Educational Administration: Theory and Practice
2024, 30(4), 872-878
ISSN: 2148-2403
https://kuey.net/

Research Article

Exploring The Interrelation Between Indoor Bacterial Burden And The Physicochemical Dynamics Of Indoor Air Quality In Public Commercial Edifices

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Citation Yogyata Srivastava et al. (2024), Exploring The Interrelation Between Indoor Bacterial Burden And The Physicochemical Dynamics Of Indoor Air Quality In Public Commercial Edifices *Educational Administration: Theory and Practice*, *30*(4), 872 -878, Doi: 10.53555/kuey.v30i4.1585

ARTICLE INFO

ABSTRACT

This study investigates the relationship between the physical dynamics of indoor diseases and indoor air quality in public buildings in the National Capital Region (NCR) of Delhi. Based on information from studies, research, health assessment, and model development focused on three specific sectors, with an emphasis on indoor microbiological quality.

This study is integrated in the context of public sector buildings in the National Capital Region of Delhi.

A systematic survey was conducted in several commercial buildings to measure the microbial content of indoor air. Methodologically, this study uses existing techniques such as passive air sampling using schemes to determine pollution. The research was inspired by the methods used in previous studies and comparisons were made to increase the strength of the findings.

Preliminary findings highlight the importance of indoor bacteria. Temperature, relative humidity, and air pollution generally appear to be factors affecting indoor air quality, reflecting correlations found in research. Bacterial isolates identified different species, demonstrating the complexity of microbial dynamics in public buildings.

This study not only contributes significantly to the understanding of indoor microbial contamination of public sector facilities in the National Capital Region of Delhi but also provides insight into its health impacts. The findings highlight the importance of physical considerations in reducing bacterial growth and thus contribute to the development of strategies to improve indoor air quality in buildings to improve people's health.

Keywords- Microbial air pollution; Indoor bacterial load; Human health; Indoor air quality.

1. Introduction

In today's society, people spend most of their daily lives indoors, and indoor air quality has become an important element of maintenance. Recent research shows that people spend 80-95% of their time indoors and breathe an average of 10-14 cubic meters of air per day. (Hayleeyesus & Manaye, 2014; Awad & Farag, 1999; Shiaka, G. P., & Yakubu et.al., 2013; Park et al., 2021; Önoğlu et al., 2011). Increasing awareness of the health effects of indoor air, combined with the fact that people now spend more time indoors than outdoors, has led to increased interest in research in this area. Indoor air is an important source of health and well-being, affecting people at home, offices, schools and many public and private buildings.(WHO, 2010). Indoor air pollution caused by bacteria, pollen, smoke, moisture and chemicals from human activities is quite common and causes serious problems in daily life. (Bhartiya Krishi Anusandhan Patrika, 2016). In addition, the increase

in global pollution, pollen and infectious diseases is associated with an increase in allergic symptoms in humans, making the solution to the problem urgent. (Patella et al., 2010).

Indoor air caused 3.8 million deaths in 2016, and it is clear that the situation is particularly serious in low- and middle-income countries, especially in Asia and Africa. (WHO, 2020). In this context, our study focused on assessing indoor air quality in public buildings in the National Capital Region of Delhi. The aim is to raise awareness and provide information for a better understanding of indoor air quality in these areas.

Considering that people spend most of their time indoors, air quality in these areas becomes an important factor affecting health, well-being, and productivity. Bacteria, including bacteria, mold, and mildew, play an important role in affecting indoor air quality. (WHO, 2009; Wemedo et al., 2012). High exposure to indoor air highlights the importance of investigating indoor pathogens, as evidenced by the increased interest in indoor pathogens in recent years. (WHO, 2012; Wemedo et al., 2012; Hospodsky et al., 2012; Soto et al., 2009).

Activities and materials in the indoor environment are thought to be important for the accumulation and spread of microbial pathogens.(Hospodsky et al., 2012; Qian et al., 2012; Täubel et al., 2009). While certain activities such as talking, sneezing, coughing, walking and showering can create toxins in the air, many places such as food, greenhouses, textiles and furniture can spread fungal infections into the air.(Kalogerakis et al., 2005; Foarde et al., 1993). Environmental factors such as temperature, humidity, air exchange rate, and building structure further encourage the proliferation and development of bacteria in indoor air.(Wemedo et al., 2012; Meadow et al., 2014; Graudenz et al., 2005).

Recognizing the significant impact of microbial air quality on health, this study focuses on understanding the bacterial, bacterial and fungal pathogens present in many public buildings in the National Capital Region of Delhi. Additionally, interactions between bacteria and fungi have been investigated to understand the impact of the environment on their growth and development in indoor air.

2. Methodology

2.1 Study design and study area

We conducted a cross-sectional study in commercial buildings to assess indoor air pollution and its relationship with indoor air quality in three commercial buildings located in the National Capital Region of Delhi.

2.2 Sampling procedure

Bacterial and fungal measurements were made by taking passive air samples in solution, especially in Petri dishes with a diameter of 9 cm. Sampling was carried out in the middle of the room, close to the human breathing zone, at a height of 1 m from the floor. Bacteria and viruses were captured on 2% nutrient agar and 4% sabourroad agar, respectively. Measure the short sample set for 60 minutes to obtain the optimal density to calculate and measure the spread over time. Additionally, samples were collected twice a day, from 9:45 to 10:45 in the morning and from 16:45 to 17:45 in the evening. After exposure, the samples were transported to the laboratory and incubated for 24 hours for bacteria at 37 °C and 25 °C for fungi for 3 days. Colony forming units (CFU) counts were made and CFU/m3 was determined using the equation described by Omeliansky (Borrego et al., 2010, Gutarowska, 2010).

$$N = 5ax10^4 (bt)^{-1},$$

In indoor air, the symbol N represents microbial colony forming units per cubic meter (CFU/m3), “a” represents the number of colonies in the petri dish, and “b” represents the petri dish. The unit of the Petri dish is square centimeters (cm2), "t" corresponds to the exposure time in minutes. Exclusions were identified after using standard methods. [Cheesbrough et al.1991, Rajash et al 2008].

2.3 Statistical analysis

Statistical analysis was performed using SPSS statistical software to evaluate the possibility of detecting differences between bacterial and fungal species in different regions. Additionally, the software was used to examine the relationship between measured bacteria and fungi.

3. Results:

There is a strong positive correlation of 0.990 was observed with bacterial load (B) which suggests that bacterial load increase with the morning temperature. The correlation coefficient is 0.988; This demonstrates the positive relationship between relative humidity and bacteria and refers to the effect of higher humidity on bacteria that emerge in the morning.

Both $PM_{2.5}$ (0.911) and PM_{10} (0.994) were positively correlated with bacterial load, indicating that the increase of the PM is mostly associated with the presence of bacteria during early morning.

Correlations

	Morning Fungal Load(F)	Temp	RH	PM 2.5
Temp	0.947			
RH	0.971	0.961		
PM 2.5	0.983	0.874	0.929	
PM 10	0.986	0.974	0.992	0.948

Correlations

	Evening Fungal Load(F)	Temp	RH	PM 2.5
Temp	0.925			
RH	0.999	0.937		
PM 2.5	0.792	0.581	0.783	
PM 10	0.870	0.663	0.859	0.983

Correlations

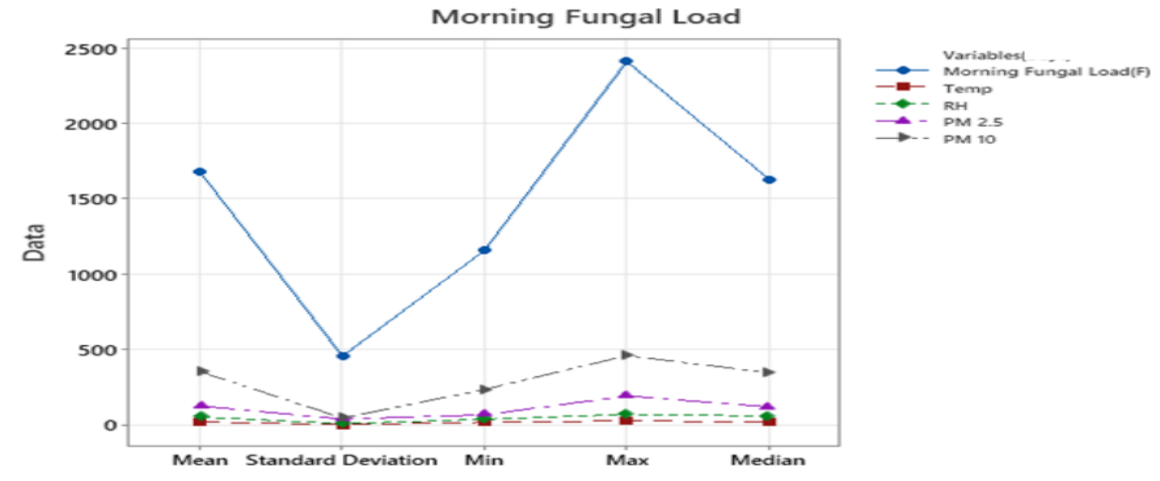
	Morning Bacterial Load(B)	Temp	RH	PM 2.5
Temp	0.990			
RH	0.988	0.961		
PM 2.5	0.911	0.874	0.929	
PM 10	0.994	0.974	0.992	0.948

Correlations

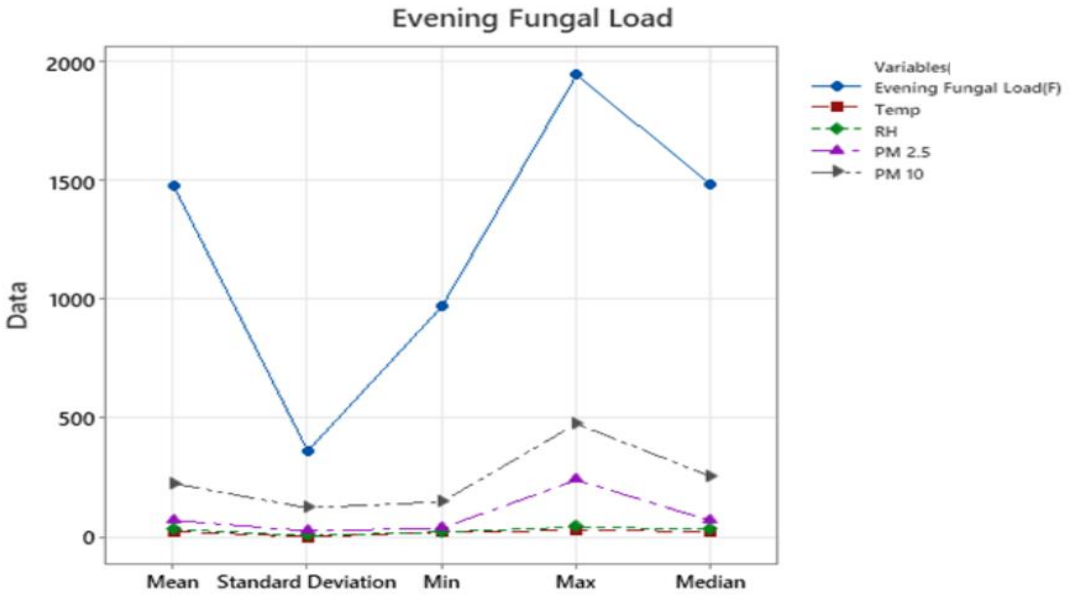
	Evening Bacterial Load(B)	Temp	RH	PM 2.5
Temp	0.972			
RH	0.988	0.937		
PM 2.5	0.683	0.581	0.783	
PM 10	0.776	0.663	0.859	0.983

Table 1: Illustrating the relationships between morning and evening fungal as well as bacterial loads in connection with Temperature (Temp), Relative Humidity (RH), PM $_{2.5}$, and PM $_{10}$.

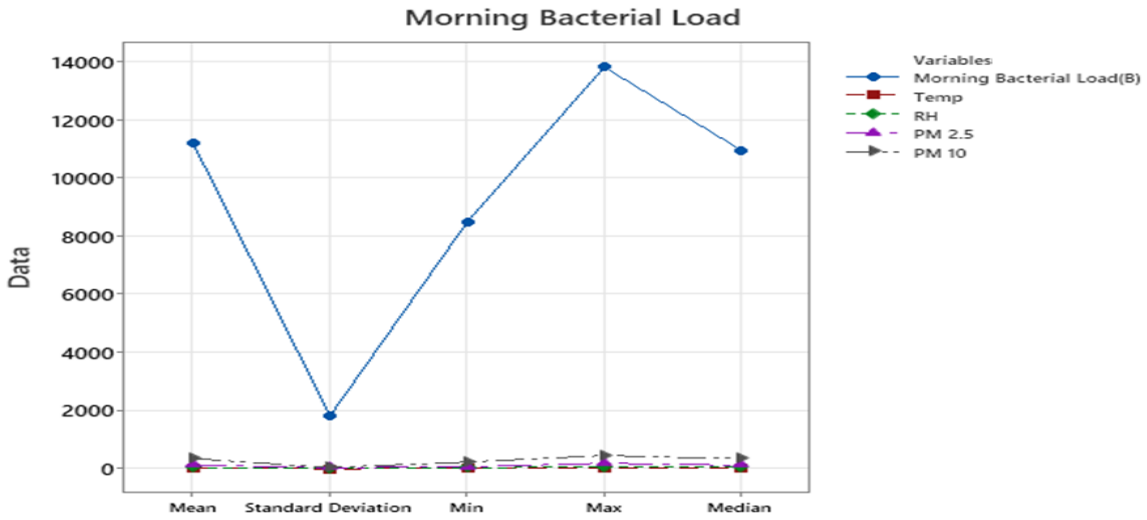
Similar to the morning findings, evening bacterial load was positively correlated with temperature (0.972) and relative humidity (0.988). Although PM $_{2.5}$ (0.683) and PM 10 (0.776) show a positive correlation, the coefficients are lower in the morning, indicating that variation of PM in the evening influences the bacterial load. Fungal load (F) in both morning and evening tests showed good correlation with temperature, with coefficients of 0.947 and 0.925, respectively. Strong positive correlation coefficients (morning: 0.971, evening: 0.999) indicate the importance of humidity which impacts the fungal presence in indoor air(Table-1). Fungal infections in both morning and evening samples showed a positive correlation with $PM_{2.5}$ and PM_{10}; This suggests a possible link between PM concentration and the presence of fungi in the indoor environment(Dig 1 A and dig 1B).



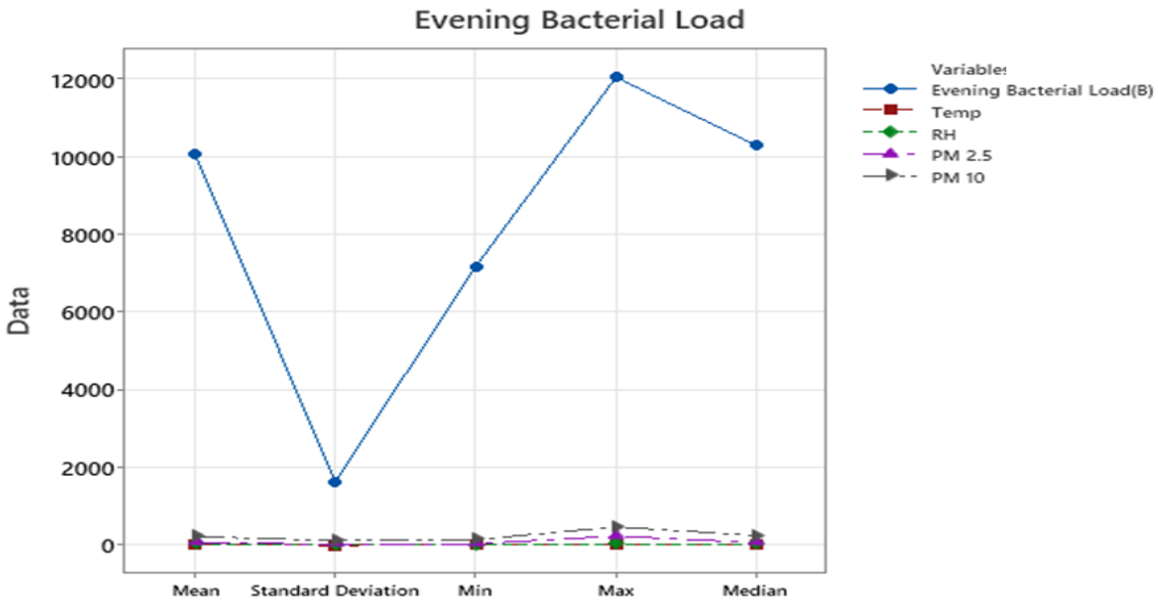
(A)


Evening Fungal Load
Data
2000
1500
1000
500
0
Mean
Standard Deviation
Min
Max
Median
Variables
Evening Fungal Load(F)
Temp
RH
PM 2.5
PM 10

(B)


Morning Bacterial Load
Data
14000
12000
10000
8000
6000
4000
2000
0
Mean
Standard Deviation
Min
Max
Median
Variables
Morning Bacterial Load(B)
Temp
RH
PM 2.5
PM 10

(C)


Evening Bacterial Load
Data
12000
10000
8000
6000
4000
2000
0
Mean
Standard Deviation
Min
Max
Median
Variables
Evening Bacterial Load(B)
Temp
RH
PM 2.5
PM 10

(D)

Dig.1 A to D The graphs illustrate the statistical data for the day variables, including- Morning Temperature (Temp), Evening Temperature (Temp), Morning Relative Humidity (RH) , Evening Relative Humidity (RH), Morning PM2.5, Evening PM2.5, Morning PM10, Evening PM 10.

Evening bacterial counts showed a similar trend; Building 1 had the highest average (18945.77 CFU/m3), followed by Buildings 3 and 2. The standard deviation and variance show the differences in the number of bacteria in the air in the evening. , indicating the possible factors influencing this change.

Analysis of physicochemical variables (temperature, relative humidity, $PM_{2.5}$, PM_{10}) shows different patterns over the three days. For example, temperature changes in the morning and evening can affect fungal and bacterial infections. Correlation analysis showed a strong relationship between temperature and both bacteria and viruses(Dig1 C and Dig 1D)

4. Discussion:

In this study, we aimed to investigate the relationship between the physicochemical dynamics of indoor air quality and indoor pathogens in public buildings in the National Capital Region of Delhi. Results from three consecutive days of monitoring provide insight into the interaction between environmental variables and microbial load.

An early study conducted by Jimma University Library showed a high prevalence of bacterial and fungal infections and highlighted the need to control environmental factors that promote microbial growth. Additionally, research shows that libraries should be expanded to accommodate current and future students (Hayleeyesus and Manaye, 2014). Another study in public primary schools in the city of Gondar found increased pollution compared to indoor air quality standards. Factors such as temperature, relative humidity, and certain problems have been associated with indoor bacterial concentration, and the importance of physical control in the classroom has been emphasized to ensure the health of students and teachers (Andualem et al., 2019).In our three-day study, the average morning temperature varied between 29.77 °C and 31.85 °C, while the evening temperature varied between 34.13 °C and 36.83 °C, showing a lower standard deviation temperature. The relationship between bacterial and fungal loads and temperature suggests that, based on available data, temperature can promote microbial proliferation. Relative humidity showed differences, and a positive relationship was found between humidity and microbial load, suggesting its role in shaping internal microbial dynamics. Increased humidity can create an environment suitable for microbial activity, as evidenced by the association with bacteria and fungi.

Most particulate matter ($PM_{2.5}$ and PM_{10}) varies daily and is positively correlated with microbial load, especially in the morning. This suggests that there may be daily differences in the effects of particulate matter on indoor microbial dynamics. Changes in the environment and microbial loads were observed over these three days, highlighting the importance of determining several days for a full understanding of indoor air quality.

There is a consistent relationship between environmental changes in the morning and evening and fungal infections; This suggests a synergistic relationship between temperature, humidity and fungal problems. Correlation with humidity indicates the potential effect of humidity on fungal growth. Bacterial concentrations are closely related to temperature, humidity and PM-specific problems which suggests the need to improve indoor air quality, including the interaction of various environmental factors in the environment.

5. Conclusion

In summary, this study revealed the interaction between indoor diseases and physical changes in public buildings in the National Capital Region of Delhi. The results indicate the need to adapt to the development of indoor air, including the presence of diseases and the environment. Future research may examine more deeply the specific factors that influence microbial dynamics and demonstrate their impact on public health and building quality management.

The results of this study provide a better understanding of the small-scale link between indoor pathogens and the physicochemical dynamics of air quality in public buildings in the National Capital Region of Delhi. A deeper understanding of these relationships is necessary to develop strategies to improve indoor air quality and reduce health risks associated with microbial contamination. Further research is recommended to investigate other factors affecting indoor microbial dynamics and validate the findings in different indoor environments.

Acknowledgments

The author wants to thank Vaibhav Srivastava and Urvashi Gupta for their help in the data mining & and analytical presentation of the research data and Amity University for providing the technical infrastructure in the conduction of this research work.

Abbreviations
RH: Relative humidity.
PM: Particulate matter.
$PM_{2.5}$: Fine particles with a diameter of 2.5 microns (μm) or less.
PM_{10}: Coarse particles with a diameter of 10 μm or less.

Authors Contribution
Yogyata Srivastava: Writing - Review & Editing, Visualization, Formal analysis, Investigation, conducted the conceptualization, Formal analysis, Data Curation, Writing - Original Draft.
Tanu Jindal: Helped in methodology, visualization and supervision.
Abhishek Chauhan: Helped in editing and review.
Lokender Kumar: helped with the methodology.

Declaration of interests
Yogyata Srivastava is the recipient of a CSIR UGC NET fellowship, [File no. is 09/915(0015)/2019-EMR-I] with funding being provided by HRDG.

Consent for publication
All the authors have understood, complied, and read and is applicable to all the statement on "Ethical responsibilities of Authors" as found in the Author's Instructions and are acquainted with minor exceptions, no changes can be made to authorship once the paper is submitted.

Competing interests
There is no conflict of interest as declared by the authors

Funding
CSIR (The Council of Scientific & Industrial Research), India for the CSIR-UGC-NET fellowship. File no. is [09/915(0015)/2019-EMR-I].

Data Availability
The document and its annexes contain all the information necessary to evaluate the outcome of this study. More information about this article can be requested directly from the author

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