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COMPARATIVE STUDY OF MICROBIOLOGICAL AIR QUALITY OF PRIVATE AND GOVERNMENT HOSPITALS IN MYSURU CITY

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ABSTRACT

Air contains large number of microorganisms including bacteria and fungi and their estimation is important as an index of cleanliness for any particular environment. The microbial quality of indoor air of five wards/units of private and government Hospital was conducted. Sedimentation technique using open petri-dishes containing different culture media was employed and samples were done twice daily, one in the morning shortly after cleaning before influx of people into wards and other in the noon when lot of activities would have taken place in these wards. The highest bacterial population was recorded in the afternoon ranging from 31cfu/m3 to 90cfu/m3 in government hospital and 20cfu/m3 to 78cfu/m3 in private hospital, with the orthopedic ward recording the highest bacterial counts of 90cfu/m3 in government hospital and lobby with the bacterial count of 78cfu/m3 in private hospital. The concentration of fungal population in the air of five different wards in two hospitals studied was recorded high in the afternoon ranging from 18cfu/m3 to 48cfu/m3 with the maternity ward recording the highest fungal counts of 40cfu/m3 in government hospital and lobby with the fungal count of 48cfu/m3 in private hospital. The statistical analysis showed no significant difference between the microbial population obtained during the wet and dry seasons in both hospitals studied.

KEYWORDS: Hospital, Indoor air quality, Bacteria, Fungi.

1. INTRODUCTION

Atmospheric pollution is one of the most pressing problems of our age. This pollution has now reached an advance level those posses a potential threat to the health and well being of the population. The atmosphere consists of different component, which enhance or promote the survival of microorganisms in the air. It is composed of 75% nitrogen, 21% oxygen, 0.9% argon, 0.03% carbon dioxide and 0.076% other trace gases, very low concentration of organic and inorganic nutrients and free waters as an irregular internals (F.O. Ekhaise et al.,2008). Microorganisms abound in the earth's atmosphere as particle or bacteria, fungi, lichen and algal cell. The composition and concentration of these particles are generally related to man's activities (F.O. Ekhaise et al.,2010).

Indoor air quality is an important determinant of human health and comfort. Airborne bacteria can also contributes to indoor air pollution (D.H. Tambekar et al.,2007). Indoor air pollutant means substances that are normally dispersed in indoor air, and which may directly or indirectly affect public health or the living environment after long-term exposure, including carbon dioxide (CO_2), carbon monoxide(CO), formaldehyde(HCHO), total volatile organic compounds (TVOC), bacteria, fungi, airborne particles with a particle diameter of 10 micrometers or less (PM_{10}), airborne particles with a diameter of 2.5 micrometers or less ($PM_{2.5}$) and ozone(O_3) (K. F. R. Liu et al.,2015). Microorganisms are the primary source of air contamination in indoor environments. Indoor air has a greater potential to endanger patients health than outdoor air. Indoor aerosol types may have the ability to cause different levels of infection. Although many present biological substances in inhaled air are not considered as pollution but if their amount increases by several folds of their ambient amount, they can stimulate or poison people once inhaled (Edris Hoseinzadeh et al.,2013).

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In hospital facilities, Indoor Air Quality (IAQ) is a critical factor in preventing infections. Unpleasant hospital IAQ may lead to hospital-acquired infections, sick hospital syndrome, and various occupational risks (Faramarz azmi et al.,2013). Nosocomial infections also known as hospital acquired infection are infections acquired from healthcare services (hospitals) during treatment, which are secondary to the patient's original condition (F.O. Ekhaise et al.,2010). The indoor air quality of hospitals has become an important issue now days. The airborne route of transmission is important for a number of pathogenic microorganisms in hospital buildings. As it is, 5% of all patients who go to hospitals for treatment will develop an infection while they are there. This is because the density of pathogens is greater in hospitals than in most other environments. Indeed, it has been estimated that the airborne route of transmission accounts for between 10 and 20% of endemic nosocomial infection. Unfortunately, hospitals tend to be places where harmful organisms are concentrated (D.H. Tambekar et al.,2007).

Statistical Factors Related to Patient Risk

Healthcare facilities have to pay particular care and attention to indoor air concerns. People with pre-existing health problems who are going through treatment and those who may have depressed immune systems are very susceptible to indoor air exposures. Three key three factors make attention to indoor air quality particularly important in health care settings.

a. Patients at risk: healthcare facilities house many persons with heightened susceptibility to infections, respiratory distress, and other problems associated with air contaminants
b. Occupant density: Because the density of people in health care settings is relatively high, at risk patients are likely to be in close proximity to infectious individuals.
c. Aging systems: Many hospitals are aging and their ventilation systems are outdated and are in serious need of maintenance and repair. (D. Riley et al)

Briefly the increased frequency of hospital infection has a multifactor etiology, been influenced by factors related to:

- newly invasive diagnostic and treatment medical procedures;
- antibiotic resistance and increasing pathogenicity of hospital germs;
- patient increasing receptivity,
- long, sometimes less justified, length of Hospitalization
- and last but not least neglected sanitary rules as functional circuits, cleaning crowding (D. Lupulescu et al.,2006)

Airborne Microbial Pollutants

The most important source of airborne pathogens inside the hospital is the infected patient. Airborne transmission occurs when pathogenic microorganisms are transferred from an infected to a susceptible individual via the air. The predo-minant mechanism that makes the pathogens airborne is the production of aerosol droplets by sneezing or coughing, and their subsequent loss of water which allows them to float in the air over considerable distances and for a long time (K. Qudiesat et al.,2009).

Organisms that are often associated with the hospital acquired infection are Staphylococcus aureus, Micrococcus sp., Pseudomonas sp., Proteus sp., Aspergillus sp., and viruses. Pseudomonas aeruginosa has been particularly incriminated in nosocomial infection because of its intrinsic resistance to most antibiotics and its ability to survive and multiply at low temperatures and in disinfectant solutions (Awosika SA et al.,2012)

Table 1. Sources of airborne microbial pollutants

Pollutants	Sources
TB bacteria	When an active TB patient coughs, sneezes or speaks, airborne TB droplets will be generated
Legionella bacteria	A common source of this bacterium in hospitals is the water mist discharged from the cooling towers and then draw into the indoor environment through the outdoor air intake

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	Other probable sources include evaporative condensers, potable water systems, and hot water systems.
Staphylococcus aureus	The bacteria are present on the skin and in the nose, blood, and urine of an infected patient. During some surgical procedures that require the use of power tools, such as oscillating bone saws and bone drills, microbial aerosols will be generated
Aspergillus spores	Hospital renovation or nearby construction work are major sources of aerosolized Aspergillus spores The fungal spores from soil, plants, animals, and dust particles can attach themselves to the clothing of healthcare workers or visitors.

(source: Michael Leung et al.,2006)

Control measures

Controlling airborne pathogens in healthcare facilities is not only important for the safety of the patient, but it is also important for hospital personnel. Various contamination control procedures can limit exposure and risk of infection. Although it is not possible to eliminate all NI, their incidence can be significantly reduced by implementation of appropriate infection control policies (K. Qudiesat et al.,2009). Measures often taken in preventing nosocomial infections include effective use of antiseptics, disinfectants, adequate cleaning, sterilization and isolation of patients with highly infectious diseases (Awosika SA et al.,2012).

The counting and identification of microbes in air is not an easy task. Various methods are used and these can be divided into four groups: counts of colony forming units per cubic meter of air (CFU/m^3); counts of CFU on settle plates; counts under a microscope; and measurement of a chemical component of the microbial cells per cubic meter of air (K. Qudiesat et al.,2009).

The Spanish Association of Hospital Engineering (AEIH) has de-fined the following criteria for assessing indoor air quality in hospital environments

Table 2. Quantitative indoor air quality index

Microbial Density, CFU/m^3	**Index**
<10	Very Clean
10 - 100	Clean
100 - 200	Acceptable
>200	Contaminated

(Source: Carlos A. Rocha et al.,2012)

This study was aimed at investing the concentration and type of airborne microorganisms in various wards of two selected hospitals of mysuru city

2. MATERIALS AND METHODS

Study Area

The study was carried out in two-selected hospital, (government and private owned hospital) in mysuru city. Mysuru city is located in the southern part of the Deccan Plateau; it is geographically located between 12° 18" 26 North Latitude and 76° 38' 59" East Longitude. It is located at an altitude of 2427 feet. The city covers a total area of 128.42 sq. km.

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Government hospital has 1050 bed capacity and private hospital is having 1800 bed capacity. The study site was divided into 5 units which include orthopedic ward, I.C.U, general ward, maternity ward and lobby. The study was carried out in the month of February, March and April.

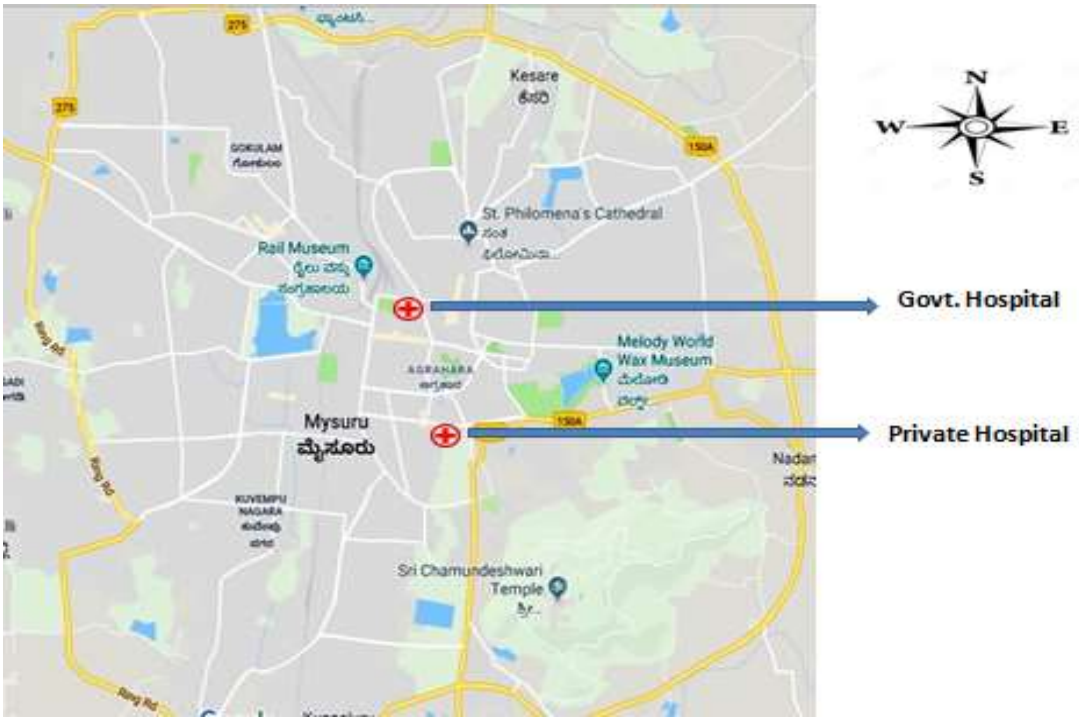

Figure 1: location of hospitals in mysuru city

Air Sampling and Microbiological Examination

The sedimentation technique using open petridishes containing different culture media was used for the collection of microbiological air samples. The plates containing nutrient agar (NA) and potato dextrose agar (PDA) were used for the isolation of bacterial and fungal isolates respectively. figure 2 shows the petridishes prepared with appropriate nutrient agar and potato dextrose agar before the collection of samples

Figure 2: Prepared Petridishes

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The samples were collected from five different units in the hospitals by the settled plate technique by exposing the prepared petridishes for a period of 10-20 minutes. Each day, the air samples were collected two times: in the morning between 9am and 11am, in the afternoon between 12noon and 2pm upon exposure, the plates were transported to the laboratory for examination. The bacterial culture plates were incubated at 37°C for 24- 48hrs while the fungal culture plates were incubated at room temperature for 3-4 days. Total density of pathogens as CFU/m^3 will be estimated using the equation

$$CFU/_{m^3} = \frac{\text{Total Number of Colonies on Agar Strips}}{\text{Time of Exposure in Minutes}} \times 25$$

Bacterial colonies were initially characterized by cultural, morphological and microscopic examinations. The fungal colonies were identified based on colony appearance and microscopic examination. The bacterial and fungal isolates are presented in figure 3 (a) and (b) respectively

Figure 3: cultured petridishes

3. RESULTS

The total heterotrophic microbial population of five different wards studied from the two hospitals varied from ward to ward. Four bacterial isolates and three fungal isolates were isolated. The frequency of distribution of the hospital air microorganisms isolated from five different wards in the private hospital and government hospital have been tabulated in Tables 3 and 4 for both bacterial and fungal isolates.

The highest bacterial population was recorded in the afternoon ranging from 31cfu/m^3 to 90cfu/m^3 in government hospital and 20cfu/m^3 to 78cfu/m^3 in private hospital, with the orthopedic ward recording the highest bacterial counts of 90cfu/m^3 in government hospital and lobby with the bacterial count of 78cfu/m^3 in private hospital. The concentration of fungal population in the air of five different wards in two hospitals studied was recorded high in the afternoon ranging from 18cfu/m^3 to 48cfu/m^3 with the maternity ward recording the highest fungal counts of 40cfu/m^3 in government hospital and lobby with the fungal count of 48cfu/m^3 in private hospital.

The comparison of bacterial count during morning and afternoon for private and government Hospital are shown in Fig4.1 and Fig4.2 respectively. Similarly, Fig 5.1 and Fig 5.2 show comparison of fungal count.

The microbial isolates characterized and identified in the air of five different wards in the two hospitals included five bacterial and three fungal genera, among which the bacterial isolates are: Staphylococcus, Escherichia coli, Pseudomonas and Bacillus subtilis and the fungal isolates include Aspergillus, Penicillum and Candida.

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Table 3: Taxonomic Bacterial Air Quality at Private and Government Hospital

Bacteria	Months	Orthopedic ward		I.C.U		General ward		Maternity ward		Lobby	
		M	A	M	A	M	A	M	A	M	A
PRIVATE HOSPITAL											
Staphylococcus	**February**	04	10	02	04	06	09	03	03	17	11
	March	08	09	04	09	03	07	04	05	15	16
	April	06	11	03	05	03	05	02	04	16	12
Pseudomonas	**February**	02	11	01	03	02	06	02	03	14	13
	March	06	09	02	02	03	04	03	08	20	17
	April	04	11	02	04	03	05	04	04	17	18
Bacillus subtillis	**February**	05	15	03	03	02	06	01	05	09	10
	March	09	16	04	06	04	02	-	07	11	15
	April	07	17	05	03	03	04	03	06	10	22
E. coli	**February**	04	20	03	03	09	08	02	02	11	10
	March	06	17	04	02	05	06	01	03	11	18
	April	05	14	02	03	04	04	02	03	09	14
GOVERNMENT HOSPITAL											
Staphylococcus	**February**	10	10	03	10	08	09	05	08	13	12
	March	18	12	08	04	04	06	04	06	08	20
	April	08	17	04	07	06	09	09	07	09	13
Pseudomonas	**February**	10	18	03	08	04	07	01	05	05	10
	March	18	12	-	03	03	15	03	03	07	11
	April	20	18	03	04	08	08	03	04	06	06
Klebsiella	**February**	10	28	02	04	10	06	02	08	11	16
	March	16	20	07	03	09	07	07	04	10	17
	April	16	24	03	04	05	08	03	06	06	12
E. coli	**February**	15	20	07	09	08	11	04	09	07	11
	March	20	14	04	13	05	13	-	13	08	15
	April	19	23	07	11	08	06	03	02	06	13

*M – Morning *A - Afternoon

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Table 4: Taxonomic Fungal Air Quality at Private and Government Hospital

Bacteria	Months	Orthopedic ward		I.C.U		General ward		Maternity ward		Lobby	
		M	A	M	A	M	A	M	A	M	A
PRIVATE HOSPITAL											
Aspergillus miger	**February**	09	09	03	06	09	12	06	08	10	10
	March	08	04	04	04	11	13	07	11	08	12
	April	04	05	02	05	04	17	02	11	12	11
Pencillum	**February**	04	08	04	07	04	10	09	07	11	15
	March	06	07	-	05	09	14	07	09	14	13
	April	05	06	02	06	08	15	05	10	08	14
Candida	**February**	03	10	05	03	04	07	03	04	05	10
	March	02	08	03	04	08	12	05	06	08	13
	April	04	09	01	02	03	08	04	05	03	16
GOVERNMENT HOSPITAL											
Aspergillus miger	**February**	08	08	06	10	04	10	04	08	10	06
	March	05	11	04	04	11	14	03	14	05	09
	April	08	11	02	07	06	09	05	08	03	09
Pencillum	**February**	10	10	04	08	08	10	14	12	10	12
	March	08	13	08	02	10	06	11	13	06	10
	April	06	04	03	05	09	11	05	12	05	08
Candida	**February**	10	10	02	13	10	10	10	10	05	07
	March	06	16	05	11	05	05	05	11	07	04
	April	05	11	03	06	09	09	09	08	03	07

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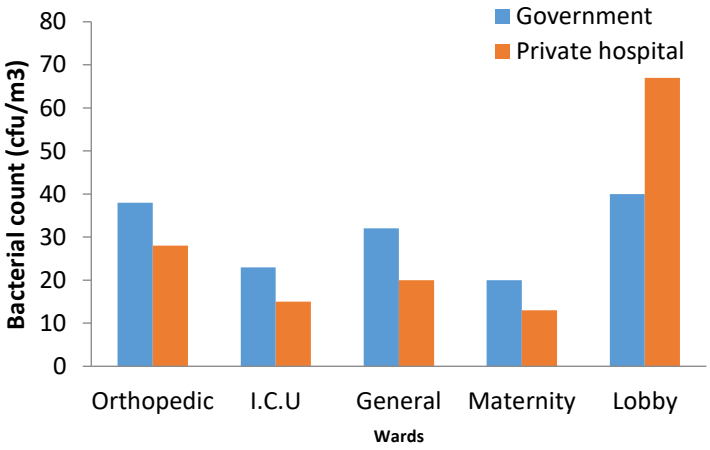

Fig 4.1 Comparison of Bacterial Count in the Morning

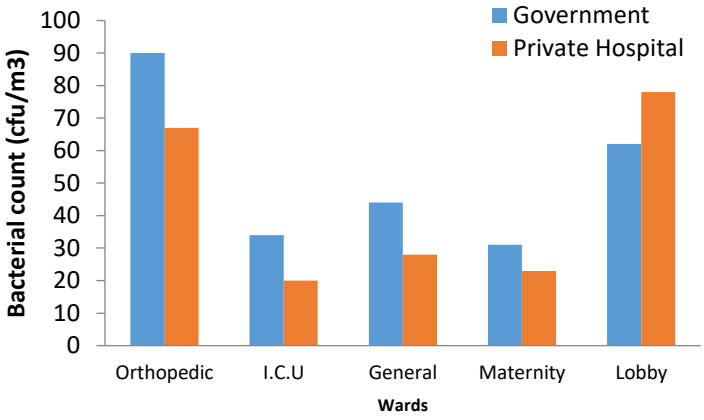

Fig 4.2 Comparison of Bacterial Count in the Afternoon

Fig 4: Comparison of Bacterial count

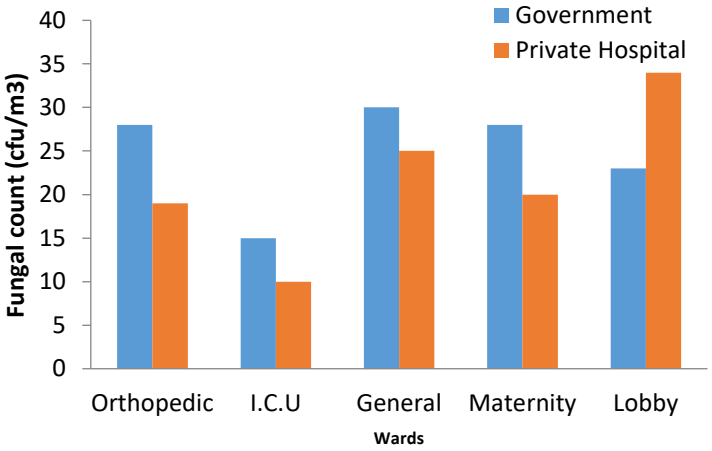

Fig 5.1 Comparison of Fungal Count in the Morning

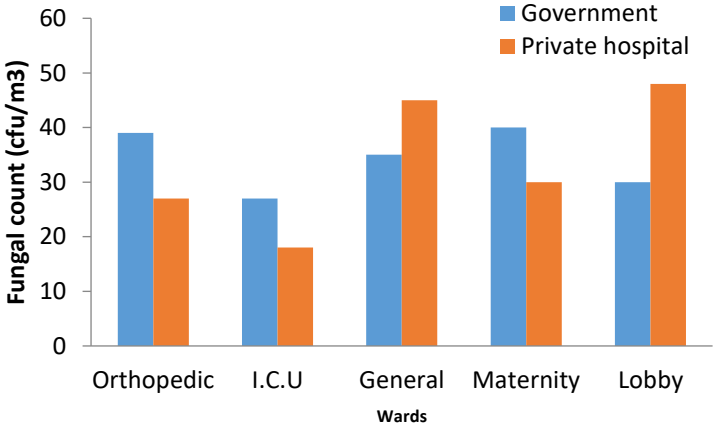

Fig 5.2 Comparison of Fungal Count in the Afternoon

Fig 5: Comparison of Fungal count

4. DISCUSSION

The study of airborne microorganisms in indoor environments is important to understand the dissemination of airborne microbes particularly the pathogenic ones (Jaffal *et al.*, 1997). It is believed that the environment where patients are treated has an important influence on the prospect of such patients recovering or acquiring infection that may complicate their conditions (Ekhaise *et al.*, 2010). It is therefore, important to evaluate the quality of the air whether indoor or outdoor in the hospital environments. The number and type of airborne microorganisms can be used to determine the degree of cleanliness.

In this study, the three investigated factors, namely the kind of hospital, the type of room and the time of sampling, were found to influence the microbial rate in indoor air of hospitals. The results from this study showed that the governmental hospital had a higher degree of contamination with airborne bacteria and fungi in indoor air of wards rather than the private hospital. These high rates in the governmental hospital might be attributed to the age of the building, poor and deficient hygienic conditions, low degree of cleanness and minimal disinfection procedures against airborne bacteria and fungi might raise the airborne bio-contaminants..

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The governmental hospitals usually have specific times for visiting patients. In these times, the hospitals are crowded with the visitors in addition to the hospital employees and patients. since this location is occupied with high number of people all of times; patients, visitors and personnel and lead to increase in-door rate of airborne microorganisms. The high number of visitors that commonly enter the patient rooms, and the amount of materials brought from outside by the visitors, such as food, fruits, and flowers, were more common in patients rooms. These are recognized source of hospital contamination in the government hospital.

On the other hand, the private hospitals do not have limitations about the time of visits. As there is restrictions for the entry of more numbers of persons into the ward at a time, more number of persons will be waiting in the lobby, this resulted in more number of fungal counts. The key to the growth and spreading of fungi in building units is a moisture supply. Fungi appear on materials and introduced into the indoor air in a particular succession according to their minimum moisture demands. Especially with old and defective air conditioning system in building units

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