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QUANTITATIVE ASSESSMENT OF AIRBORNE MICROBIAL LOAD IN CLINICAL AND ADJACENT ENVIRONMENTS

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ABSTRACT

Airborne microbial contamination in hospital environments poses a significant risk to infection control, especially in operating rooms. This study evaluates airborne microbial loads in six different hospital and adjacent locations through passive sampling using nutrient agar plates. Samples were exposed to air for 10 minutes and incubated for 48 hours to quantify colony-forming units (cfus). The highest microbial counts were observed near the bike stand outside the lab, while the immunology lab recorded the lowest counts. The findings underscore the importance of air quality monitoring and control strategies in healthcare settings.

INTRODUCTION

Although a number of microorganisms are present in air, it doesn't have an indigenous flora. Air is not a natural environment for microorganisms as it doesn't contain enough moisture and nutrients to support their growth and reproduction. Quite a number of sources have been studied in this connection and almost all of them have been found to be responsible for the air micro flora. One of the most common sources of air micro flora is the soil. Soil microorganisms when disturbed by the wind blow, liberated into the air and remain suspended there for a long period of time. Man made actions like digging or plaguing the soil may also release soil borne microbes into the air. Similarly microorganisms found in water may also be released into the air in the form of water droplets or aerosols. Splashing of water by wind action or tidal action may also produce droplets or aerosols. Air currents may bring the microorganisms from plant or animal surfaces into air. These organisms may be either commensals or plant or animal pathogens. Studies show that plant pathogenic microorganisms are spread over very long distances through air. For example, spores of Puccinia graminis travel over a thousand kilometers. However, the transmission of animal diseases is not usually important in outside air. The main source of airborne microorganisms is human beings. Their surface flora may be shed at times and may be disseminated into the air. Similarly, the commensally as well as pathogenic flora of the upper respiratory tract and the mouth are constantly discharged into the air by activities like coughing, sneezing, talking and laughing. The microorganisms are discharged out in three different forms which are grouped on the basis of their relative size and moisture content. They are droplets, droplet nuclei and infectious dust.

FACTORS AFFECTING AIR MICROFLORA

Several intrinsic and environmental factors influence the presence of microorganisms in the air:

- **INTRINSIC FACTORS:** Spore-forming organisms are more resilient and prevalent in the air. Microorganism size affects suspension duration; smaller organisms remain airborne longer.
- **ENVIRONMENTAL FACTORS:** Temperature, relative humidity, air currents, and altitude impact microbial survival. For example, most bacteria show decreased viability at higher temperatures. Relative humidity between 40% and 80% favors microbial survival, while extremes reduce viability.

2. LITERATURE REVIEW

Ullah & Kazmi [1]. This study quantified aerobic bacterial counts and identified Bacillus cereus group species in selected indoor environments in Karachi. Using settle plate techniques, it established a baseline microbial load and revealed the presence of potential pathogens in healthcare settings. It highlights the

need for improved air filtration and disinfection protocols in urban healthcare infrastructure. Belay et al [2]. Conducted a comprehensive microbial survey of indoor air, surfaces, and medical equipment in an Ethiopian hospital. Results showed significant contamination levels, with bacterial counts exceeding WHO standards in several areas. The study emphasized cross-contamination risks and recommended strict hygiene practices and routine microbiological monitoring. Ashuro et al [3]. This cross-sectional study assessed airborne microbial loads across different departments in Dilla University hospital. The authors identified a correlation between patient density and microbial counts, suggesting occupancy-driven bioaerosol generation. The data support policies promoting natural ventilation and occupancy control in hospitals. Ahmednur et al [4]. Investigated air quality in a correctional health facility, linking high microbial counts with poor ventilation and overcrowding. The study reported pathogenic Staphylococcus and Bacillus species as dominant airborne microbes. The authors advocated for minimum air exchange standards and HVAC upgrades in confined healthcare environments. Stockwell et al [5].

This systematic review explored the relationship between hospital ventilation systems and bioaerosol concentration. It found that poor ventilation significantly increases airborne microbial loads. The paper also highlighted how natural and mechanical ventilation influence the prevalence of fungi and bacteria in patient-care areas. Fakunle et al [6]. A meta-analysis linking indoor microbial aerosols with respiratory symptoms in children under five. It concluded that airborne bacterial and fungal exposures were significant risk factors for respiratory illness. This underscores the public health significance of microbial monitoring in pediatric clinical settings. Kembel et al [7]. An informal yet data-backed narrative exploring microbial ecology in office buildings. While not clinical, it provides insight into the built environment's impact on microbial dispersion, especially from HVAC systems. The article helps contextualize microbial assessments in adjacent non-clinical environments like administration blocks. Sautour et al [8]. Simultaneously monitored SARS-CoV-2, bacteria, and fungi in a hospital in Iran. It emphasized multiplex bioaerosol surveillance and the synergistic impact of viral and bacterial presence on indoor air quality. The study called for integrated bioaerosol sampling frameworks for infection control. Maleki & Nazari [9]. Analyzed bacterial bioaerosols in Imam Hossein Hospital, Tehran. The study used both passive and active sampling methods and reported high levels of *Staphylococcus aureus* and *Micrococcus* spp., especially in ICUs and surgical wards. It recommended the use of HEPA filters and UV sterilizers to reduce microbial load.

Benammar et al[10]. Focused on microbial air quality in the emergency department of an Algerian hospital. The researchers documented substantial seasonal variations in microbial load, with peaks in summer months due to inadequate HVAC systems. Their work contributes to region-specific air quality control strategies. Dashti et al [11]. Examined microbial air profiles in a major Iranian hospital, identifying airborne bacterial genera such as Pseudomonas, Acinetobacter, and Bacillus. Their study also evaluated the effectiveness of existing disinfection regimes, revealing gaps in procedural efficacy. Findings advocate periodic microbial audits in clinical zones. Abdelrahman et al [12].This study evaluated indoor air quality in four primary health care centers in Qatar, quantifying airborne bacteria indoors and outdoors. The findings revealed elevated bacterial concentrations indoors, with Staphylococcus and Micrococcus species being predominant. The study emphasized the need for improved ventilation and regular monitoring to ensure a safe healthcare environment. Li et al[13]. Investigated airborne bacteria and fungi levels in a female dormitory, analyzing the effects of heating, relative humidity, and occupancy. The study found that microbial concentrations were influenced by these factors, with higher counts observed during periods of increased occupancy and heating. The research underscores the importance of environmental controls in shared living spaces. Abdel Hameed & Farag [14]. Assessed indoor bio-contaminant air quality, highlighting the presence of various microbial species in indoor environments. The study suggested that building design, ventilation, and maintenance play crucial roles in controlling microbial loads, emphasizing the need for comprehensive indoor air quality management strategies. Peter & Yakubu [15].

Conducted a comparative analysis of airborne microbial concentrations in two clinical laboratories. The study revealed significant differences in microbial loads between the laboratories, attributing variations to factors such as ventilation efficiency and hygiene practices. The findings advocate for standardized protocols to maintain optimal air quality in clinical settings. Uzoechi et al. [16]. Evaluated the microbiological quality of indoor air in a university library, identifying high levels of bacterial and fungal contaminants. The study highlighted the impact of human traffic and inadequate ventilation on microbial concentrations, recommending regular air quality assessments and improved ventilation systems. Fekadu & Melaku [17].

Investigated the microbiological quality of indoor air in university libraries, finding elevated levels of airborne bacteria and fungi. The research emphasized the influence of environmental factors such as temperature and humidity on microbial proliferation, suggesting the implementation of environmental controls to mitigate contamination. Awad Abdel Hameed & Farag [18]. Explored indoor bio-contaminants air quality, focusing on the presence and sources of microbial pollutants. The study identified factors contributing to microbial growth, including moisture accumulation and poor ventilation, and recommended strategies for effective indoor air quality management. Peter & Yakubu [19]. Analyzed airborne microbial concentrations in clinical laboratories, observing significant variations linked to laboratory practices and environmental conditions. The study advocated for regular monitoring and adherence to strict hygiene protocols to ensure a safe laboratory environment. Uzoechi et al [20].

Assessed indoor air quality in a university library, detecting high microbial loads associated with human activity and inadequate ventilation. The research recommended the implementation of air purification systems and routine air quality evaluations to maintain a healthy indoor environment. Fekadu & Melaku [21]. Studied the microbiological quality of indoor air in university libraries, identifying significant microbial contamination influenced by environmental factors. The findings highlighted the necessity for environmental controls and regular maintenance to reduce microbial presence. Awad Abdel Hameed & Farag [22]. Examined indoor bio-contaminants air quality, focusing on the sources and levels of microbial pollutants. The study emphasized the role of building design and maintenance in controlling indoor microbial loads, recommending comprehensive strategies for air quality improvement. Peter & Yakubu [23]. Conducted a comparative analysis of airborne microbial concentrations in clinical laboratories, revealing disparities linked to environmental and operational factors. The research underscored the importance of standardized procedures and regular monitoring to ensure optimal air quality. Uzoechi et al [24]. Evaluated the microbiological quality of indoor air in a university library, finding significant microbial contamination associated with human occupancy and ventilation inadequacies. The study suggested the adoption of effective ventilation systems and routine air quality assessments. Fekadu & Melaku [25] Investigated the microbiological quality of indoor air in university libraries, identifying high levels of airborne microbes influenced by environmental conditions. The research recommended environmental management practices to mitigate microbial contamination.

3. MATERIALS AND METHODS

3.1 STUDY DESIGN:

The study was conducted over two days, from March 23 to 24, 2017. Six different sampling sites were chosen within and around laboratory environments.

3.2 MATERIALS USED

- Nutrient agar (8.5 g)
- Distilled water (300 mL)
- Conical flasks, Petri dishes
- pH meter, electronic balance
- Non-absorbent cotton

3.3 MEDIA PREPARATION AND STERILIZATION

Agar media was prepared by dissolving 8.5 g of nutrient agar in 300 mL of distilled water. The mixture was sterilized using an autoclave at 121°C for 15 minutes. Sterilized media was poured into Petri dishes and cooled in a Laminar Air Flow (LAF) chamber.

3.4 SAMPLING PROCEDURE

Six Petri dishes were placed at selected locations in open air for 10 minutes (passive sampling). The dishes were then incubated at room temperature for 48 hours.

3.5 SAMPLING LOCATIONS

- Downstream Processing Lab
- Microbiology Lab
- Immunology Lab
- Bio-processing Lab
- Water Stagnant Area
- Outside Lab (Bike Stand)

Table 1. Number of Colonies

LOCATION	DAY 1(CFUs)	DAY (CFUs)
Downstream processing lab	12	29
Microbiology lab	11	21
Immunology lab	2	8
Bio processing lab	10	17
Water stagnant area	15	25
Outside Lab (Bike Stand)	19	35

4. RESULT AND DISCUSSION:

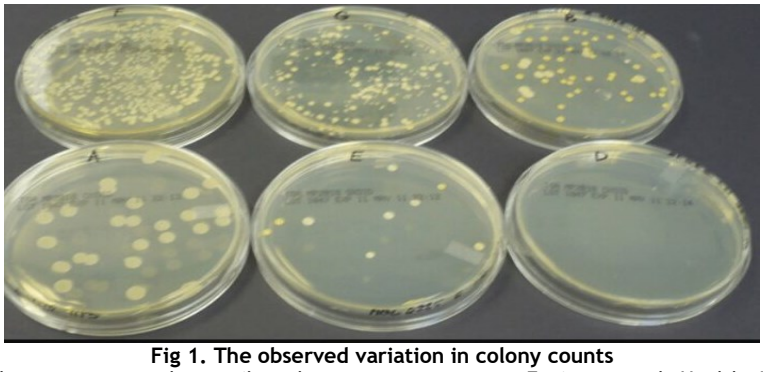

Fig 1. The observed variation in colony counts

The observed variation in colony counts can be attributed to environmental conditions and human activity levels. Outdoor locations and water stagnant areas exhibited higher microbial loads due to exposure to dust, wind currents, and decaying organic matter. Indoor labs maintained relatively lower counts, suggesting better air control and reduced exposure.

CONCLUSION

This study confirms the variability of airborne microbial contamination in clinical and adjacent environments. Higher CFU counts in outdoor and poorly maintained areas point to potential risks for contamination and infection. Effective air control strategies and routine monitoring are essential in minimizing microbial presence in critical healthcare zones such as operating rooms.

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