DOI:10.22373/ijes.v3i1.7688
ISSN 3046-885X

IJES
Indonesian Journal of Environmental Sustainability

Published by :
Center For Environmental Studies
UIN Ar-Raniry Banda Aceh

CHARACTERISTICS AND CONCENTRATION OF AIRBORNE FUNGI IN PUBLIC BUS TRANSPORTATION IN BANDA ACEH CITY, ACEH PROVINCE

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Received: 13 May 2025 Accepted: 20 June 2025 Published: 30 June 2025

ABSTRACT

Airborne fungi are one of the common pollutants that spread through the air and frequently found in public bus transportation. Their transmission of airborne fungi can have an impact on health and is considered an important public health problem. The presence of airborne fungi can cause various respiratory diseases such as asthma, bronchopulmonary infections, rhinitis and other allergic symptoms. The concentration of airborne fungi in buses has a significant correlation between the level of fungi and the number of passengers. High concentrations of fungi in transportation can affect human health. The purpose of this study was to determine the concentration of airborne fungi in buses and the types of fungi in the air on buses that had just arrived and those that were about to depart for Medan. The sampling method used for collecting airborne fungi is the probability sampling technique, especially by using the random sampling technique and the open plate technique which is left open for 15 minutes while measuring physical factors such as temperature, humidity, light intensity and number of passengers. Samples were taken from 3 buses X, Y and Z found on public transportation buses. The results of this study obtained the concentration of fungi in the air on buses that had just arrived and those that were leaving for Medan reaching 105, 9 CFU/m^3 on bus X, 70, 6 CFU/m^3 and 141, 2 CFU/m^3 on bus Y, and 46, 9 CFU/m^3 and 151, 8 CFU/m^3 on bus Z, meaning that these values do not exceed the indoor air quality standards set by WHO of < 500 CFU/m^3. The types of airborne fungi on buses X, Y and Z are *Alternaria* sp., *Aspergillus* sp., *A. niger*, *A. flavus*, *A. fumigatus, Penicillium* sp., *Clasdoporium* sp., *C. clasporioides*, dan *Acremonium* sp.

Keywords : Airborne Fungi, Concentration of Airborne Fungi, Public bus transportation

ABSTRAK

Airborne fungi merupakan salah satu polutan umum yang tersebar melalui udara dan dapat di temukan pada berbagai transportasi bus umum. Penularan airborne fungi dapat berdampak pada kesehatan dan dianggap sebagai masalah kesehatan masyarakat yang penting. Keberadaan airborne fungi ini dapat menyebabkan berbagai penyakit pernafasan seperti asma, infeksi brankopulmonalis, rinitis dan gejala alergi lainnya. Konsentrasi airbone fungi di dalam bus memiliki korelasi yang signifikan antara tingkat fungi dan jumlah penumpang. Tingginya konsentrasi fungi pada transportasi umum dapat mempengaruhi kesehatan manusia. Tujuan penelitian ini adalah untuk mengetahui konsentrasi airborne fungi pada bus dan jenis - jenis airborne fungi pada bus yang baru tiba dan yang akan berangkat ke Medan. Metode yang digunakan untuk pengambilan sampel airborne fungi adalah teknik probability sampling, khususnya dengan menggunakan teknik random sampling dan teknik open plate yang dibiarkan

DOI:10.22373/ijes.v3i1.7688
ISSN 3046-885X

secara terbuka selama 15 menit sambil melakukan pengukuran faktor fisik seperti suhu, kelembaban, intensitas cahaya dan jumlah penumpang. Sampel diambil dari 3 bus X, Y dan Z yang terdapat pada transportasi bus umum. Hasil penelitian ini diperoleh nilai konsentrasi airborne fungi pada bus yang baru tiba dan yang akan berangkat ke Medan mencapai mencapai 105, 9 CFU/m^3 pada bus X, 70, 6 CFU/m^3 dan 141, 2 CFU/m^3 pada bus Y, serta 46, 9 CFU/m^3 dan 151, 8 CFU/m^3 pada bus Z, artinya nilai tersebut tidak melebihi standar kualitas udara dalam ruangan yang ditetapkan oleh WHO sebesar < 500 CFU/m^3. Jenis - jenis airborne fungi yang terdapat pada bus X, Y dan Z meliputi Alternaria sp., Aspergillus sp., A. niger, A. flavus, A. fumigatus, Penicillium sp., Clasdoporium sp., C. clasporioides, dan Acremonium sp.

Kata Kunci : Airborne fungi, Konsentrasi Airborne Fungi, Transportasi Bus umum

Introduction

Airborne fungi are one of the common pollutants in the environment that can reduce indoor air quality to a certain extent and pose health risks to humans worldwide (Xin *et al*., 2021). Airborne fungi are found everywhere, including in human living environments (Yang *et al*., 2023). According to Kasprzyk *et al*., (2021), many fungi cause pathological infections in humans. Fungi commonly found in the air can affect health. Exposure to fungal allergens is considered a major risk factor due to the prevalence and severity of asthma in humans (Qi *et al*., 2020). Airborne respiratory diseases are transmitted through respiratory fluids in the form of aerosols carried by air movement (Mikszewski *et al*., 2022). Tellier *et al*., (2019) revealed that the potential for airborne transmission of other pathogens, such as the influenza virus, depends on various host, viral, and environmental factors. This aligns with previousstudies showing that airborne fungi are associated with various respiratory diseases (Sio *et al*., 2021).

Exposure to airborne fungi can cause various diseases such as rhinitis, asthma, respiratory allergy symptoms, and infections like mycosis. The most frequently found spores in outdoor markets, hospitals, residential areas, high schools, and commercial areas in Lagos, Nigeria, include *Aspergillus niger*, *A. sydowii*, *A. flavus*, *A. oryzae*, *Penicillium funiculosum*, *P. oxalicum*, *P. pinophilum*, *P. simplicissimum*, *Fusarium verticillioides*, *Aphaderanum* sp., *Curvularia* sp., *Neurospora crassa*, and *Paecilomyces* sp. (Odebode *et al*., 2020). This is consistent with the study by Hughes *et al*. (2022), which stated that *Aspergillus* sp., *Cladosporium* sp., *Penicillium* sp., and *Alternaria* sp. can worsen respiratory disorders and cause airborne allergies.

Metiner *et al*. (2021) explained that the concentration of airborne fungi in buses is higher than in the indoor air of other transportation vehicles, and there is a significant correlation between fungal levels and the number of passengers. The highest and lowest concentrations of airborne fungi (CAF) in public transportation in Istanbul were found to be 40 - 660 CFU/m^3 in buses, 20 - 400 CFU/m^3 in the metro, 40 - 360 CFU/m^3 in the metrobus, and 20 - 260 CFU/m^3 in ferries. The high concentration of fungi in public transport vehicles can affect human health. *Penicillium* sp., *Paecilomyces* sp., and *Aspergillus* sp. are airborne fungi found in public transportation vehicles in Istanbul (Metiner *et al*., 2021).

Kim *et al*., (2020) also stated that the concentration of airborne fungi in public transportation in Korea was found to be below the environmental standard (500 CFU/m^3) set for public facilities. The number of airborne fungi was relatively higher in the summer compared to autumn. During the summer, the concentration of airborne fungi reached 252.0 CFU/m^3 in subways and 45.1 CFU/m^3 in trains, while intercity buses had a higher concentration, reaching 111.9 CFU/m³. *Cladosporium* sp., *Penicillium* sp., and *Aspergillus* sp. were detected in Korean public transportation systems. This is in line with the study by Arowan *et al*., (2021), which reported that airborne fungi concentrations at bus and train stations ranged from 140 to 776 CFU/m³ and from 27 to 168 CFU/m³, respectively.In Tianjin, China, the concentration of airborne fungi ranged from 0 to 340 CFU/m³. The most dominant fungal genera identified in Tianjin were *Alternaria* sp., *A. alternata*, *A. tenuissima*, *Cladosporium* sp., *C. cladosporioides*, *Penicillium* sp., *P. oxalicum*, *Talaromyces* sp., *T. funiculosus*, *Didymella* sp., and *Aspergillus* sp s(Nageen *et al*., 2023). *Cladosporium* is the most commonly found allergenic fungus in the MRT-SKV system (Harnpicharnchai *et al*., 2023).

According to Sivri *et al*., (2020), high relative humidity in indoor environments can enhance fungal growth. Fungal growth tends to be faster at night because nighttime humidity is higher than in the morning, and fungi prefer low-light conditions (Ščevková *et al*., 2019). Temperature can also influence the growth and spread of fungi in the atmosphere (Nageen *et al*., 2023). Lam *et al*., (2022) also stated that light exposure can affect the growth rate and survival of indoor fungi on different surface materials. Additionally, wind speed can increase the spread and diversity of airborne fungi (Lu *et al*., 2022).

Airborne fungal spores constitute the majority of biological particles in the atmosphere. Airborne fungi are also a major cause of respiratory allergies (SenGupta *et al*., 2023). According to Upadhyay, (2023) fungi release volatile metabolites, mycotoxins, other secondary metabolites that cause allergic reactions and hypersensitivity in humans. The average concentration of airborne fungal spores is higher in buildings and there is a correlation between fungal contamination and health problems of its occupants. In addition, the most common fungal species appearing on surfaces are often identified in indoor air. Some fungal species that contaminate rooms may be harmful to human health because they produce mycotoxins (Al-Hallak *et al*., 2023).

Indoor fungal exposure can have an impact on the health of its occupants so that fungi can germinate, grow and sporulate and spread in the indoor air (Saosa, 2022). Fungal spores suspended in the air have become multicellular variations so that they can provide resistance to the environment (Roy & Gupta, 2020). The concentration of airborne fungi can vary significantly depending on several factors including the type of room, the environment, and human activities in it. The concentration of airborne fungi that is considered normal for indoor air is <500 CFU/m^3. If the concentration of fungi in the room exceeds 500 CFU/m3, there may be a problem with the quality of the indoor air (Guo *et al*., 2020). Although this limit is not an absolute standard, a number higher than 500 CFU/m3 may indicate a possible risk to health, especially for individuals who are susceptible to fungal infections or allergies. The highest concentration can reach thousands or even tens of thousands of CFU/m^3 (Albasri & Alsharif, 2024). This is in line with the research of Frąk *et al*., (2024) which states that the concentration of fungi in the car cabin reaches 8,369 CFU/m^3.

Tellier *et al*., (2019) revealed that infectious diseases such as tuberculosis, chickenpox and measles are caused by certain microorganisms that are spread through airborne (aerosol). Meanwhile, *Aspergillus* particles and other fungi in the air have the potential to worsen asthma status (Rozaliyani, 2019). According to Anees-Hill *et al*.,

DOI:10.22373/ijes.v3i1.7688
ISSN 3046-885X

(2022) the fungi most commonly found in outdoor air are *Alternaria* and *Cladosporium.* Based on previous research, it was also stated that *Penicilium, Cladosporium*, *Alternaria*, *Aspergillus*, and *Trichoderma* are the most dominant fungi in the Hangzao air. Airborne fungi found indoors can have an impact on human health such as Alternaria, Aspergillus, Penicillium. The spread of spores of *Penicillium* sp., and Aspergillus sp. fungi in the air enters the body through droplet infection, which is a method of transmitting spores through dust particles or through the remains of dried saliva droplets (Fang *et al*., 2019). In addition, Datau, (2020) stated that in shopping rooms there are *Rhizopus* sp., *Mucor* sp., Aspergillus sp., *A. niger*, *A. Fumigatus*, *Neurospora* sp., *Saccharomyces* sp., *Cryptococcus* sp., *Candida* sp., and *Rhodoturula* sp. According to Atya *et al*., (2019) airborne fungi that spread in various environments are *Aspergillus* and *Penicilium*. This is in line with the research of Wu *et al*., (2019) that there are pathogenic fungi such as *Aspergillus*, *Cladosporium*, *Penicillium* and *Alternaria* in the Nanjing Utility tunnel. Lu *et al*., (2022) also stated that there were Alternaria, Cladosporium and Aspergillus in the research and teaching building of Tianjin University. *Penicilium*, *Cladosporium* and *Acremonium* were also found in school rooms (Sauliene *et al*., 2023). This is in line with the research of Jabeen *et al*., (2023) which stated that *Penicillium*, *Rhizopus*, *Fusarium*, *Mucor*, *Cladosporium*, *Aspergillus niger* and *Alternaria* are the most common fungal species found in India.

Buses are a type of land vehicle used to transport many people. Buses are divided into two types, namely midibuses and minibuses. Long-distance services sometimes use large buses. There are many types of large buses, including visually appealing metropolitan and intercity buses as well as cheaper school or campus buses. Buses can be used for education, rental, tourism and long-distance travel (Nuryadi *et al*., 2021). Airborne fungi are one of the common pollutants that are spread through the air and can be found on various public bus transportation. The presence of airborne fungi can cause various diseases such as rhinitis, asthma, respiratory allergy symptoms and infections such as mycosis (Odebode *et al*., 2020).

According to Kim et al., (2020) *Cladosporium* sp., *Penicillium* sp., and *Aspergillus* sp., were found on public transportation in Korea. Airborne fungi found in bus stations, train stations and airports in Ahvaz City, Iran include *Cladosporium* sp., and *Alternaria* sp., *Aspergillus* sp., and *Penicillium* sp., (Baboli et al., 2024). This is in line with the research of Fernández-Iriarte *et al*., (2021) which stated that public buses and tourist buses contain *Penicillium* sp., *Aspergillus* sp., and *Cladosporium* sp. Traveling by bus is a good solution to reduce traffic congestion and toxic emissions to the environment. Although the benefits of using buses for individuals and society are enormous, the use of buses in Ho Chi Minh City is still limited and insufficient. Many people tend to choose private vehicles over buses because of the inconvenience. Attractive public transportation services are currently the most important component of a sustainable transportation system (Friman *et al*., 2019). Metrobus has mechanical and electrical dimensions. Ferry ventilation is provided through a cooling and heating air conditioning system (Metiner et al., 2021). In general, poor ventilation, indoor pollutant sources, microorganisms, building materials all contribute to poor indoor air quality (Hernawati, 2022). Exposure to air pollutants in public transportation around urban areas and the highly diverse air environment can be a growing problem for individual and public health (Zhang et al., 2023).

According to Dillon *et al*., (2023) commonly used airborne collection methods

DOI:10.22373/ijes.v3i1.7688
ISSN 3046-885X

include impaction, impingement, filtration and electrostatic precipitators. Measurement of airborne concentration includes temperature, humidity and lighting (Asril *et al*., 2023). Temperature and relative humidity are measured using a weatherman, light intensity is measured using a luxmeter and the number of colonies is calculated using a colony counter (Fan *et al*., 2020). Physical factors are taken in triplicate and the average is taken. Measurements of physical factors and the number of passengers is carried out at the same time as the air sampling process (Sivri *et al*., 2020). Factors that affect airborne fungi include temperature, wind speed, light, humidity and rainfall (Ščevková *et al*., 2019). According to Abbasi & Samaei, (2019) incubation temperature has tremendous effect on airborne fungi. Temperature can also have a higher effect on fungal communities in spring and summer, because temperature has an impact on the metabolic rate and reproduction of airborne fungi, temperature can also have an impact on the growth and spread of fungi in the atmosphere (Nageen *et al*., 2023).

Lower temperatures can limit the formation of fungi, while higher temperatures tend to accelerate the formation of fungi. In addition, certain species of fungi in the air are more resistant to temperature fluctuations than others, therefore temperature can also affect the composition of these organism species (Chakraborty *et al*., 2023). Wind speed is an environmental parameter that has a major influence on the concentration of airborne fungi (Ščevková *et al*., 2019). Wind speed can increase the spread and diversity of airborne fungi (Lu *et al*., 2022). Certain fungi can only thrive in bright light, while other fungi can be inhibited by sunlight (Hadi & Alamudi, 2019).

Exposure to light can affect the survival of fungi on the surface. In addition, exposure to light can affect the development of spores and the ability of fungi to spread through the air. This is in line with the research of Lam *et al*., (2022) which states that light can affect the growth rate and survival of fungi indoors on different surface materials. Certain types of fungi are more susceptible to direct light exposure, while other types of fungi are more tolerant. Fungi prefer conditions with low light intensity (Ščevková *et al*., 2019). High relative humidity in indoor environments can increase the formation of fungi (Sivri *et al*., 2020). Fungi often thrive in humid conditions. Low humidity can prevent the growth of fungi that certain types of fungi can become more active due to increased humidity after rain.

The transmission of airborne fungi can impact human health and is considered a significant public health issue. Airborne fungi play an important role in infectious diseases, acute toxic effects, allergies, and cardiovascular symptoms, particularlyFor example because many people use public transportation systems daily (Baboli *et al*., 2024). Therefore, it is important to determine the concentration and types of airborne fungi in public buses that have just arrived and are about to depart for Medan. Based on this context, the researcher is interested in studying the characteristics and concentration of airborne fungi in public bus transportation in Banda Aceh City, Aceh Province. The objective of this study is to determine the concentration and types of airborne fungi found on buses that have just arrived and are departing for Medan.

Methods

The method of airborne fungi sampling uses a sampling technique with a probability sampling category, which is done by determining certain criteria in the sample. Especially by using the random sampling technique, namely by determining the characteristics of the population randomly such as buses X, Y and Z must have 1

DOI:10.22373/ijes.v3i1.7688
ISSN 3046-885X

floor, buses arriving from Medan at 17:00 to 18:30 WIB and buses that will depart for Medan at 20:00 to 21:00 WIB, buses that have traveled long distances such as Medan - Banda Aceh and have been operating for more than 1 year. Sampling of airborne fungi was carried out on public bus transportation in Banda Aceh City, Aceh Province, then isolated for 5-7 days. After that, the concentration of airborne fungi was measured. Then the airborne fungi were purified for 5-7 days to obtain pure cultures. After that, characterization and identification were carried out. The number of airborne fungi sample colonies was calculated using a colony counter. According to Minister of Health Regulation, (2004) the microbial number index can be given a unit of CFU/m^3.Conversion: 1 colony CFU/m^3 = 35,32 CFU/m^3 Examination of the number of airborne fungi is calculated using the formula:

$$X = \frac{\Sigma\, fx}{\Sigma\, f} \qquad \Sigma y = CFU/m^3 \times X$$

Description:
X : Average number of fungal colonies
Σfx : Total number of colonies in petri dishs
Σf : Number of Petri dishes
Σy : Total number of colonies in the room

The indoor air quality standard set by WHO is 500 CFU/m^3.

The data were analyzed descriptively. The data obtained were qualitative data and quantitative data. Qualitative data were analyzed by describing the temperature, humidity, number of bus passengers and characteristics of the types of airborne fungi on buses arriving at 17:00 WIB and buses departing at 20:00 WIB which were presented in the form of a frequency distribution table. While quantitative data were analyzed by determining the concentration value of airborne fungi on public bus transportation using the open plate method.

Results and Discussion

Based on the results of airborne fungi concentration measurements that were carried out at 17:00 WIB to 18:30 WIB for buses that had just arrived and buses that would depart for Medan at 19:00 WIB to 21:00 WIB, the following concentration data and physical factor measurements were obtained:

Tables

Table 1. Concentration Airborne Fungi In Public Bus Transportation

No	Bus	Consentration Airborne Fungi		IAQ (Indoor Air Quality) Standard<500 CFU/m^3	
		Arrived	Departed	Arrived	Departed

 DOI:10.22373/ijes.v3i1.7688
ISSN 3046-885X

1	X	105, 9 CFU/m^3	105, 9 CFU/m^3	Does not exceed the standard	Does not exceed the standard
2	Y	70, 6 CFU/m^3	141, 2 CFU/m^3	Does not exceed the standard	Does not exceed the standard
3	Z	46, 9 CFU/m^3	151, 8 CFU/m^3	Does not exceed the standard	Does not exceed the standard

Based on the table above, it can be seen that the concentration value of airborne fungi on bus X that has just arrived and is about to depart reached 105.9 CFU/m^3. While the concentration value on bus Y that has just arrived reached 70.6 CFU/m^3 and 141.2 CFU/m^{3}on bus Y that is about to depart. The concentration value of airborne fungi onbus Z that has just arrived reached 46,9 CFU/m^3, while the concentration value on bus Z that is about to depart reached 151,8 CFU/m^3. The highest concentration value of airborne fungi was found on buses Y and Z, which ranged between 141,2 CFU/m^3 with 25 passengers and 151,8 CFU/m^3 with 32 passengers. In addition, the moderate concentration value was found on bus X that had just arrived and was about to depart, which ranged from 105,9 CFU/m^3 with 28-32 passengers.

Meanwhile, the lowest concentration values were found on buses Y and Z that had just arrived, ranging from 70.6 CFU/m^{3}with 22 passengers and 46,9 CFU/m^3 with 25 passengers. In general, it can be concluded that the lowest CAF concentration value was detected on bus Z that had just arrived with a capacity of 32 people with a low passenger density of 25 people. Meanwhile, the highest concentration value was detected on bus Z that was about to depart, with 32 people and a high passenger density. Although the maximum number of passengers on bus Z is 32 people in each seat, the average concentration of airborne fungi on bus Z was 46,9 CFU/m^3 and 151,8 CFU/m^3, which means that the value does not exceed the standard because the indoor air quality standard set by WHO (World Health Organization) is <500 CFU/m^3.

Airborne fungi in the air are greatly influenced by the number of vehicle passengers, therefore the number of fungi and bacteria is higher in trains and buses (Buitrago *et al*., 2021). The concentration of fungi in summer is higher than that determined in autumn, which is 252.0 CFU/m^3 in the metro, 45.1 CFU/m3 in trains, and 111.9 CFU/m^3 in buses (Kim *et al*., 2022). This is in line with the research of Metiner *et al*., (2021) which stated that the high concentration of CAF determined in the bus room is related to the number of bus passengers and the low interior air flow in the vehicle.Exposure to high concentrations of indoor fungal spores can cause various diseases, such as bronchial asthma, in addition, exposure to high concentrations of mycotoxins can be harmful to health in the long term (Saad-Hussein & Ibrahim, 2021). Public bus transportation systems worldwide transport more than 34 million people every day worldwide, and as a result, bus air quality is a significant source of urban air pollution (Fernández-Iriarte *et al*., 2021). The use of buses as public transportation is a choice for people because of its low cost and flexibility. Exposure to air pollutants in public transportation around cities and the highly variable air environment can be a growing problem for individual and community health (Zhang *et al*., 2023). Indoor air quality (IAQ) in public transportation stations (UPTS) in China has adverse effects on the health of station staff and passengers (Fan *et al*., 2024).

Table 2. Types of Airborne Fungi on Bus X

DOI:10.22373/ijes.v3i1.7688
ISSN 3046-885X

No	Isolate Code	Fungi	Description
1	XM 1	*Alternaria* sp.,	Pathogen
2	XM 2	*Aspergillus* sp.,	Normal flora
3	XM 3	*Alternaria* sp.,	Pathogen
4	XS 1 A	*Penicillium* sp.,	Normal flora
5	XS 1 B	*Aspergillus* sp.,	Normal flora
6	XS 1 C	*Alternaria* sp.,	Pathogen
7	XS 2 A	*Alternaria* sp.,	Pathogen
8	XS 2 B	*Aspergillus flavus*	Pathogen
9	XS 2 C	*Aspergillus flavus*	Pathogen
10	XS 3	*Alternaria* sp.,	Pathogen

Table 3. Types of Airborne Fungi on Bus Y

No	Isolate Code	Fungi	Description
1	YM 1 A	*Aspergillusniger*	Normal flora
2	YM 1 B	*Clasdoporium* sp.,	Normal flora
3	YM 2 A	*Aspergillusniger*	Normal flora
4	YM 2 B	*Penicillium* sp.,	Normal flora
5	YM 2 C	*Alternaria* sp.,	Pathogen
6	YM 3	*Penicillium* sp.,	Normal flora
7	YS 1	*Alternaria* sp.,	Patogen
8	YS 2 A	*Aspergillus* sp.,	Normal flora
9	YS 2 B	*Alternaria* sp.,	Patogen
10	YS 3	*Penicillium* sp.,	Normal flora

Table 4. Types of Airborne Fungi on Bus Z

No	Isolate Code	Fungi	Description
1	ZM 1 A	*Aspergillus sp.,*	Normal flora
2	ZM 1 B	*Alternaria sp.,*	Pathogen
3	ZM 1 C	*Penicillium sp.,*	Normal flora
4	ZM 1 D	*Aspergillus niger*	Normal flora
5	ZM 1 E	*C. clasdoporioides*	Normal flora
6	ZM 1 F	*Acremonium sp.,*	Normal flora
7	ZM 2	*Aspergillus flavus*	Pathogen
8	ZM 3	*A. fumigatus*	Normal flora
9	ZS 1	*Aspergillus* sp.,	Normal flora
10	ZS 2	*Penicillium sp.,*	Normal flora
11	ZS 3	*Clasdoporium* sp.,	Normal flora

Based on table 2. it can be seen that on bus X there are 3 different genera and 1 type of airborne fungi species, namely *Alternaria* sp., *Aspergillus* sp., *Penicillium* sp., and *A. flavus*. In addition, in table 3. it can be seen that there are 5 different types of airborne fungi on bus Y, such as *Clasdoporium* sp., *Alternaria* sp., *Penicillium* sp., Aspergillus sp., and A. niger. Based on table 4. on bus Z, it shows that there are 9 types of airborne fungi, namely *Clasdoporium* sp., *C. clasdoporioides*, *Acremonium* sp., *Aspergillus* sp., *A. flavus, A. niger, A. fumigatus, Penicillium* sp. *and Alternaria* sp. In general, there are 9 types of airborne fungi found on buses X, Y and Z, namely *Alternaria* sp., *Aspergillus* sp., *A. flavus*, A. *niger*, *A. fumigatus*, *Penicillium* sp.,

 DOI:10.22373/ijes.v3i1.7688
ISSN 3046-885X

Clasdoporium sp., C. clasdoporioides, and Acremonium sp. This is in line with the research of Baboli *et al*., (2024) which stated that the most dominant airborne fungi in the environment are *Cladosporium* sp., and *Alternaria* sp., while in public transportation rooms there are *Cladosporium* sp., *Aspergillus* sp., and *Penicillium* sp.

Airborne fungi found on public transportation in Korea are Aspergillus sp., *Penicillium* sp., and *Malassezia* sp., (Kim *et al*., 2022). According to Alam *et al*., (2022) airborne fungi spores *Aspergillus* sp., *Cladosporium* sp., *Candida* sp., *Curvularia* sp., *Epicoccum* sp., *Fusarium* sp., *Geotrichum* sp., *Helminthosporium* sp., *Mucor* sp., *Penicillium* sp., *Rhizopus* sp., *Trichoderma* sp., *Trichothecium* sp., and *Alternaria* sp., are found most dominantly in the air in many cities around the world.

The genus *Alternaria* sp., can grow in various ecosystems around the world as parasitic, saprophytic or endophytic species (Wang et al., 2022). According to Feng, & Sun, (2020). *Alternaria* sp., is a plant pathogen that can cause diseases in various plants and some of them are pathogenic to humans and animals. One of the impacts of exposure to *Alternaria* sp., in humans is an increased risk of contracting asthma (Hernandez-ramirez *et al*., 2021). This is in line with research by Kiasat *et al*., (2022) which states that the genus *Alternaria* sp., can cause respiratory diseases, such as fungal allergenicity and mycotoxin production in food. The species *Aspergillus* sp., can affect human health (Ekemezie *et al*., 2022).

Conidia *Aspergillus* sp., can survive for a long time in the atmosphere. *Aspergillus* sp., is a normal flora, but its conidia can cause various risk factors, including aspergillosis and other serious allergies due to high concentrations of *Aspergillus* sp., (Dhar *et al*., 2021). According to Farooq *et al*., (2023) *A. niger* is usually found in damp buildings and can grow on cement composites. *A. fumigatus* is saprotrophic and is usually found in soil (Latgé & Chamilos, 2020). This is in line with the research of Wong *et al*., (2021) which states that *A. fumigatus* can cause invasive pulmonary infection. In addition, *A. flavus* can cause various diseases and allergic reactions such as asthma, rhinitis, allergic bronchopulmonary mycosis and hypersensitivity pneumonitis can occur in residents in India when aflatoxins, spores, vegetative cells, and fungal metabolites are inhaled (Nayak *et al*., 2020). According to Wong *et al*., (2021) *A. flavus* is a common cause of superficial infections. *A. flavus* is also a pathogenic fungus that attacks many plants and is one of the main sources of aflatoxin contamination (Podgórska-Kryszczuk, 2023).

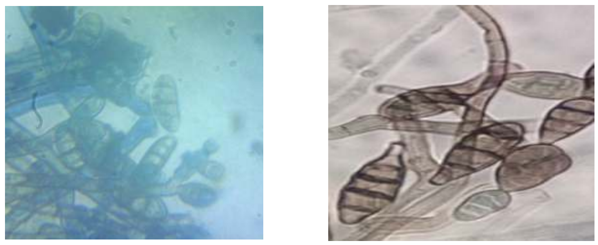
Cladosporium sp., acts as a major contaminant in the indoor environment that can raise concerns about the health and safety of individuals exposed to this fungus (Buthelezi, 2021). Bush, (2020) also suggested that *Cladosporium* sp., can involve various diseases related to indoor environmental conditions. *C. cladosporioides* is widespread and does not require specific ecological conditions because it can grow at moderate temperatures (Buthelezi, 2021). Dominguez-Moñino *et al*., (2021), suggested that in Southern Spain, *C. cladosporioides* was also found in the Cueva del Tesoro, Cueva de Ardales and Gruta de las Maravillas caves.

This is in line with the research of García-Mozo *et al*., (2020) which stated that there were *C. cladosporoides*, *C. herbarum*, *Coprinus*, *Alternaria* and *Torula* which were the most abundant in public transportation in the City of Córdoba (Southern Spain) and closed transportation can act as a reservoir of biological pollution that can impact passenger health. The species *Penicillium* sp., is a fungus found in indoor air and is considered an important agent causing extrinsic bronchial asthma (Sham *et al*.,

DOI:10.22373/ijes.v3i1.7688
ISSN 3046-885X

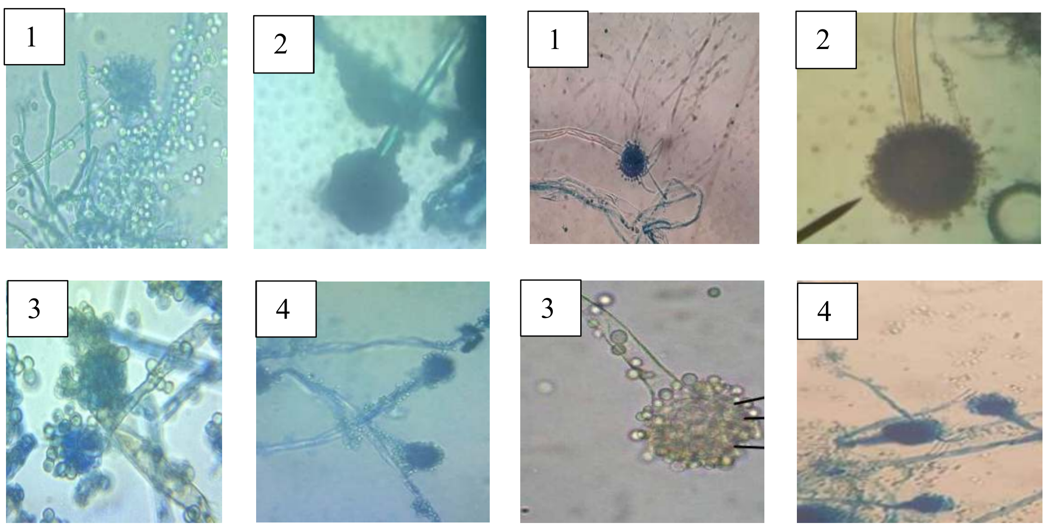
2021). In addition, *Penicillium* spp., is also a pathogenic fungus that can contaminate food (Otero *et al*., 2020). *Acremonium* sp., is a very common genus of fungi and includes saprobic, parasitic, or endophytic fungi that inhabit various environments. Species of this genus are widely exploited in industrial, commercial, pharmaceutical, and biocontrol applications, and have proven to be a rich source of novel and bioactive secondary metabolites (Hou *et al*., 2023).

Figure



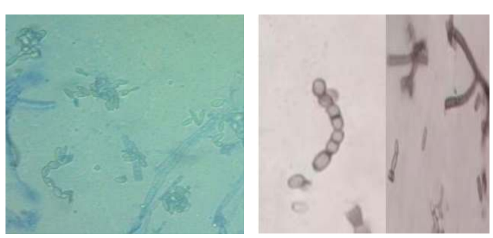
(a) (b)

Figure 1. Microscopic Fungi Alternaria sp., (XS3) (a) Mikroscopic Research (b) Comparison Microscopic (Kiasat et al., 2022).



(a) (b)

Figure 2. Microscopic Fungi *Aspergillus* sp., (XS 1B) (Rosa *et al*., 2020), *A. niger* (YM 1A) (Septiana *et al*., 2023), *A. flavus* (ZM 2) (Novalia *et al*., 2019) dan *A. fumigatus* (ZM 3) (Abdul-Kareem *et al*., 2022), (a) Mikroscopic Research (b) Comparison Microscopic.



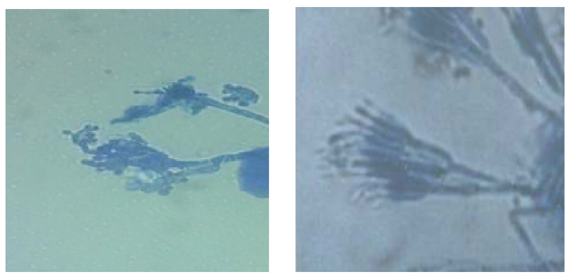
(a) (b)

DOI:10.22373/ijes.v3i1.7688
ISSN 3046-885X

Figure 3. Microscopic Fungi *Clasdoporium* sp., (YM 1B) Kurniasari *et al*., (2019), (a) Mikroscopic Research (b) Comparison Microscopic

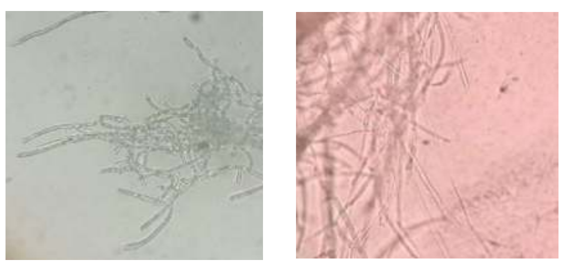
(a) (b)

Figure 4. Microscopic Fungi *C. clasdoporioides* (ZM 1 E) *C. clasdoporioides*(El-Dawy *et al*., 2021), (a) Mikroscopic Research (b) Comparison Microscopic



(a) (b)

Figure 5. Mikroskopis Fungi *Penicillium sp.,* (YM 3) (Annathurai & Kounthoujam, 2021)., (a) Mikroscopic Research (b) Comparison Microscopic



(a) (b)

Figure 6. Mikroskopis Fungi *Acremonium* sp., (JM 1F) (Triwidodo *et al*., 2021), (a) Mikroscopic Research (b) Comparison Microscopic.

Conclusion

Based on the results of this study, it can be concluded that the concentration value of airborne fungi on buses that have just arrived and those that will depart for Medan reached 105.9 CFU / m^3 on bus X, 70.9 CFU / $m^3$and 141.2 CFU / m^3 on bus Y, and 46.9 CFU / m^3 and 151.8 CFU / m^3 on bus Z, meaning that the value does not exceed the concentration standard specified on the bus. The types of airborne fungi found on buses X, Y and Z include *Alternaria* sp., *Aspergillus* sp., *A. niger*, *A. flavus*, *A. fumigatus*, *Penicillium* sp., *Clasdoporium* sp., *C. clasporioides*, sp., and *Acremonium* sp.

References

DOI:10.22373/ijes.v3i1.7688
ISSN 3046-885X

Abbasi, F., & Samaei, M. R. (2019). The Effect of Temperature on Airborne Filamentous Fungi in The Indoor and Outdoor Space of AHospital. *Environmental Science and Pollution Research, 26*, 16868-16876.

Alam, S., Nisar, M., Alam, S., Bano, S. A., & Ahmad, T. (2022). Impact of Aerial Fungal Spores on Human Health. *In Hazardous Environmental Micro-Pollutants, Health Impacts and Allied Treatment Technologies Cham: Springer International Publishing.*, (219-240).

Albasri, H. M., & Alsharif, S. M. (2024). Outdoor Assessment of Airborne Microorganisms During the COVID-19 Outbreak in Madinah City, KSA. *Journal of Pure and Applied Microbiology*, *18*(1), 638 - 652.

Anees-Hill, S., Douglas, P., Pashley, C. H., Hansell, A., & Marczylo, E. L. (2022). A Systematic Review of Outdoor Airborne Fungal Spore Seasonality Across Europe and The Implications for Health. *Science of the Total Environment*, *818*.

Al Hallak, M., Verdier, T., Bertron, A., Roques, C., & Bailly, J. D. (2023). Fungal Contamination of Building Materials and the Aerosolization of Particles and Toxins in Indoor Air and Their Associated Risks to Health: A Review. *Toxins*, *15*(3).

Arowan, S. M. U. J., Das, K. K., & Feroz, F. (2021). Microbiological Surveillance of Air and Contact Surface of Pubic Transports With its Correlation To Human Infection Risks. *Stamford Journal of Microbiology*, *11*(1), 7-10.

Asril, M., Sugiarto, S., & Zurfi, A. (2023). Airborne Microbial Quality Assessment in The Educational Buildings During The COVID -19 Pandemic. *Civil Engineer ing Journal (Iran)*, *9* (1), 114–126.

Atya, A. K., Alyasiri, M. H., Altamimy, R., & Ethaib, S. (2019). Assessment of Airborne Fungi in Indoor Environment for Biological Lab Rooms. *Journal of Pure and Applied Microbiology*, *13*(4), 2281 - 2286.

Baboli, Z., Hayati, R., Mosavion, K., Goudarzi, M., Sadeghi-Najad, B., Ghanbari, F.,... & Gaoudarzi, G. (2024). An Evaluation of Fungal Contamination and Its Relationship With PM Levels in Public Transportation Systems. *Environmental Research, 252,* 118901.

Buitrago, N. D., Savdie, J., Almeida, S. M., & Verde, S. C. (2021). Factors Affecting The Exposure To Physicochemical and Microbiological Pollutants in Vehicle Cabins While Commuting in Lisbon. *Environmental Pollution*, *270*, 116062.

Bush, A. (2020). *Kids , Difficult Asthma and Fungus*. *Journal of Fungi*, *6*(2), 55.

Buthelezi, Z. M. (2021). *Cladosporium Species in The Natural Habitat : A Source of Contamination For Indoor Environments*.

Datau, S. Y. (2020). Gambaran Kualitas Fisik Udara dan Identifikasi Jamur Udara. *Jurnal Health and Science*, *4*(2).

Dhar, D. G., Dhar, P., Das, A. K., & Uddin, N. (2021). Assessment of Airborne Fungi in Children's Hospital Located in Kolkata (India). *Defence Life Science Journal*, *6*(3), 228–234.

Dillon, K. P., Tignat-Perrier, R., Joly, M., Grogan, S. N. C. M., Larose, C., Amato, P., & Mainelis, G. (2023). Comparison of Airborne Bacterial Populations Determined by Passive and Active Air Sampling at Puy De Dôme, France. *Aerosol and Air Quality Research*, *23*(4).

Dominguez-Moñino, I., Jurado, V., Rogerio-Candelera, M. A., Hermosin, B., & Saiz-Jimenez, C. (2021). Airborne Bacteria in Show Caves From Southern Spain. *Microbial Cell*, *8*(10).

Ekemezie, S. C., Gusen, N. J., Okoye, C. T., & Modibbo, M. S. (2022). Isolation and Identification of Toxigenic *Aspergillus* Species Associated with Sorghum Grains and Locally Brewed Beer (Burkutu) in Bukuru Metropolis of Jos South Local Government Area, Nigeria. *International Journal of Pathogen Research*, *July*, 11–23.

Fan, L., Han, X., Li, L., Liu, H., Ge, T., Wang, X., Wang, Q., Du, H., Su, L., Yao, X., & Wang, X. (2024). Indoor Air Quality of Urban Public Transportation Stations in China: Based on Air Quality Evaluation Indexes. *Journal of Environmental Man agement, 349,* 119440.

Fan, C., Liu, F., Zhao, X., Ma, Y., Yang, F., Chang, Z., & Xiao, X. (2020). An Alternative Comprehensive Index To Quantify The Interactive Effect of Temperature and Relative Humidity on Hand, Foot and Mouth Disease: A Two-Stage Time Series Study Including 143 Cities in Mainland China. *Science of the Total Environment*, *740*, 140106.

Fang, Z., Zhang, J., Guo, W., & Lou, X. (2019). Assemblages of Culturable Airborne Fungi in ATypical Urban, Tourism-Driven Center of Southeast China. *Aerosol and Air Quality Research*, *19*(4), 820 -831.

Farooq, S. B., Sikandar, M. A., Khan, M. H., Qiuhong, Z., Zhu, H., Ullah, N., Noman, M., & Khan, I. U. H. (2023). Effect of Sodium Paraben-based Anti-fungal Agents in Controlling the *Aspergillus Niger* Growth in Cement Mortars. *Journal of Advanced Concrete Technology*, *21*(9), 680 - 694.

Feng, Z. H., & Sun, G. Y. (2020). Advances in The Classification of Alternaria and Related Genera. *J. Fungal Res.*, *18,* 294–303.

Fernández-Iriarte, A., Duchaine, C., Degois, J., Mbareche, H., Veillette, M., Moreno, N., ... & Moreno, T. (2021). Bioaerosols in public and tourist buses. *Aerobiologia, 37, 525-541.*, *37,* 525 – 541.

Frąk, M., Gładyszewska-Fiedoruk, K., Łuniewski, M., & Teleszewski, T. (2024). Microbiological Tests of Air Quality in Car Cabins - Preliminary Tests. *Journal of Ecological Engineering*, *25*(4), 323 - 331.

Friman, M., Gärling, T., & Ettema, D. (2019). Improvement of Public Transport Services for Non - CyclingTravelers. *Travel Behaviour and Society*, *16*(3), 235–240.

García-Mozo, H., López-Orozco, R., Canalejo, C., & Oteros, J. (2020). Indoor Biological Particles in A Train: Comparative Analysis With Outdoor Atmosphere. *Aerobiologia, 36*(3), 481-492.

 DOI:10.22373/ijes.v3i1.7688
ISSN 3046-885X

Guo, K., Qian, H., Zhao, D., Ye, J., Zhang, Y., Kan, H., Zhao, Z., Deng, F., Huang, C., Zhao, B., Zeng, X., Sun, Y., Liu, W., Mo, J., Sun, C., Guo, J., & Zheng, X. (2020). Indoor Exposure Levels of Bacteria and Fungi in Residences, Schools, and Offices in China: A Systematic Review. *Indoor Air*, *30*(6), 1147–1165.

Hadi, M & Alamudi, M. (2019). *Imunodiagnostik Pada Bakteri dan Jamur* (M. Kumalasari (ed.); 1st ed.). Zifatama Jawara. ISBN: 978602 - 5814 - 39- 3.

Harnpicharnchai, P., Siriarchawatana, P., Pumkaeo, P., Likhitrattanapisal, S., Mayteeworakoon, S., Zhou, X., Liang, J., Gafforov, Y., Eurwilaichitr, L., Cai, L., & Ingsriswang, S. (2023). Temporal Dynamics in Diversity and Composition of The Air Mycobiome and Dominant Allergenic Fungi in The Subway Environment. *Environmental DNA*,*(4)*, 1- 24.

Hernandez-ramirez, G., Barber, D., Tome-amat, J., Garrido-arandia, M., Diaz-Perales, A. (2021). *Alternaria* as an Inducer of Allergic Sensitization. *Journal of Fungi*, *7*(10), 1–14.

Hernawati, N. (2022). *Pencemaran Udara dan Implikasinya Pada Anak Jalanan* (R. Fadhli (ed.); 1st ed.).Bandung: PT INDONESIA EMAS GROUP. ISBN: 978 - 623 - 535913 - 7.

Hou, L. W., Giraldo, A., Groenewald, J. Z., Rämä, T., Summerbell, R. C., Huang, G. Z., ... & Crous, P. W. (2023). Redisposition of *Acremonium*-Like Fungi in Hypocreales. *Studies in Mycology, 105,* 23.

Hughes, K. M., Price, D., Torriero, A. A. J., Symonds, M. R. E., & Suphioglu, C. (2022). Impact of Fungal Spores on Asthma Prevalence and Hospitalization. *International Journal of Molecular Sciences*, *23*(8).

Jabeen, R., Kizhisseri, M. I., Mayanaik, S. N., & Mohamed, M. M. (2023). Bioaerosol Assessment in Indoor and Outdoor Environments: A Case Study from India. *Scientific Reports*, *13*(1), 1 -12.

Kasprzyk, I., Grinn-Gofroń, A., Ćwik, A., Kluska, K., Cariñanos, P., & Wójcik, T. (2021). Allergenic Fungal Spores in The Air of Urban Parks. *Aerobiologia*, *37*(1), 39–51.

Kiasat, N., Takesh, A., & Fatahinia, M. (2022). Identification and genetic diversity of Alternaria species recovered from the air of Ahvaz city, the Southwestern part of Iran. *International Journal of Molecular Epidemiology and Genetics*, *13*(2), 24–31.

Kim, J., Han, S. J., & Yoo, K. (2022). Dust-Associated Bacterial and Fungal Communities in Indoor Multiple-Use and Public Transportation Facilities. *Atmosphere*, *13*(9).

Kim, H.-G., Cho, E.-M., Jeon, B.-I., Lee, J.-H., Kim, H.-H., & Kwon, H. (2020). Concentration of Airborne Fungi in Public Transportation During Operation. *Journal of Environmental Health Sciences*, *46*(6), 757 -763.

Latgé, J. P., & Chamilos, G. (2020). *Aspergillus fumigatus* and Aspergillosis in 2019. *Clinical Microbiology Reviews*, *33*(1), 10-1128.

Lam, M. I., Vojnits, K., Zhao, M., MacNaughton, P., & Pakpour, S. (2022). The Effect

DOI:10.22373/ijes.v3i1.7688
ISSN 3046-885X

of Indoor Daylight Spectrum and Intensity on Viability of Indoor Pathogens on Different Surface Materials. *Indoor Air*, *32*((7)).

Lu, Y., Wang, X., Almeida, L. C. S. d. S., & Pecoraro, L. (2022). Environmental Factors Affecting Diversity, Structure, and Temporal Variation of Airborne Fungal Communities in A Research and Teaching Building of Tianjin University, China. *Journal of Fungi*, *8*(5).

Metiner, K., Kekec, A. I., Halac, B., Bagcigil, A. F., Maslak, B., Sivri, N., & Onat, B. (2021). Characterization and Concentration of Airborne Fungi in Public Transport Vehicles in Istanbul. *Arabian Journal of Geosciences*, *14*(21).

Mikszewski, A., Stabile, L., Buonanno, G., & Morawska, L. (2022). The Airborne Contagiousness of Respiratory Viruses: A Comparative Analysis and Implicatio ns for Mitigation. *Geoscience Frontiers*, *13*(6), 101285.

Nageen, Y., Wang, X., & Pecoraro, L. (2023). Seasonal Variation of Airborne Fungal Diversity and Community Structure in Urban Outdoor Environments in Tianjin, China. *Frontiers in Microbiology*, *13*(1).

Nayak, S., Dhua, U., Samanta, S., & Chhotaray, A. (2020). Management of Indoor Airborne *Aspergillus flavus* by Traditional Air Purifiers Commonly used in India. *Journal of Pure and Applied Microbiology*, *14*(2), 1577–1588.

Nuryadi, D. W., Marwahyudi, M., & Hasana, H. T. H. (2021). Desain Interior Bus Penumpang Kelas Ekonomi dengan Konsep Modern Tradisional. *(Doctoral Dissertation, Universitas Sahid Surakarta),* 5 -18.

Odebode, A., Adekunle, A., Stajich, J., & Adeonipekun, P. (2020). Airborne Fungi Spores Distribution in Various Locations in Lagos, Nigeria. *Environmental Monitoring and Assessment*, *192*(2).

Otero, C., Arredondo, C., Echeverría-Vega, A., & Gordillo-Fuenzalida, F. (2020). *Penicillium* spp. Mycotoxins Found in Food and Feed and Their Health Effects. *World Mycotoxin Journal*, *13*(3), 323 -343.

PERMENKES. (2004). *Peraturan Menteri Kesehatan Republik Indonesia No 7 Tahun 2004 Tentang Kesehatan Lingkungan Rumah Sakit*.

Podgórska-Kryszczuk, I. (2023). Biological Control of *Aspergillus flavus* by The Yeast Aureobasidium pullulans in Vitro and On Tomato Fruit. *Plants*, *12*((2),), 236.

Qi, Y., Li, Y., Xie, W., Lu, R., Mu, F., Bai, W., & Du, S. (2020). Temporal-Spatial Variations of Fungal Composition in PM2.5 and Source Tracking of Airborne Fungi in Mountainous and Urban Regions. *Science of the Total Environment*, *708*, 135027.

Roy, S., & Gupta Bhattacharya, S. (2020). Airborne Fungal Spore Concentration in an Industrial Township: Distribution and Relation With Meteorological Parameters. *Aerobiologia, 36* (4), 575 -587.

Rozaliyani, A. (2019). Kadar Kotinin Urin dan CO Ekspirasi pada Perempuan Dewasa yang Terpajan Asap Rokok di Lingkungan Rumah. *Respirologi Indones ia*, *39*(3). 210 - 214.

DOI:10.22373/ijes.v3i1.7688
ISSN 3046-885X

Saad-Hussein, A., & Ibrahim, K. S. (2021). Health Impact of Airborne Fungi. *Handbook of Healthcare in the Arab World,* 1421 - 1435.

Saosa, J. (2022). Association Between Home Characteristics and Occupant's Behaviours and Concentrations of Bacteria, Fungi and Endotoxins. *Journal of Building Engineering*, *45*, 103409.

Sauliene, I., Valiulis, A., Keriene, I., Sukiene, L., Dovydaityte, D., Prokopciuk, N., Valskys, V., Valskiene, R., & Damialis, A. (2023). Airborne Pollen and Fungi Indoors: Evidence from Primary Schools in Lithuania. *Heliyon*, *9*(1).

Ščevková, J., Hrabovský, M., Kováč, J., & Rosa, S. (2019). Intradiurnal Variation of Predominant Airborne Fungal Spore Biopollutants in The Central European Urban Environment. *Environmental Science and Pollution .Research, 26*, 34603–34612.

SenGupta, K., Karmakar, B., Roy, S., Kaur, A., & Gupta Bhattacharya, S. (2023). Analyzing Airborne Fungal Concentration in Kolkata, India: Temporal Distribution, The Effect of Atmospheric Parameters and Health Impact. *Air Quality, Atmosphere & Health*, *16*(5), 963 - 948.

Sham, N. M., Ahmad, N. I., Pahrol, M. A., & Leong, Y. H. (2021). Fungus and Mycotoxins Studies in Hospital Environment: A Scoping review. *Building and Environment*, *193*(11), 107626.

Sivri, N., Dogru, A. O., Bagcigil, A. F., Metiner, K., & Seker, D. Z. (2020). Assessment of The Indoor Air Quality Based on Airborne Bacteria and Fungi Measurements in A Public School of Istanbul. *Arabian Journal of Geosciences*, *13*(24), 1 - 16.

Sio, Y. Y., Pang, S. L., Say, Y. H., Teh, K. F., Wong, Y. R., Shah, S. M. R., Reginald, K., & Chew, F. T. (2021). Sensitization to Airborne Fungal Allergens Associates with Asthma and Allergic Rhinitis Presentation and Severity in the Singaporean/Malaysian Population. *Mycopathologia*, *186*(5), 583–588.

Tellier, R., Li, Y., Cowling, B. J., & Tang, J. W. (2019). Recognition of Aerosol Transmission of Infectious Agents: A Commentary. *BMC Infectious Diseases*, *19*(1), 1–9.

Upadhyay, R. (2023). Impact of Fungi on Indoor Air Quality: Health Hazards and Management Strategies. *Current Status and Future Perspectives, Springer Nature Singapore.*, 623-641.

Wang, H., Gou, L., Lou, Z., Gao, L., Li, R., Zang, Y., ... & Chen, S. (2022). Recent Advances in *Alternaria* Phytotoxins: A Review of Their Occurrence, Structure, Bioactivity and Biosynthesis. *Journal of Fungi*, *8*(2).

Wong, S. S. W., Venugopalan, L. P., Beaussart, A., Karnam, A., Mohammed, M. R. S., Jayapal, J. M., Bretagne, S., Bayry, J., Prajna, L., Kuppamuthu, D., Latgé, J. P., & Aimanianda, V. (2021). Species-Specific Immunological Reactivities Depend on the Cell-Wall Organization of the Two *Aspergillus, Aspergillus fumigatus* and *A. flavus*. *Frontiers in Cellular and Infection Microbiology*, *11*(February), 1–13.

Xin, T. K., Azman, N. M., Firdaus, R. R., Ismail, N. A., & Rosli, H. (2021). Airborne Fungi in Universiti Sains Malaysia: Knowledge, Density and Diversity. *Environmental Monitoring and Assessment*, *193*, 1 -13.

Yang, J., Yi, H., Li, Z., & Ren, C. (2023). Automatic Calibration System of Thermo - Hygrometers. *Journal of Physics: Conference Series*, *2554*(1).

Yang, L., Li, W., Qi, S., Jiang, Q., Huang, N., Yang, Y., Ma, D., Zhang, W., Chen, H., & Zhu, R. (2023). A Survey of Airborne Fungi and Their Sensitization Profile in Wuhan, China. *International Archives of Allergy and Immunology*, *0*.

Zhang, Y., Guo, Z., Zhuo, L., An, Ni., & Han, Y. (2023). Ventilation Strategies for Highly Occupied Public Environments: A Review. *Buildings*, *13*(7), 1-24.

Abbreviation:

CAF	=Culturable Airborne Fungi
CFU/m³	= Colony Form Unit
IAQ	= Indoor Air Quality
PDA	= Potato Dextrose Agar
WIB	=Waktu Indonesia Barat