positive relationship with SBS symptoms which included fatigue, throat irritation and eye irritation in the occupants of the offices. The results emphasize that the tropical climatic cycle with high temperature and humidity provides a perfect environment to support microbial growth, thereby, increasing SBS prevalence (Zhang et al., 2025).

Bacteria and fungi are significant biological causes of the Sick Building Syndrome due to their capacity to emit spores, toxins, and volatile organic compounds to maintain the quality of indoor air and affect the respiratory and overall health of occupants. Microbial contamination and minimization of SBS in office buildings are therefore reduced through preventive strategies including periodical HVAC checks, moisture regulation, and microbiological air checks.

Dust

Dust is one of the most important causes of Sick Building Syndrome (SBS) because it can act as a physical

pollutant, as well as a biological carrier of bacteria and fungi. Dust accumulation in offices creates a favorable microhabitat in which the growth and proliferation of microbes can thrive, especially in areas that are ill-ventilated, whose humidity is high, and whose cleaning frequency is low (Hickman et al, 2022). Research has revealed that common bacterial genera (Staphylococcus, Micrococcus, and Bacillus) and fungal genera (Aspergillus, Cladosporium, and Penicillium) are commonly present in species of indoor dust and are closely related to SBS-related symptoms of respiratory irritation, headaches, and fatigue.

Together, all these pieces of evidence affirm the fact that dust contributes to the poor indoor air quality and worsening SBS both as a physical contaminant and a carrier of microorganisms. It is thus important to perform regular ventilation systems, dust minimization and environmental monitoring processes to reduce the microbial content of the indoor dust and maintain the health of occupants.

Management Issues

The problem of management has been pointed out as one of the greatest causes of Sick Building Syndrome (SBS) at work. It is imperative that in effective building management, the building must be well maintained, ventilated, hygienic, and controlled as regards the environment. Poor indoor air quality and discomfort in occupants due to inadequate management practices, including the irregular maintenance of HVAC systems, poor housekeeping, and the absence of indoor environmental monitoring can lead to SBS symptoms (Yildiz, 2020). Such results highlight the fact that SBS is not only due to physical conditions of the building, but also due to how the management responds to the environment and operations of the building in the working conditions of employees.

Economic Consequences

When financial savings take precedence over occupant well-being, economic considerations fundamentally dictate building design and management (Khovalyg et al, 2023). Research by Khovalyg et al, (2023) indicates that office buildings engineered for minimal operational costs often correlate with an increased prevalence of Sick Building Syndrome (SBS) symptoms, such as headaches and eye irritation, due to inadequate ventilation. Consequently, prioritizing fiscal efficiency in design and operation directly contributes to indoor environments that foster SBS.

Economic impact is one of the crucial aspects that lead to the incidence and maintenance of SBS. Economic constraints, economy measures and profit-making decisions undermine the construction of health and building comfort, and result into a vicious cycle of reduced productivity, high turnover and high operations costs. It is also crucial to tackle the economic aspect of building management to minimize SBS risk and enhance work-related well-being.

Common Symptoms of Sick Building Syndrome (SBS)

Sick Building Syndrome (SBS) refers to non-specific symptoms such as upper respiratory irritation, headaches, fatigue, and skin rashes that are typically linked to a specific building based on the temporal pattern and clustering of symptoms among occupants or coworkers (Subri et al., 2024). The World Health Organization (1984) has estimated that indoor air quality (IAQ) problems significant enough to result into health complaints may occur in as much as 30 percent of buildings that are new and those that undergo renovations. The other definition given by WHO was that SBS was any kind of discomfort or irritation that has no definite cause (Subri et al., 2024). SBS is generally recognized by the reaction in the body, which are the headaches, irritation of eyes, nose, throat, dry cough, itchiness of skin or dry skin, dizziness, nausea, inability to focus, fatigue as well as hypersensitivity to smell or odor (Nduka et al., 2021).

General symptoms are those which are classified as the non-specific symptoms which may be related to certain diseases. These include headaches, nausea, and drowsiness, as mentioned by (Mentese et al., 2020). According to (Zainal et al., 2019), such symptoms are caused by exposure to carbon dioxide, formaldehyde, ultrafine particles, and respirable dust.

The common symptoms of the upper respiratory system mucous membrane among those who occupy admirative offices are the presence of itchy throat, sore throat, eye irritation, swollen eyes, running nose, nasal irritation, and cough (Mansor et al., 2024). SBS can also cause reduced respiratory symptoms like the shortness of breath by occupants. These symptoms are primarily caused by poor indoor air quality. Mucous-related symptoms are triggered by high levels of carbon dioxide, air movement issues, and the presence of respirable fine particles such as dust within the building.

The other typical group of SBS-associated effects is skin-related that involves itchy scalp, dry skin, and skin rashes. These are the symptoms which are connected with air pollution and poor building ventilation. Mansor et al., 2024 stated that skin symptoms are caused by indoor air contaminants that facilitate microbial growth, which can negatively affect occupant health. In spite of the fact that skin symptoms are less common than other ones, they still appear, particularly in educational buildings (Mansor et al., 2024; Mohd Noor & Mamat, 2023).

Mucosal Symptoms

Mucosal symptoms are some of the most frequent irritation-based symptoms of Sick Building Syndrome (SBS), commonly of the eyes, nose, and throat. They are characterized by such symptoms as irritation of the eyes, eyelid swelling, runny nose or its blockage, sore throat, and dry or coughing, which all testify to inflammation of the mucosal membrane in the case of poor indoor air quality or being discomforted by the environment. It has been repeatedly proved in the previous studies that the occurrence of these symptoms is largely determined by such factors as gender, smoking, and respiratory disorders in individuals and such environmental factors as air temperature, humidity, indoor air pollutants.

Skin Related Symptoms

One of the most common symptoms of Sick Building Syndrome (SBS) is skin- related, and they include skin drying and irritation, redness, itching, and sore or swollen skin. These symptoms tend to manifest as a retaliation to poor indoor environmental quality in which, the air temperature, humidity, light and air contaminants are significant in increasing or worsening the condition. Skin symptoms, like dryness, irritation, redness, itching, and urticaria, are typical signs of SBS; in particular, they are the result of the interplay between environmental and personal predispositions (Aziz et al., 2023).

These studies in totality highlight the fact that, environmental factors which include the temperature, relative humidity and illumination have a significant effect on the skin related symptoms and the individual factors which include the gender and sensitivity. At the KOMTAR office building at Penang, one can anticipate similar trends especially in areas that are not well controlled in terms of thermal control and ventilation. The knowledge of these relationships is vital when it comes to enhancing the comfort of occupants, minimizing SBS related complaints and setting the path to effective implementation of indoor air quality management strategies.

General or Systemic Symptoms

General or systemic symptoms are one of the most commonly reported effects of Sick Building Syndrome (SBS) described as overall physiological and psychological reactions of the occupants to the stressors in the indoor environment. These symptoms are often characterized by fatigue, headache, dizziness, loss of concentration, and some feeling of discomfort in the head (Sun et al., 2019; Aziz et al., 2023). These symptoms are not usually specific, but they indicate a high level of indoor air quality and a lack of ventilation in office buildings in time.

The same could be observed in the systematic review by Aziz et al. (2023), as the researchers have found that the most prevalent general symptoms in the office setting included tiredness, headaches, and poor concentration. The effects of season on the occurrence of these symptoms also happened, with the fatigue, eye irritation, and nervousness showing greater prevalence during summer months. The authors Aziz et al. also mentioned that older workers had a propensity to general symptoms, which is an indication of an age-related vulnerability to environmental factors (Aziz et al., 2023). Moreover, psychosocial stressors, such as workload, mental effort, conflict with colleagues, job dissatisfaction were also reported to worsen the occurrence of general SBS symptoms. It was also noted in the review that there were links between long computer use and eye irritation

and exposure to printers and photocopiers with skin and respiratory problems.

Severo al. (2024) were the other researchers who examined the connection between microbial volatile organic compounds (MVOCs) and SBS symptoms in 159 northern European dwellings. Their results revealed that there were positive relationships between general symptoms and high levels of VOCs including 2- pentanol, 2-hexanone, and formaldehyde. It was interesting to note that the levels of bacterial and fungal contaminants were more in buildings that had a history of dermal symptoms were identified (Wang et al., 2022). The research highlighted the significance of volatile organic compounds (VOCs) especially 2-ethyl-1-hexanol, in the development of general symptoms. In addition, Wang et al. (2022) established that general and skin symptoms were more frequent when the ventilation rate decreased to less than 0.7 h -1, which makes the insufficiency of air exchange an important factor in the worsening of SBS-related discomfort in occupants of a building.

Neuropsychological and Psychological Symptoms

Among the significant elements of Sick Building Syndrome (SBS) are neuropsychological and psychological symptoms, which are usually associated with the occupant's perception of the quality of indoor environment. The symptoms can usually be tiredness, headache, feeling dizzy, inability to focus, and the presence of a heaviness in the head that may severely impact work performance and overall well- being (Mansor, 2024). Poor air quality, unpleasant odours, noise, and exposure to environmental tobacco smoke are two of the environmental conditions linked to the incidence of neuropsychological SBS symptoms according to Mentese (2020). The same research also pointed out that the perception of stuffiness in air in any enclosed setting also led to mucosal and neuropsychological discomfort to the occupants.

In the longitudinal research of the population of Danish employees, it was revealed that dry air is correlated with the mucous membrane irritation as well as the neuropsychological symptoms e.g., fatigue, headache (Mansor, 2024). This is an indication that the long-term effects of low moisture and poor humidification could cause the central nervous system to be activated and result in mental anguish. Similar results were also found in previous studies conducted in Northern European nations, as the occurrence of neuropsychological symptoms, such as fatigue, headache, and heaviness of the head, seemed to be an endemic among office workers. All these regularities suggest that neuropsychological symptoms constitute a central part of the general profile of SBS, which may be explained by multifaceted interactions of environmental and psychosocial stressors. Moreover, one of the studies in Japan indicated that 7.9% of female and 3.9% of male office workers reported at least one of mucocutaneous or neuropsychological symptoms, which could indicate a gender-specific difference in SBS susceptibility (Mansor, 2024).

According to research by Zubir et al, (2022), the role of the psychosocial and psychological factors in SBS manifestation was again supported. Their research concluded that the risk of developing SBS-related symptoms including headaches, dizziness, anxiety, and sleep disturbances was higher in workers experiencing job insecurity and psychosocial issues in newer buildings in case they were exposed to low indoor air quality. Besides, they found that the level of psychosocial stress was a bit higher in occupants of older buildings and that female workers reported higher levels of stress as compared to their male colleagues. This disparity was explained by the gender ratio and, possibly, the increased sensitivity of female workers to indoor environmental and social stressors (Zubir et al, 2022). The results suggest that physical (indoor air quality, ventilation, contaminants) and psychological (stress, anxiety, job insecurity) factors have a synergistic effect on the prevalence and severity of the neuropsychological SBS symptoms.

In conclusion, neuropsychological and psychological SBS manifestation is due to environmental discomfort and psychosocial stressors, at the workplace. Unfriendly air, the lack of humidity and unpleasant smells may directly cause neurological reactions, and stress, workload, and job insecurity are the indirect precursors of the symptoms. As such, it is important to deal with environmental and psychological factors to reduce SBS and enhance the mental and physical wellbeing of occupants.

Symptoms Patterns and Duration

Symptoms like fatigue and irritation of the mucosal lining also linger on even after the occupants are out of the

affected building especially after prolonged exposure period. This implies a direct relationship between the exposure time and the severity of the symptoms as well as recovery time.

Altogether, it is possible to conclude that the trend of SBS symptoms is that the health impact typically manifests when the occupants are within the building and it decreases when they are out of the building. Exposure time is a determinant factor when it comes to the severity as well as the continuity of the symptoms. When doing this, proper management of ventilation systems, indoor air quality, and humidity level should be put in place to ensure that the symptoms of SBS are reduced and that indoor environments are healthier and comfortable.

Preventive Measures

Increase the Ventilation Rates and Air Distribution

The heating, ventilation and air-conditioning machinery are to be constructed to comply with the standards of ventilation in the local building regulations. The HVAC system must be utilized and given attention so as to have desired rates of ventilation. In case of a strong pollutant, one may have to make direct ventilation to the outside. The technique is particularly advisable in the elimination of pollutants which have accumulated in certain areas like rest rooms, copy rooms and printing rooms.

Maintenance of HVAC systems

The pollutant source can be removed or changed due to a periodic maintenance of the HVAC systems, replacement of water-marked ceiling tiles and carpets, use of stone, ceramic or hard woods floors, good water proofing, the use of synthetic or treated upholstery fabrication and a limited use of electronic materials and unplugging of inactive appliances; ventilation of the contaminants outdoors, storage of paints, solvents, pesticides and adhesives in close containers in a well-ventilated environment and use of the pollutant sources during low or Some of the measures that can be applied include allowing time of off-gas pollution by building material in new areas prior to occupancy, and smoking cut-off (Subri et al, 2024).

Air Cleaning

To control the air pollution the air cleaning may be an effective practice. The air cleaning can be done through ensuring uncongested interiors with open office designs, the use of frosted glass and skylights that expose people to natural light, terrace gardens, community places and indoor plants that remove carbon monoxide and formaldehyde out of the air. Pollutants can also be removed using air filters which take away some or all the pollutants (Subri et al, 2024).

Education and Communication

Communication and education play significant roles in every air quality management programme in order to operate with greater efficiency and efficacy to stop and eradicate the health issues (Subri et al, 2024).

Legislation

Prohibition of smoking at the workplace or that the smoking should be done in the well-ventilated places away of the work stations and establishing no-smoking places with the assistance of the law. Even in Europe, there is a legal provision where the workers are given a right to participate in the plans of the employer concerning changes in the work place (Subri et al, 2024).

Construction Concepts

Building material should be of nature, should not be fabricated, non toxic, walls, floors and ceilings should not be mould and fungus prone, basement should be water resistant and well ventilated, building environment should not cause magnetic field of earth to change or distort, there should be no environment pollution due to production, installation and disposal of building material and use of building material should not cause exploitation of non-renewable and non-rate resources (Subri et al, 2024).

Interiors

Lighting and colour should blend well with the environment without irritating the senses, manmade electromagnetic radiations must be minimized and interiors should be constructed using natural materials without toxic substance, should be economically designed, toxic outgases should be absent, strong smell-free, indoor air should be naturally regulated, air pollutants should be filtered and neutralized, thermal insulation should be balanced to retain heat without making the interiors too hot, emphases should be put on the use of solar heating, moisture content of new buildings should be limited, and protective measures to noise pollution and harmful infrasound (Subri et. al., 2024).

METHODOLOGY

This study focuses on the KOMTAR (Kompleks Tun Abdul Razak) building in George Town, Penang. KOMTAR was selected through purposive sampling as it serves as the headquarters for the Penang City Council (MBPP), providing a concentrated target population for this study. Completed in the early 1980s, the building's aging infrastructure specifically its legacy Heating Ventilation and Air Conditioning (HVAC) systems and the potential accumulation of indoor pollutants like mold and Volatile Organic Compounds (VOCs) makes it an ideal case study for Sick Building Syndrome (SBS). Furthermore, as a high-rise tower, KOMTAR represents a typical "sealed building" that relies entirely on centralized mechanical ventilation.

A total of 70 respondents were selected using purposive sampling. Data were collected through a structured questionnaire designed to address all research objectives. The primary objectives were to identify the key contributing factors, evaluate the impacts on occupants, and determine effective preventive measures and an appropriate remediation framework.Adopting a quantitative research design, the study utilized a structured digital questionnaire distributed via purposive sampling, resulting in 70 valid responses. The collected data were analyzed using Jamovi software, with emphasis on descriptive statistical analysis.

RESULTS

The study concludes that a substantial relationship exists between indoor environmental quality within the KOMTAR building and the prevalence of SBS symptoms among occupants.

Impact of Indoor Building Condition on the Health, Comfort, and Work Performance Related to Sick Building Syndrome (SBS) Among Office Occupants

Ranking	Health Symptoms	Statistics (Often + Sometimes)
1	Fatigue or tiredness	62 (88.6%)
2	Coughing or sneezing	62 (88.6%)
3	Shoulder, neck, or back pain	59 (84.3%)
4	Stuffy/runny nose	59 (84.3%)
5	Headache	59 (84.3%)
6	Sleepy during working hours	58 (82.9%)
7	Sore or dry throat	56 (80.0%)
8	Dizziness or nausea	53 (75.7%)
9	Itchy/dry skin	53 (75.7%)

10	Concentration interference	51 (72.9%)
11	Unusual sensitivity to odors	50 (71.4%)
12	Eye irritation/watery eyes	40 (57.1%)

Analysis of perceived Impact of the Work Environment

Ranking	Impact Inquiry	Statistics (Agree + Strongly Agree)
1	Environment affects comfort	66 (94.3%)
2	Maintenance reduces symptoms	66 (94.3%)
3	Desire to remain in the office	60 (85.7%)
4	Air quality affects productivity	56 (80.0%)
5	SBS symptoms disrupt work concentration	55 (78.6%)
6	Decrease in efficiency/task errors	40 (57.2%)
7	Need for medical leave/treatment	37 (52.8%)

Propose Effective Measures to Improve Indoor Building Condition to Minimize Occurrence of SBS in the Building

Ranking	Proposed Preventive Measures	Statistics (Agree + Strongly Agree)
1	Use of non-toxic building materials	64 (91.4%)
2	Clear workplace policies	62 (88.6%)
3	Increasing ventilation rates	62 (88.6%)
4	Use of air purifiers	60 (85.7%)
5	Periodic servicing of ventilation ducts	60 (85.7%)
6	Routine building quality inspections	60 (85.7%)
7	Cleanliness of personal workspaces	60 (85.7%)
8	Periodic servicing of existing HVAC	55 (78.6%)
9	Encouragement of staff feedback	55 (78.6%)
10	Periodic monitoring of IAQ parameters	54 (77.1%)
11	Education/Information to staff	51 (72.9%)

DISCUSSIONS

The analysis of health symptoms and performance identifies fatigue and respiratory issues as the primary concerns, aligning with the non-specific SBS characterizations of Mentese et al (2020). High frequencies of

musculoskeletal symptoms, nasal congestion, and headaches because the effects of "stuffy air" in enclosed offices. These conditions significantly impact performance; 94.3% of respondents confirmed that a non-conducive environment diminishes both comfort and productivity. Furthermore, drowsiness and concentration interference were linked to reduced work efficiency and cognitive disruption. Physical manifestations such as medical leave, throat irritation, and skin itchiness correlated to research on chronic pollutant exposure. Ultimately, the strong link between clinical symptoms and decreased motivation underscores the urgency of implementing more effective maintenance protocols at KOMTAR.

Respondents placed an exceptionally high priority on the use of non-toxic building materials, with a 91.4% support rate. The data also highlights a clear demand for workplace policies and improved ventilation rates. Technical measures including air purifiers, duct maintenance, and regular inspections were identified as essential defences against microbial growth. Furthermore, participants emphasized individual workspace hygiene and HVAC maintenance as primary preventive strategies. To ensure optimal air quality, the findings suggest that employee feedback and personal control over air parameters are vital. Staff education and information sharing were identified as the catalysts for a successful, holistic management program to mitigate future SBS risks.

RECOMMENDATIONS

Based on the findings, a multi-tiered approach is recommended to address Indoor Air Quality (IAQ) and occupant well-being. Administratively, the KOMTAR management should institutionalize annual professional IAQ audits to ensure strict adherence to Department of Occupational Safety and Health (DOSH) Malaysia regulations regarding oxygen levels and humidity. These audits should be supported by a significant infrastructure upgrade, specifically the modernization of the aging Heating Ventilation and Air Conditioning (HVAC) system with High-Efficiency Particulate Air (HEPA) filtration and a rigorous duct-cleaning protocol to eliminate microbial contaminants. Complementing these technical fixes, the adoption of a "Green Office" concept—incorporating indoor plants and low-Volatile Organic Compounds (VOCs) furnishings, will further purify the air while enhancing the aesthetic environment. To ensure responsiveness, a digital reporting platform should be launched, allowing employees to log environmental discomforts in real-time for immediate facilities intervention. Finally, it is proposed that a longitudinal research framework be established to quantify the impact of these interventions, comparing health outcomes before and after implementation to refine future SBS prevention strategies.

CONCLUSION

In conclusion, this study demonstrates a significant correlation between the indoor environmental quality of the KOMTAR building and the prevalence of Sick Building Syndrome (SBS) among the staffs. The primary physical stressors identified include inadequate ventilation, inconsistent temperature control, dust accumulation, and a lack of routine maintenance. Beyond physical ailments, the research highlights that SBS also negatively impacts psychological well-being and overall workplace productivity. Consequently, these findings should serve as a critical reference for building management to implement more proactive and responsible maintenance based-on remediation SBS framework.

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