Sick Building Syndrome: Towards Safer and Healthier Living and Working Environments in Buildings(A Case Study of a Higher Institution in Nigeria)

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***Abstract*-Safety in buildings today can no longer be taken for granted nor considered purely from the point of view of prevention of building collapse and other structural failures but must now cover wider issues of prevention of home accident and protection from the hazards of microbial lives that are invading our home and working environments as these find environments more and more conducive for their growth and multiplication. Consequently, we are now sharing our living and working environments with some bacteria in spaces created by design, construction methods, wrong use of materials, poor usage by occupants, or a combination of all of these. This paper therefore examined some buildings for "sick building syndrome" to determine their state on our health conditions with respect to the level of dangers that might be imposed by them. Samples were taken of some stains on the walls of some of these buildings to establish their true nature and confirm whether or not they are merely harmless growth that might just be dusted off. These samples were taken to the microbiology laboratory for analysis and identification purposes. The results showed that the samples are not just mere harmless stains to ignore in that they contain evidence of active and harmful microbial lives that can constitute health hazard to the occupants. These microorganisms were identified, their concentrations determined and the condition that will support their growth was investigated. Microorganisms found/identified to be growing within the building elements of construction, such as insulation materials or wood construction parts and block-wall includes such bacteria as straphylococus aurens, Bacillus spp, and Pseudomonas spp. In addition four fungi genera were isolated from swab samples of visible growth on the walls and under vinyl wall coverings. These fungi genera were Aspergillus Flavus, Mucor, Penicillium spp, and Cladosporium spp. The study therefore concluded that the growths that we see on our walls and other building elements might be more than just stains of harmless nature but bacteria and/or fungal genera associated with sick building syndrome dangerous to healthy living and making our buildings unsafe for human habitation. In certain cases these conditions can be avoided during the development process or may need special attention for their eradication by use of special chemicals yet to be developed. Hasty painting over such growth might just be providing additional growth nutrients for further multiplication.**

Key words: Bacteria, healthy living, Microorganisms, Safety in building, Sick Building Syndrome,

I INTRODUCTION

Occupational health and safety is relevant to all branches of industry, business and commerce including traditional industries, information technology companies, the National Health Service, care homes, schools, universities, leisure facilities and offices [1]. It is all about identifying risks and eliminating or controlling it to prevent accidents and occupational ill-health [2].Therefore everyone involved in construction has a responsibility towards creating safe working and living environments. However, Safety in buildings today can no longer be taken for granted nor considered purely from the point of view of prevention of building collapse and other structural failures but must now cover wider issues of prevention and protection from the hazards of microbial lives that are invading our homes and working environments due to spaces created by design, construction methods, wrong use of materials, poor usage by occupants, or a combination of all of these.

Over the last two decades there have been an increasing number of instances where the occupants of buildings have complained of a general feeling of being unwell or experiencing acute ill-health and discomforting effects that appear to be linked to time spent in a building, but no specific illness or cause could be identified. These complaints may be localized in a particular room or zone, or may be widespread throughout the building. This phenomenon is called "Sick Building Syndrome" (SBS) which has been a major cause of employees' high level of absenteeism at workplaces. [3], [4]

The indicators of SBS include the building occupants complaints of symptoms associated with acute discomfort,

e.g., headache; eye, nose, or throat irritation; dry cough; dry or itchy skin; dizziness and nausea; difficulty in concentrating; fatigue; and sensitivity to odors. The cause or causes of these symptoms are not easily known but most of the complainants usually report relief soon after leaving their working environments.[5]. found that the length of time spent working in a building could be related to the occurrence of symptoms of sick building syndrome

In various parts of the world, several other terms have been used for what is essentially the same phenomenon.[6] These terms include:- 'Indoor Air Quality Syndrome', 'Closed Building Syndrome', 'Tight Building Syndrome'. According to the Health & Safety Executive, SBS causes half a million people a year to take time off work. There are a number of contributing factors to SBS including poorly maintained air conditioning systems, incorrect room temperatures or humidity, inappropriate lighting and noise [3]. Others are [7] Inadequate ventilation, Chemical contaminants from indoor sources (e.g adhesives, carpeting, upholstery, manufactured wood products, copy machines, pesticides, and cleaning agents) may emit volatile organic compounds (VOCs), including formaldehyde. Environmental tobacco smoke contributes high levels of VOCs, other toxic compounds, and respiratory particulate matters. Chemical contaminants from outdoor sources (e.g. pollutants) from motor vehicle exhausts; plumbing vents, and building exhausts (e.g., bathrooms and kitchens) can enter buildings through poorly located air intake vents, windows, and other openings. In addition, combustion products can enter a building from a nearby garage.

Biological contaminants: bacteria, molds, pollen, and viruses are types of biological contaminants are found in buildings. These contaminants may breed in stagnant water that has accumulated in ducts, humidifiers and drain pans, or where water has collected on ceiling tiles, carpeting, or insulation. Sometimes insects or bird droppings can be a source of biological contaminants. Physical symptoms related to biological contamination include cough, chest tightness, fever, chills, muscle aches, and allergic responses such as mucous membrane irritation and upper respiratory congestion.

One indoor bacterium, Legionella, has caused both Legionnaire's Disease and Pontiac Fever. These elements may act in combination, and may supplement other complaints such as inadequate temperature, humidity, or lighting. Even after a building investigation, however, the specific causes of the complaints may remain unknown.

A 1984 World Health Organization Committee report suggested that up to 30 percent of new and remodeled buildings worldwide may be the subject of excessive complaints related to indoor air quality (IAQ). Often this condition is temporary, but some buildings have long-term problems. Frequently, problems result when a building is operated or maintained in a manner that is inconsistent with its original design or prescribed operating procedures. Sometimes indoor air problems are a result of poor building design or occupant activities [7].

This paper therefore examined some buildings for “Sick Building Syndrome” in relation to the rate of workers’ output particularly in pursuance of a specific organizational goal, and the state of their health conditions with respect to the level of dangers that might be imposed by them leading to legal tussles. A particular individual may not be able to explain why his or her performance has been on the decline over time. Samples were taken of some stains on the walls of some of these buildings to establish their true nature and confirm whether or not they are merely non-pathogenic growth that might just be dusted off.

II RELATED STUDIES

A. A. Economic Effect of SBS

In [8], an investigation carried out by [9]. on 600 office workers in the **USA** showed that 20% of the employees experience symptoms of **SBS** and most of them were convinced that this reduces their working efficiency. Other estimates report that up to 30% of new and refurbished buildings throughout the world may be affected by this syndrome [10], [1]. According to [13], definition of sick building syndrome and the [7] the symptoms of sick building syndrome fade away after the person leaves the building. The cause of these signs and symptoms are unknown but they can reduce work efficiency, cause employees to take sick leave and to resign their employment position

B. Biological Effects of SBS

In [13], researches by [14] and [15] identified that sick building syndrome can cause Chronic Fatigue Syndrome with the suffers of this Syndrome having health improvements when no longer working in the building that was causing their illness. [16] reported his investigations into causes of sick building syndrome identified that *irritant*, or *allergic dermatitis* is usually due to fibre glass dust or to formaldehyde particles in the building air. Fibre glass is a skin irritant and is commonly found in building insulation. Fibre glass particles can be blown into the air through the building ventilation system. Roy also identified that a common cause of *hay fever* is mould spores in the building.

In [8], a study performed in the UK on 4373 office workers in 46 buildings revealed that 29% of those studied experienced five or more of the characteristic symptoms of **SBS. [17]**. In 1970, following the observations of [18], the attention of the medical profession was drawn to the development of an allergic respiratory disorder (allergic alveolitis) among the employees working in air-conditioned offices. It is similar to "humidifier fever1' which has been described both in homes [19], [20], [21] and in industrial situations where cold water spray humidification systems

have become heavily contaminated with microorganisms [8].

C. . Legal Effect of SBS

According to [13], [22] highlighted the legal responsibilities of the building owners and tenants in New South Wales (NSW) in relation to indoor air quality. There is a general duty of care for an employer, under the Occupational Health and Safety Act 1983 of NSW, to provide a safe workplace that does not harm the health of employees or anyone else who comes to the workplace. There are Common Law requirements and the Occupier's Liability Act that require the air that people breathe in a building to be safe. As an example of a court case related to a building's air quality, [22] cites the case of Carey v Australian Telecommunications (1985) 2 AAR 457. In this case a postal clerk, who had a history of having asthma, claimed that on being changed to working in an air conditioned office his asthma became worse. He produced evidence in court that mould and dust found in the building's air conditioning system aggravated his respiratory condition. In this case the employee was awarded Worker's Compensation for his asthma becoming worse when in his employer's air conditioned building.

[23], [24] stated that there were five possible ways that a person with sick building syndrome in Western Australia (WA) could find to instigate legal action against building architects, builders, engineers, employers or product manufacturers which include 1. *Breach of contract* that is *For building construction the materials used should be of good quality and fit for purpose . Negligence 3. Occupiers' liability legislation.* Actions against manufacturers and importers under the *Trade Practices Act 1974 (Commonwealth).* For example, this law could be used to make product manufacturers liable for the health effects caused by formaldehyde-based building materials, if there is no warning of the effects of formaldehyde provided with the product as the health effects of formaldehyde (a cause of sick building syndrome) are well known [13].

D. Biological Hazards

[13] Stated that there are biological contaminants in many buildings. Biological contaminants can include bacteria, fungi and animal products. [25] reports that "there are over 200,000 species of fungi and microbes known, of which approximately 60–100 are a cause of concern in the indoor environment." A common contaminant that causes sick building syndrome is mould. Excess humidity with poor ventilation in a building allows mould to grow. The presence of mould is usually associated with water leakage, condensation or a relative humidity in the building of above 70%.

Occupational Safety Professional study illustrates the health effects that can occur from having mould in a building. When investigating causes of sick building syndrome in Western Australia, [16] identified that a common cause of sick building syndrome in the buildings that he investigated was poor ventilation and mould in the buildings Corrective actions included mould remediation, interim humidity control measures, building modifications to masonry walls and planned installation of modified HVAC systems. In these three stories by [16] it is clear that having inadequate ventilation and excessive moisture can lead to mould growth in buildings. It is also clear that building occupants can have allergic reactions to mould toxins. [26] Divides biological building pollutants into those that are living and those that are non living. Living biological pollutants are viruses, bacteria, moulds and other fungi. These are capable of causing infections. Viruses are usually introduced into the building by humans, but the stability, concentration and distribution of the viruses may be influenced by the building's ventilation rate and relative humidity level. Bacteria and fungi become established and proliferate in humid conditions and on wet surfaces, particularly if there is dust present or if the building has been water damaged. Components of the air conditioning system, particularly if poorly designed or maintained, may be a site of bacterial, fungal or protozoan growth and may spread these micro organisms throughout the building atmosphere. People can have allergic reactions to micro organism mycotoxins, endotoxins or antigens [27] Protozoans and dust mites can be present in building air and these usually cause allergic conditions such as asthma.

[28] Conducted research in 23 buildings with offices in Mauritius to identify if there was any relationship between bio-contaminants in these buildings and the incidences of sick building syndrome symptoms. The researchers identified that there was a strong association between offices that had moderate to heavy microbial contamination and the symptoms of sick building syndrome as the occupants of these offices experienced headaches, excessive mental fatigue, loss of concentration and forgetfulness, particularly if there was high fungal spore counts in the building atmosphere. Moreover [29], conducted a 22 months research study in 48 schools in the United States of America in which there were complaints of sick building syndrome symptoms by the building occupants. The indoor air quality of these buildings was tested. In all cases it was identified that the cause of the occupants experiencing the symptoms of sick building syndrome were either fungal contamination with *Stachybotrys* species or *Penicillium* species of mould. In all cases it was determined that the initial microbial growth commenced after a water leak occurred and wetted the building materials. Following this the HVAC system had become contaminated with the microbial growth. Based on the findings of this research it was determined in these 48 schools the cause of sick building syndrome symptoms in the building occupants was due to the *Stachybotrys* or *Penicillium* species of mould. Remedial action was under taken to remove the mould in these schools building materials and air conditioning systems.

Non living biological pollutants can also cause sick building syndrome symptoms as they are associated with allergic conditions in susceptible people. These pollutants can originate from both inside and outside the building. If the outdoor air filtration system is inadequate or damaged then outside air contaminants, such as pollen, can enter the building. Inside the building dead skin cells, animal excreta, insect body parts (such as parts of a dead cockroach that are an allergen for some people) and dander may be circulated, particularly where the filtration of recycled air is inadequate. These factors do not just affect old buildings they can affect the occupants of all buildings.

E. General Effects on Buildings

In [13] all buildings the indoor building environment is affected by the air quality, lighting, building windows, acoustic comfort, radiation, layout of the building rooms and equipment and by ergonomic factors. Indoor air quality is important to the occupants of all buildings. [22], when analysing health survey results from 4,479 respondents from 27 air conditioned office buildings, reported that claims of sick building syndrome symptoms increased when employees perceived that the indoor air quality was poor. Indoor air quality is affected by the environmental factors of temperature, humidity, amount of carbon dioxide in the air, air contaminants, air circulation and the ratio of outdoor air to recirculated air. All of these can affect the building occupants' health, comfort and productivity. For all indoor areas having adequate ventilation is important in preventing the occurrence of sick building syndrome symptoms.

Building emissions concerns. When [23] conducted research in 22 office areas in 12 buildings these researchers identified that the combination of 39 volatile organic compounds VOCs together produced a synergistic effect that caused the symptoms of sick building syndrome in the building occupants

In a related study [32], the researchers conducted significant environmental monitoring, that included building air monitoring and noise monitoring in 5 different buildings. The researchers identified that low frequency noise in these buildings was a significant cause of sick building syndrome symptoms. As well as noise levels lighting levels can affect the health of building occupants. [33] identified that a significant lack of natural day light, flickering mechanical lights or lights that are too bright or too dull for the work that needs to be performed can contribute to causing sick building syndrome symptoms

VI. Research Methods

The samples from the affected walls were taken to the microbiology laboratory for analysis and identification purposes. They were suspended in normal saline and Tween 80, shaken for 1hr to remove or extract the cells. Serial dilution was done from 10^{-1} to 10^{-7} and 0.5 aliquot of the dilution was pipetted and plated using pour plate Technique. Nutrient Agar , Trypone soy Agar and Sabour and Dextrose Agar were used to cultivate the organisms. The Nutrient Agar and Trypone Soy Agar plates were incubated at 37^0C for 24hrs while the Sabour and Dextrose Agar plates were incubated at 25^0C for 5 days. After incubation biochemical test were carried out for the identification of bacteria while microscopic identification of fungi was carried out by preparing wet mount using lacto phenol cotton blue to observe for the characteristics of fungi such as type of hyphae, sporangium, myceliumetc. The fungi were identified using fungi atlas.

VII. Results and Discussion

The results showed that the samples are not just non-pathogenic stains to ignore but contain evidence of active and harmful microbial lives that can constitute health hazard to the occupants. These microorganisms were identified, their concentrations determined and the condition that will support their growth was investigated. Microorganisms found/identified to be growing within the building elements of construction, such as insulation materials or wood construction parts and block-wall includes such bacteria as Straphylococus aurens, Bacillus spp, and Pseudomonas spp. In addition four fungi genera were isolated from swab samples of visible growth on the walls and under vinyl wall coverings. These fungi genera were Aspergillus Flavus, Mucor, Penicillium spp, and Cladosporium spp. These are harmful organisms of varying concentrations. (See Appendices1&2)

VIII. Conclusion

The study therefore concluded that the growths that we see on our walls and other building elements might be more than just stains of harmless nature but bacteria and/or fungal genera associated with sick building syndrome dangerous to healthy living and making our buildings unsafe for human habitation. Hasty painting over such growth might just be providing additional growth nutrients for further multiplication.

IX. Recommendation

The study recommended immediate replacement of water-stained ceiling tiles and carpeting, Increasing ventilation rates and air distribution, Education and communication with building occupants is important. Opening of windows to let in fresh air in some places may upset the balance of the ventilation system. Most importantly, further investigation on the other stains to ascertain the causes, nature and provide chemicals for making building elements inhabitable for these pathogens. Finally, determine ways to prevent further incidences of sick building syndrome and enhance the well-being of building occupants becomes an imperative.

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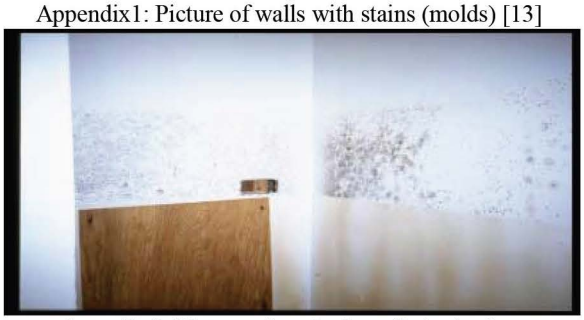
Appendix1: Picture of walls with stains (molds) [13]



Appndix2: Picture of cracks in walls harboring microorganisms[13]