STUDY ON SICK BUILDING SYNDROME IN OFFICE ENVIRONMENT

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ABSTRACT

Prevalence of harmful natural and artificial substances combined with poorly ventilated interiors can lead to various building related health problems among those who spend long periods indoors. A group of symptoms of unclear etiology divided into mucous membrane symptoms related to eyes, nose, throat, dry skin, together with general symptoms of headache and lethargy due to poor indoor air quality is defined as Sick Building Syndrome. Literature revealed many evidence of indoor air quality and other symptoms that affect to staff in office buildings in Sri Lanka. Thus purpose of this study is to appraise the impact of sick building syndrome on building occupants in an office environment.

Case study was selected as the research approach. Semi structured interviews were conducted with responsible parties on indoor air quality and occupants of three selected office buildings. Case studies revealed that uncomfortable indoor environment and unsystematic maintenance of existing indoor air caused prevalence of symptoms related to sick building syndrome among building occupants, such as lethargy and eye irritation. Results showed that occupants in three office buildings bore many common symptoms while working in same premises in same timing pattern. Further, findings showed that three office buildings that are already affected with sick building attributes have in fact complied with existing Indoor Environment Quality standards. This study discusses approaches to identify sick building syndrome in working environments and standards to mitigate unhealthy conditions in buildings. This study enhances the comprehension on sick building syndrome and attributes that can be applied to evaluate impact of poor indoor environment quality on sick building syndrome.

Keywords: *Building Occupants, Indoor Environment Quality, Office Environment, Sick Building Syndrome, Symptoms.*

1. INTRODUCTION

The ultimate objective of comfort of work place is to acquire better productivity at work place in any culture (Lloze, 2001). Complaints about discomfort and health effects at non-industrial workplaces have increased during late eighties (Skov *et al.*, 1990).

Health problems are usually divided as Building Related Diseases and Sick Building Syndrome (SBS) (Burge, 2004). Furthermore, Burge (2004) mentioned that building related diseases include infectious diseases spreading from building services such as Legionnaires' disease and diseases spreading from worker to worker within a building, such as viral infections. As defined by World Health Organisation (WHO) sick building syndrome "comprises a collection of non-specific symptoms including eye, nose and throat irritation, mental fatigue, headaches, nausea, dizziness and skin irritation, which seem to be linked with occupancy of certain workplaces" (Hedge and Erickson 1995). These symptoms are common in places of large populations and may vary from one building to another (Morris and Dennison, 1995). Lack of personal control of working conditions, indoor climate, work load and interpersonal relationships at work also aggravated SBS symptoms (Bachmann and Myers, 1995). In SBS, symptoms appear when a person is at work and disappear when he is away from the building (Morris and Dennison, 1995).

According to Hedge and Erickson (1995), symptoms prevailed more among workers who work in an air conditioned building than naturally ventilated buildings. According to Burge (2003) SBS symptoms occur in office buildings, particularly schools, hospitals, care homes, residential and hotels. Among these office workers are the mainly affected community as they work in the same place for long durations (Hedge and

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Erickson, 1995). Complaints on discomfort and health effects in non-industrial workplaces increased during the past few decades (Skov *et al.*, 1990).

Central Bank Reports (Annual report, 2007) prove that office workers in Sri Lanka play a significant role in the Sri Lankan economy. However, it was revealed that many workers get absent from work in office buildings due to symptoms such as eye, nose and throat irritation, mental fatigue, headaches, nausea, dizziness and skin irritation they felt whilst engaging in work. Thus, this study attempts to find how SBS affects employees in office environments of Sri Lanka.

2. LITERATURE REVIEW

2.1. SICK BUILDING SYNDROME

SBS symptoms occur in an increasing frequency since 1970s and the most energy efficient, "airtight" buildings are more affected than older naturally ventilated buildings (Redlich *et al.*, 1997). Most researchers extracted the WHO definition to define SBS. Fisk *et al.* (2009) illustrated that many studies appraise health symptoms such as eye, nose or throat irritation, headache and fatigue as common to SBS. Morris and Dennison (1995) demonstrated that these symptoms usually develop on the first day back at work after a break, often in the same afternoon where it can become severe in evening and night after the person has left work. Because of these effects SBS is a major problem at many organisations. Skov *et al.* (1990) mentioned that there was a rapid increase of complaints about discomfort and health effects in workplaces and prevalence of diseases that affect during working time.

Personal factors, job category, type of work, psychosocial factors, building factors, building related factors such as high indoor temperatures, little or no outdoor ventilation, poor individual control of temperatures and lighting, air conditioning and especially poor maintenance, poor office cleaning regimes and water damage are main factors that affect SBS, as identified through previous research. Table 1 demonstrates factors identified by several researchers.

Table: 1 Factors Affecting SBS

Year	Factors affecting Sick Building Syndrome					
	Personal factors	Job Category	Type of work	Psychosocial factors	Building factors	Building related factors
Skov *et al.*(1990)	√	√	√	√	√	√
Morrice and Dennison (1995)					√	√
Redich *et al.* (1997)	√			√		√
Bholah and Subratty (2002)	√					√
Runeson *et al.* (2004)	√					√
Fisk *et al* (2009)				√		√
Crock and Burton (2010)	√			√	√	√

Personal, psychosocial and building related factors were identified as common factors affecting SBS from 1990 to 2010. Among these indoor air quality has been included in to building related factors.

2.2. INDOOR AIR QUALITY (IAQ)

As per a study of Llozor *et al.* (2001) prevalence of harmful natural and artificial substances combined with poorly ventilated interiors lead to various health problems among those who spend long periods indoors.

Table 2 illustrates factors affecting SBS in which indoor air quality related aspects were identified as main factors.

Table 2: Indoor Air as a Main Factor

Research	**Factors affecting on SBS**
Skov *et al.* (1990)	Sex, Job category, photocopying, handling of carbonless papers and **indoor climate factors**.
Bachmann and Myers (1995)	Personal factors, work organisation, gender roles and **indoor climate**
Redish *et al.* (1997)	**Air contaminants, ventilation,** work organisation, host factors
Runeson *et al.* (2004)	Personal factors, physical factors in **indoor environment**
Wong *et al*.(2007)	**Indoor air chemicals**, and high stress during work
Fisk *et al.* (2009)	**Indoor environmental conditions**, psychosocial conditions
Crook and Burton (2010)	Personal factors, female gender, lower Status, Building factors, office Dust, cigarette smoke, paper dust and other factors, **high indoor temperature, air conditioning**, outdoor air ventilation.

As per above studies, indoor climate is a major and common factor that affects SBS.

IAQ refers not only to comfort, which is affected by temperature, humidity and odours, but also to harmful biological contaminants and chemicals in the conditioned space. Illinois Department of Public Health (IDHP) consistently ranked indoor air pollution among top five environmental risks affecting public health. According to Bholah and Subratty (2002), IAQ leads to increased health related symptoms. Though being a tropical country Sri Lanka is expected to have good indoor ventilation, limited data suggest that indoor air is more polluted than outdoor (Nandasena *et al*., *2010).*

Indoor climate is not a characteristically unique factor that causes several diseases. Skov *et al.* (1995) stated that indoor climate consists of several other factors, too.

Internationally, organisations observe certain IAQ standards to prevent prevalence of SBS. Summary of such standards published by IDPH, ASHRAE and OSHA are shown in Table 3.

Table 3: IAQ Standards (Source: Arnold, 2010)

PARAMETER	IDPH	ASHRAE	OSHA
Humidity	20% - 60 %	30% - 60 %	N/A
Temperature	68 - 75 (winter)	68 - 75 (winter)	N/A
	73 – 79 (summer)	73 - 79 (summer)	
Carbon Dioxide	1,000 ppm	1,000 ppm	5,000 ppm
	(<800 ppm preferred)		
Carbon Monoxide	9 ppm	9 ppm	50 ppm
Hydrogen Sulfide	0.01 ppm	N/A	20 ppm
Ozone	0.08 ppm	N/A	0.1 ppm
Particulates	0.15 mg/m^3 (PM 10) (150 µg/m^3) 24-hr 0.065 mg/m^3 (PM 2.5) (65 µg/m^3) 24-hr	50 µg/m^3, annual average (PM 10)	15 mg/m^3 (total)
			5 mg/m^3 (resp.)
Formaldehyde	0.1 ppm (office)	0.1 ppm (office)	0.75 ppm
	0.03 ppm (home)	0.04 ppm (home)	
Nitrogen Dioxide	0.05 ppm	N/A	5 ppm
Pressure relationship with Zones	N/A	Restroom mechanically exhaust with no recirculation	N/A
Outdoor air floor rate	N/A	10 L/s (20 cfm) per person	N/A

2.3. IMPACTS OF SBS IN OFFICE ENVIRONMENT

Office, physical and behavioural environments must match with workers' needs as they make an impact on workers' productivity (Wong *et al.,* 2009). In an office environment workers have to work in the same working area for many hours continually in the same premises. Studies found that quality of an office building has a direct relationship with productivity. Unalterable evidence on above was contained in a survey submitted to UK Parliament by Burge (2004). It revealed statistics related to days of sickness absence per year attributed to sick building syndrome and hours per month dealing with or complaining about indoor environment. Thus many studies reveal that productivity depends on working conditions of the office building and a main factor affecting such conditions is indoor air quality.

2.4. STATUS OF SBS IN SRI LANKAN OFFICE BUILDINGS

In Sri Lanka, measuring air quality is a difficult task as costs of measurement of indoor air quality is very high and few experts realise that measurement of indoor air quality is essential. These demonstrate that health effects of occupants are not a concern of the industry. Literature reveals that measurement of indoor air quality is essential for productivity of workers.

Some researchers have illustrated symptoms that affect people in the same place due to poor indoor air quality. But they do not identify those buildings as sick buildings as they usually define these illnesses as building related illnesses. When considering all these factors in Sri Lankan context, there is a high probability that affect of SBS is prevalent in Sri Lanka.

3. METHODOLOGY

To conduct the research, case study approach was selected. The unit of analysis of this research was air conditioned office buildings located in urban areas of Sri Lanka. Three cases of fully air conditioned office buildings in urban areas of Sri Lanka were selected to conduct the multiple case study related to the research problem. Those three cases are briefly described in Table 4.

Table 4: Brief Introduction on Selected Cases

Office	Office A	Office B	Office C
Number of floors	34	7	7
Number Employees	3000-3500	700	1800
Ventilation system	Mechanical ventilation system	Mechanical ventilation System	Mechanical ventilation system
Type of office	Customer service	Customer service	Customer service

Office buildings with mechanical ventilation systems were selected since it is easy to measure indoor air quality components and maintenance aspects. All selected buildings provide customer services where more than five hundred employees provide services day to day from morning to evening. Table 5 illsutrates the interview profile of the research.

Table 5: Profiles of Case Studies

Case	Type	Interview
Case 1	Maintenance Engineer	1
	Occupants	4
Case 2	Chief Technician Officer	1
	Occupants	4
Case 3	Facility Manager	1
	Occupants	4

As a data collection technique interviews were conducted face-to-face, in a semi structured manner. Interview structure was developed using interview guidelines formed to capture data related to the research problem. Two sets of interview guidelines were prepared for two sets of people in office buildings. One was prepared to evaluate existing indoor air quality, with those who are responsible for indoor air quality systems either as facilities managers or mechanical engineers and the other was prepared to identify occupants' symptom patterns with two male and two female occupants who work day to day in same premises, within age group of 21 to 28. Altogether, 15 interviews were conducted, each lasting for about 45 minutes to one hour.

Code-based content analysis was used to capture significant findings from transcripts and for effective interpretation. The QSR.NVivo® - version 9 (copyright© 2009 Qualitative Solutions and Research Private Limited); computer software was used to conduct content analysis, using below illustrated coding structure.

Figure 1: Coding Structure to Evaluate Existing IAQ System

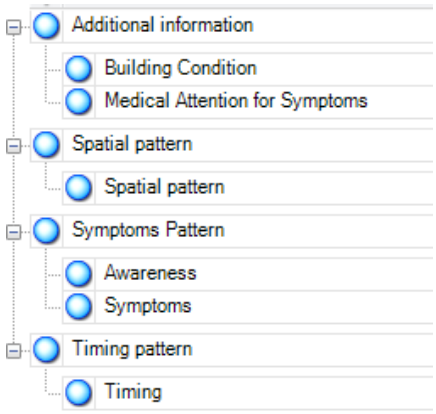

Figure 2: Coding Structure to Evaluate Occupants Structure to Evaluate Existing IAQ system

This research considered networks over matrices as a data displaying tool. Cognitive mapping was selected for data displaying within the study.

4. FINDINGS

Findings of interviews along with observations are discussed under seven sub headings. Three office buildings were selected to identify SBS in office environments Sri Lanka.

4.1. INDOOR AIR QUALITY IN THE COMPONENTS

Empirical study revealed current practices of indoor air quality components through three cases. Table 6 discloses common tendencies of practice of IAQ components in office buildings.

Table 6: Impact of Symptoms

Components	Common tendency of the Buildings
Humidity	Measure
Temperature	Measure
Carbon Dioxide	Measure
Formaldehyde	Do not measure
Particulates	Do not measure
Nitrogen Dioxide	Do not measure
Carbon Monoxide	Do not measure
Ozone	Do not measure
Outdoor air floor rate	Do not measure
Pressure relationship between zones	Measure
Total Volatile Organic Compound *Comfort range* *Discomfort range* *Toxic exposure range*	Do not measure

Findings reveal that humidity, temperature, carbon dioxide and *pressure relationships between zones are measured in office buildings in Sri Lanka and components such as Formaldehyde, Nitrogen Dioxide, Carbon Monoxide and others are not measured.*

4.2. INDOOR AIR QUALITY MEASUREMENTS

Table 7 illustrates comparison of empirical findings of three case studies with standards for IAQ, sourced from Illinois Department of Public Health (refer Table 3).

Table 7: IAQ Measurements in Office Buildings of Sri Lanka

Components	Standard IAQ Measurement	Common tendency of the buildings
Humidity	30% - 60 %	47%-70%
Temperature	73 - 79 (summer)	73- 79
Carbon Dioxide	1,000 ppm	600-1000 ppm
Pressure relationship between zones	Restroom mechanically exhaust with no recirculation	Circulate
Particulates	50 µg/m^3, annual average (PM 10)	51- 53 µg/m^3
Formaldehyde	0.1 ppm	-
Nitrogen Dioxide	0.05 ppm	-
Carbon Monoxide	9 ppm	-
Outdoor air floor rate	10 L/s (20 cfm) per person	-

Accordingly, all three buildings measured humidity, temperature and carbon dioxide, maintaining them at a satisfactory level. However, it does not prove that these office buildings are safe from SBS.

4.3. RECORD KEEPING AND MAINTENANCE

Table 8 illustrates the common result of record keeping in three selected buildings.

Table 8: Record Keeping and Maintenance

Records	Common tendency of the buildings
As-built construction documents	Yes
HVAC system commissioning reports	Yes
HVAC systems testing, adjusting and balancing reports	Yes
Operations and maintenance manuals	No
Water treatment logs	Yes
Operator training materials	No

Results show that common record keeping systems prevail at selected three buildings. OSHA standards of IAQ state that above records need to be updated to maintain a good indoor environment. Further, findings revealed that operation and maintenance manuals and operator training materials are not maintained properly. Thus, it is concluded that three buildings maintain proper records as far as record keepings for IAQ is concerned.

4.4. OCCUPANT'S COMPLAINTS AND SYMPTOMS

OSHA regulations of IAQ introduced in 1994 declare that to provide a friendly environment, entertaining written complaints of employees related to building related illnesses is mandatory. All three selected cases maintain proper written records of employee complaints. Table 9 illustrates common occupants' complaints.

Table 9: Impact of Symptoms

Symptoms		Common tendency of the buildings
Eyes	Itching/irritated	Reported
	Dry eyes	Not reported
	Itching eyes	Reported
	Watering eyes	Reported
	Eyes strain	Reported
Nose	Blocked or stuffy nose	Not reported
	Running nose	Reported
	Other itching/irritation	Not reported
Throat and Chest	Sore throat/cough	Not reported
	Dry throat	Not reported
	Dry/irritated throat	Not reported
	Chest tightness	Not reported
	Breathing difficulty	Reported
	Flu-like symptoms	Not reported
Skin	Itching face without rash	Not reported
	Rash or irritated skin	Not reported
	Other dry skin symptoms	Reported
General	Feeling heavy-headed	Reported
	Lethargy or tiredness	Reported
	Forgetfulness and/ or lack of concentration	Not reported
	Other symptoms	Not reported

As illustrated at Table 9, nine symptoms out of twenty one affected occupants who work day today in the same premises. Numerically it is 42.86%. It shows that symptoms such as itching/ irritated eyes, watering eyes, running nose, breathing difficulties and feeling heavy-headed widely affect occupants who work in the office buildings in Sri Lanka. Numerically it takes a high value. Above mentioned symptoms are defined in SBS as common symptoms that can be identified in sick buildings. Thus in Sri Lanka, 42.86% of symptoms affect the office buildings.

4.5. OCCUPANTS' SYMPTOMS PATTERN AND AWARENESS

Table 10 presents symptoms that affect the selected four occupants in the three office buildings.

Table 10: Symptoms Patterns

	Symptoms	Office A				Office B				Office C			
		M_1	M_2	F_3	F_4	M_1	M_2	F_3	F_4	M_1	M_2	F_3	F
Eyes	Itching/irritated	✓	✓										
	Dry eyes												
	Itching eyes	✓		✓	✓		✓			✓		✓	
	Watering eyes				✓		✓	✓					
	Eye Strain		✓	✓					✓				
Nose	Blocked or stuffy nose			✓	✓		✓						
	Running nose	✓	✓					✓					
	Other itching/irritation												
Throat and Chest	Sore throat/cough	✓	✓		✓				✓				
	Dry throat						✓						
	Dry/irritated throat												
	Chest tightness												
	Breathing difficulty	✓	✓										
	Flu-like symptoms												
Skin	Itching face without rash						✓						
	Rash or irritated skin			✓					✓				
	Other dry skin symptoms	✓		✓	✓	✓							
General	Feeling heavy-headed	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	
	Lethargy or tiredness	✓	✓	✓	✓	✓							
	Forgetfulness and/or lack of concentration												
	Other symptoms												

M – Male F – Female

Results reveal that occupants of two office buildings are highly affected by symptoms such as heavy-headedness, lethargy or tiredness, itching/ irritated or running nose and blocked or stuffy noses. Thus, it is possible to state that most occupants who work day to day at same premises in office buildings are highly affected by such symptoms.

Empirical study revealed that interviewees' awareness of similar symptoms among other occupants of the same building is also high.

4.6. TIMING PATTERN

Research findings revealed that symptoms are overcome when affected occupants leave the premises. Further, most symptoms occur during morning hours from 9 a.m. to 11 a.m., generally getting worse between 12 a.m. to 2 p.m. Thus, findings show that majority of office staff are stained from symptoms that defined SBS and all these symptoms appear within a same timing pattern.

4.7. SPATIAL PATTERN

To discover spatial patterns, empirical data mainly focused on places where occupants experience discomfort and place where occupants spend most of time in a building. The empirical data revealed that occupants spend most of their working time at the same place.

5. CONCLUSIONS

The ultimate objective of comfort at the work place is to obtain better productivity. However, many health problems occur among occupants specially Building Related Diseases and Sick Building Syndrome (SBS). Symptoms of SBS are common among large populations such as office buildings, schools, hospitals, care homes, hotels etc. Office workers are the people mainly affected by SBS, as they work in the same place for long durations.

Similarly in Sri Lanka, several experts revealed that absence of workers from office buildings is at a considerable level due to symptoms such as eye, nose and throat irritation, mental fatigue, headaches, nausea, dizziness and skin irritation that they feel whilst engaging in work. This research unearthed impacts of SBS on occupants of three office buildings in Sri Lanka and also factors that cause SBS. As findings revealed few IAQ components such as humidity, temperature are measured in such office buildings whilst other factors such as Formaldehyde, Nitrogen Dioxide etc were not measured. Anyway, most buildings maintain proper records. Occupants in most office buildings were affected by many common symptoms while working in same premises during same timing patterns. Approaches to identify SBS in working environments are also illustrated. Standards to mitigate unhealthy conditions of buildings by identifying prominent IAQ standards were added to knowledge. Further, this study widened limits of health and safety standards and drew attention to new research areas.

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