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Investigation of Microbial Contamination on the Computer Room Floors at the University

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ABSTRACT

Microorganisms such as viruses and bacteria exist in various environments, including the human body, soil, water, and air. They travel easily and are involved in the transmission of various diseases. In a previous study conducted by us, the status of microbial contamination on the floor of a computer room was investigated, and it was speculated that factors such as the number of users and the location of the toilet may have influenced the amount of contamination. The university's computer room was carpeted, and while shoes were not allowed when the previous research was carried out, they were allowed when this study was conducted. Here, a wiping survey was conducted to understand the status of microbial contamination due to differences in the floor surface. The microbial contamination status on floors inside and outside the computer room entrance (carpet on the indoor side and vinyl chloride resin on the hallway side) were compared, as they were adjacent to each other and were areas wherein the number of users was less likely to differ.

1. INTRODUCTION

Infectious diseases are caused by pathogenic microorganisms that invade and multiply within the human body. Many microorganisms, such as bacteria, viruses, and fungi, exist in the environment. Various transmission routes are available for infectious diseases, and contact and droplet infections are thought to be the main routes for the spread of the new coronavirus disease (COVID-19), through which the number of infected people is increasing[1)].

In a previous study conducted by us, the state of the microbial contamination on the floor of a computer room at K University was investigated, and it was confirmed that the degree of contamination varied depending on the date of sample collection, location of the room, and point of use[2)]. One speculation was that the level of contamination on the floor surface may have changed because of factors such as the number of people using the toilet and its relative location. Carpets are commonly used on computer room floors to prevent dust and dirt from adhering to computers and other equipment, run electricity and LAN wiring under the floor, and reduce noise. In the previous research, indoor slippers were used instead of shoes worn outdoors. However, during this study, outdoor shoes were allowed in the computer lab. Thus, the conditions had changed compared to the previous study. Therefore, we questioned whether they were suitable as a learning environment. Only computer rooms with carpeted floors have been studied previously. Therefore, a comparative analysis of the level of contamination of floors made of other materials was not possible. Here, a comparative analysis of the microbial contamination in computer rooms with carpet floors and that with other flooring materials was carried out. This study aimed to understand the status of microbial contamination on the floors of the two computer rooms and an adjacent hallway and the number of general live bacteria, fungi, *Staphylococcus aureus*, *Escherichia coli*, and coliform bacteria present.

2. METHOD

2-1 Outline of the survey target

The survey targets were the floor of the computer room on the second floor of Building A at K University (hereafter referred to as **A**) and the floor of the computer room on the second floor of Building B (hereafter referred to as **B**). Building A had several classrooms, while Building B had a cafeteria, library, etc. A wiping survey was conducted on a 30 × 30 cm area on the adjacent hallway side of the two entrances and exits in each room and inside the

computer room, targeting the left end when viewed from the hallway. A total of eight locations were investigated in each experiment. The front hallway side of **A** is called **a**, the front indoor side of **A** is called **b**, the rear hallway side of **A** is called **c**, and the rear indoor side of **A** is called **d**. The front hallway side of **B** is called **e**, the front indoor side of **B** is called **f**, the rear hallway side of **B** is called **g**, and the rear indoor side of **B** is called **h** (Table 1). For **c** and **d,** a shoe rack was present near the door. Thus, it was not possible to target the edge of the door. Therefore, an area approximately 10 cm away from the edge was used for measurement.

The investigated floors were carpeted indoors, and anti-slip vinyl chloride resin sheets were pasted onto the hallway floors. Walking, entering, and exiting all areas while wearing outdoor shoes was possible. **A** face window and hallway on the left and right, and all windows and doors at the front and back, were open for ventilation when the room was used as a countermeasure against the spread of COVID-19. However, entry and exit from the front were prohibited. **B** had a window on the rear side, and the front and right sides faced the hallway. The windows and the rear door were open when in use; however, the front door was closed due to heavy foot traffic in the hallway. During wiping, a 30 × 30 cm vinyl frame was placed on the floor to enable sampling of the inner corners of any area. After each use, the frames were disinfected by using rubbing alcohol.

2-2 Equipment and water used for cleaning

The sterilized water used in the experiment was prepared as follows: Purified water was produced by distillation (Auto Still WS200; Yamato Scientific, Tokyo, Japan). The water was then treated using an ultrapure water filtration system (RFU414BA; Advantech Toyo, Tokyo, Japan). The ultrapure water was subjected to high-pressure stream sterilization using an automatic laboratory autoclave (MLS-3020-PJ; Sanyo Electric Biomedical, Tokyo, Japan) and an ultrasonic cleaner (DG-1; Iuchi, Osaka, Japan) with an oscillation frequency of 43 kHz. Microorganisms were cultured in an incubator (MIR-154; Sanyo Electric, Tokyo, Japan); fungi were incubated at 25 °C, and the other microorganisms were incubated at 35 °C. A CO_2 manager (TOA-CO2MG-001; Toa, Osaka, Japan) was used to measure the temperature and humidity. Before microbial sampling, measurements were taken from the center of the room, the hallway, and outdoors. A Compact Dry Nissui kit (Nissui Pharmaceutical, Tokyo, Japan) was used to detect microorganisms. After confirming the conditions of use with the manufacturer, a Compact Dry YMR kit was used for yeast and

mold measurements. Sterile cotton swabs (code 06526) from Nissui Pharmaceutical were used to sample microorganisms.

Ultrapure water was prepared as follows: the pure water was exposed to a resistivity of 18 MΩ × cm or more using ultrapure water production equipment and sterilized at 121°C for 20 min in a high-pressure steam sterilizer. Under aseptic conditions, 6 mL of sterile water was dispensed into sterilized 15 mL centrifuge tubes using a micropipette and used for measurement.

2-3 Measurement method

Microbial sampling was conducted by wiping the floor surfaces of the target areas between 7 a.m. and 8 a.m. on 6th June, 11th July, 15th August, 21st September, and 24th October 2022. A sterile cotton swab was moistened using the sterile water in a centrifuge tube, and each measurement location was wiped three times in three different directions, i.e., horizontal, vertical, and diagonal. To prevent bias due to the order of measurement, they were performed in the order **a** → **h** on the first, third, and fifth days of measurement and in the order **h** → **a** on the second and fourth days of measurement. While being careful not to touch the swab with our bare hands, we returned it to a centrifuge tube containing the remaining sterile water (assuming that the amount of sterilized water remained at 6 mL). The centrifuge tube containing the sample was sonicated for 5 min, the microbial suspension was mixed well, and 1 mL of each was spread on the surface of a kit and cultured according to the conditions mentioned. To minimize contamination of components between media, microorganisms were inoculated in the following order: *S. aureus*, *E. coli*, coliform bacteria, fungi, and general live bacteria. To increase accuracy, two people observed each culture medium from the top and bottom to determine the total number of colonies present, and the average value obtained from the measurement results obtained by two people was multiplied by six to obtain the final number of microorganisms on each bed surface. The total number of people using the computer room was determined by observing the computer room usage list present in the room and the number of students in the classroom (Table 2). As usage is not always recorded, there was room for negative error in calculating the exact number of users. Moreover, the temperature and humidity in the computer room, hallway, and outdoors were measured during sampling (Table 3).

3. RESULTS AND DISCUSSION

3-1 Comparison of microbial load based on sampling location

The location with the highest number of live bacteria was **b,** and the location with the lowest number of live bacteria was **f** (Fig. 1). Both **b** and **f** were on the indoor side in front of the room; however, there was a difference in the way the door opened. Both entrances in front of the computer rooms in **A** and **B** were closed to the public, and it is certain that fewer people enter and exit than at entrances in the back. Unlike the front door of **B**, which is closed all day, the front door of **A** is open throughout the day. Because the door was kept open, dirt, such as sand and dust, may have entered from the hallway. Thus, **b** had a relatively large amount of dust and other debris, and many live bacteria were detected.

Regarding fungi, the location with the highest abundance was **c**, and the location with the least abundance was **f** (Fig. 2). Our previous study showed that environmental conditions that make it easier for fungi to be detected are places that people have not used for a long time, have stagnant air, and have dust. We expected less traffic at **c**, as many people were expected to pass by, and more at **f**, where fewer people passed. However, the results varied from our hypothesis, and further investigation is needed to obtain accurate results[3)].

For *S. aureus*, the location with the highest number of microorganisms wash, and the locations with the lowest numbers were **a** and **f** (Fig. 3). *S. aureus* was more abundant in the rear part of **B**, which may be due to the large number of users and slightly higher temperature than **A**.

For *E. coli*, the location with the highest abundance was **b,** and the location with the least abundance was **f** (Fig. 4). Many people were present in **b** because of the toilets installed around **A**, and *E. coli* originates from feces[5)]. Therefore, it is thought that people who used the toilet continued to use **A**, and *E. coli* was transmitted. Moreover, **f** had no people going in or out, and **B** had no toilets nearby. Therefore, this could have led to a lower microbial count.

Similar to *E. coli*, the area with the highest number of coliform bacteria was **b**, and the area with the lowest number was **f** (Fig. 5). Coliform bacteria are widely distributed in human and animal feces and in soil, water, and air[5)] and are thought to be transmitted through the shoes of computer room users.

3-2 Comparison of microbial load based on sampling date

A comparative analysis was performed to understand the difference in the microbial load on different sampling dates, i.e., between 6th June (1st time) and 11th July (2nd time), using the average values of **A** and **B** (Figs. 6 and 7). A decrease in the number of microorganisms, apart from the live bacteria, was observed in the second experiment. The optimal growth temperature for microorganisms, apart from fungi, was around 35 °C. However, the temperature during the second experiment was approximately 4 °C higher than that observed during the first experiment and was closer to the optimal growth temperature. Thus, we expected that the growth of all microorganisms except fungi would increase during the second experiment. As the air conditioner was not functional when the temperature and humidity were measured, it was thought that the air conditioner was being used longer during the second experiment compared to that in the first measurement. Moreover, the temperature inside the room decreases during the day, which could suppress the growth of microorganisms. Only general live bacteria increased during the second experiment; however, a difference of only approximately 1.2× was observed between the first and second tests. Thus, no significant difference was observed. Therefore, further analysis is required to understand the microbial load better. The fungal results obtained were thought to be influenced by the use of air conditioners. The air conditioners in K University's computer rooms were turned on as needed. The air conditioner was used every day in July, when the temperature was comparatively higher than in June. The growth of fungi increases with an increase in the frequency of using the air conditioner repeatedly, as it leads to dampness in the environment. Thus, suggesting that the air conditioner was in use for a long period. This could be a reason for the reduction in the number of fungi observed during the second experiment[6)].

3-3 Comparison by flooring materials

The average value of the four locations on the indoor side with carpet flooring and the average value of the four locations on the hallway side with vinyl flooring commonly used in educational institutions were compared (Fig. 8). The microbial species that were most prevalent indoors were general live bacteria, *S. aureus*, *E. coli*, and coliform bacteria. Only fungi were observed to be more abundant on the hallway side. For general live bacteria, carpets tend to accumulate much dust, and the bacteria that grew in the dust might have been detected. For *S. aureus*, no significant differences were observed. Therefore, it is necessary to

carry out further experiments. For *E. coli*, a 10-fold increase in the number of microorganisms was observed between the hallways and carpets, suggesting that it is easier to accumulate and multiply on carpets than on hallways. Similarly, a 10-fold difference was observed in *E. coli*, indicating that they were more likely to grow on carpets. Fungi were detected more frequently on the hallway side. However, a negligible difference of approximately 1.6-fold was observed. Environmental conditions that favor the growth of fungi include places that have not been used for a long period of time, stagnant air, and dust. Fungi proliferate in places with low activity and decrease in places with high activity.

4. CONCLUSION

Before these results were obtained, we expected that there would be a large difference when comparing the degree of dirt on vinyl chloride hallway floors, as carpets tend to get dirty easily. Once dirt gets stuck, it is difficult to remove. However, no such results were obtained. This may be due to either the fact that the level of contamination remains the same regardless of the floor material or there were differences in the number of passers-by and dirt on the soles of footwear between the computer room and the hallway. However, it was unclear whether K University's current operational methods were appropriate as a learning environment if it was concluded that microbial contamination was more likely to occur if people moved in and out of the classroom with shoes on. They should either change to indoor shoes or stop using carpets. We chose locations in close proximity to each other to ensure that usage conditions were as consistent as possible. However, it is possible that many people walked in the hallway and did not use the computer room. More detailed studies are necessary to clarify this hypothesis.

5. ACKNOWLEDGMENTS

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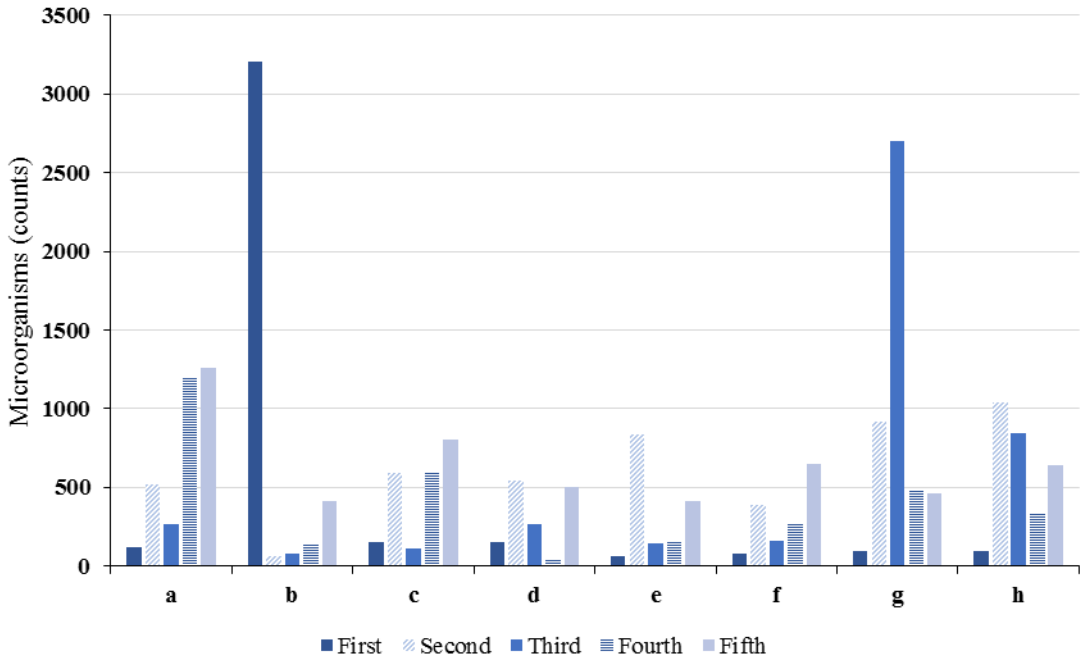

Fig. 1 General live bacteria counts on each floor

First, second, third, fourth, and fifth refer to the sampling times.

A-h refer to the sampling locations.

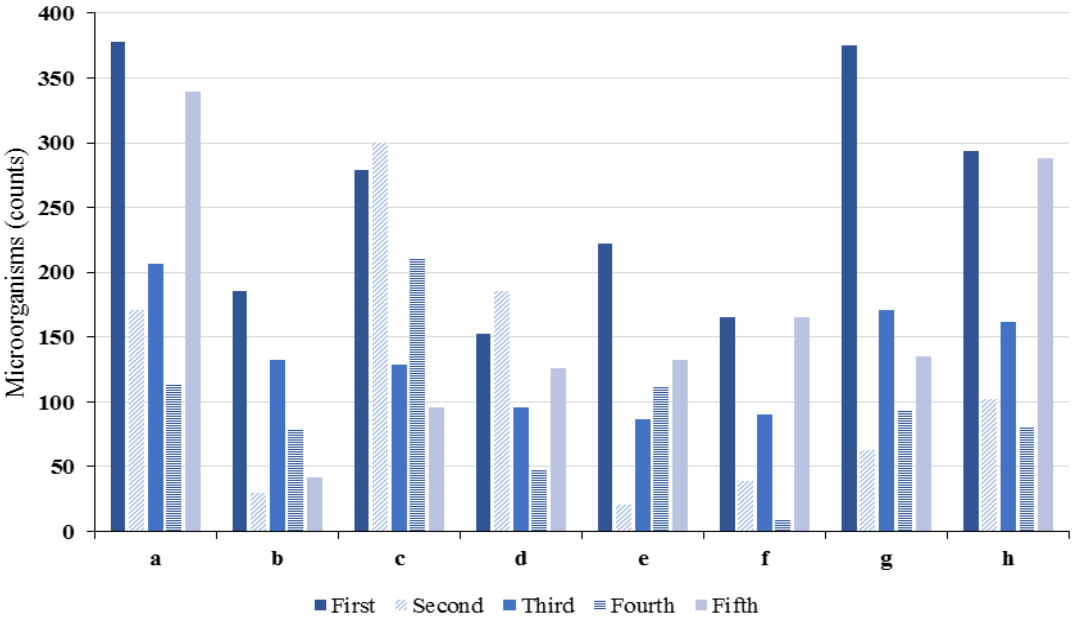

Fig. 2 Fungus counts on each floor

First, second, third, fourth, and fifth refer to the sampling times.

A-h refer to the sampling locations.

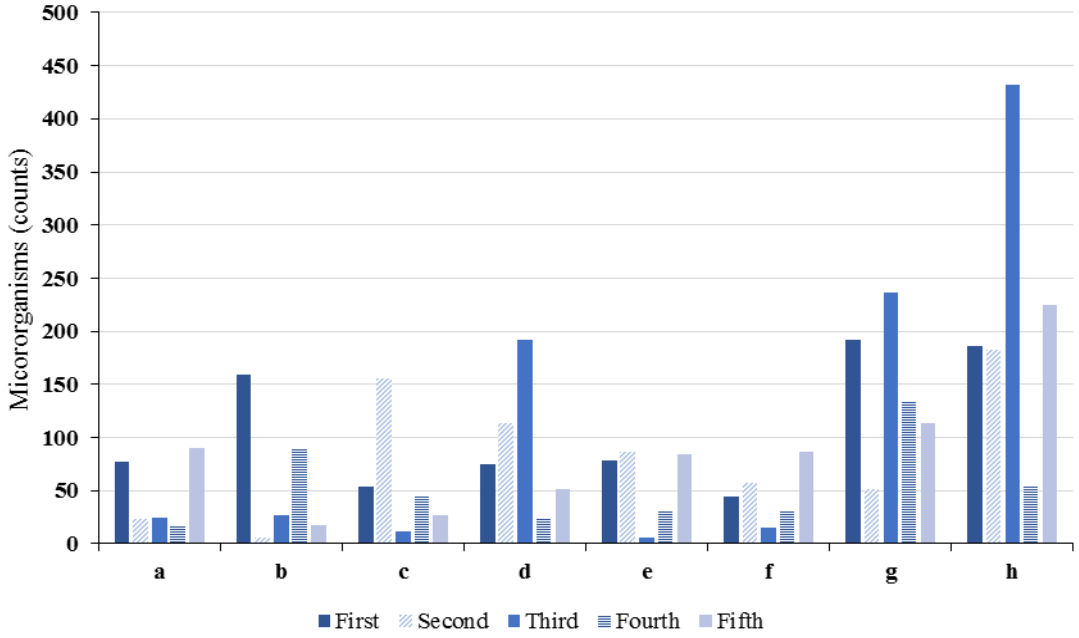

Fig. 3 *Staphylococcus aureus* counts on each floor

First, second, third, fourth, and fifth refer to the sampling times.

A-h refer to the sampling locations.

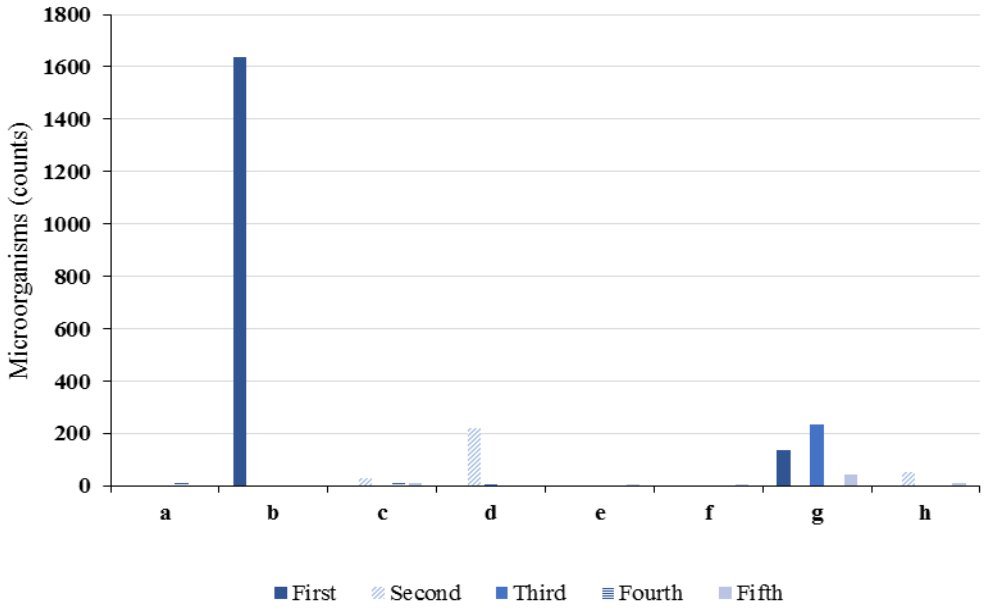

Fig. 4 *Escherichia coli* counts on each floor

First, second, third, fourth, and fifth refer to the sampling times.

A-h refer to the sampling locations.

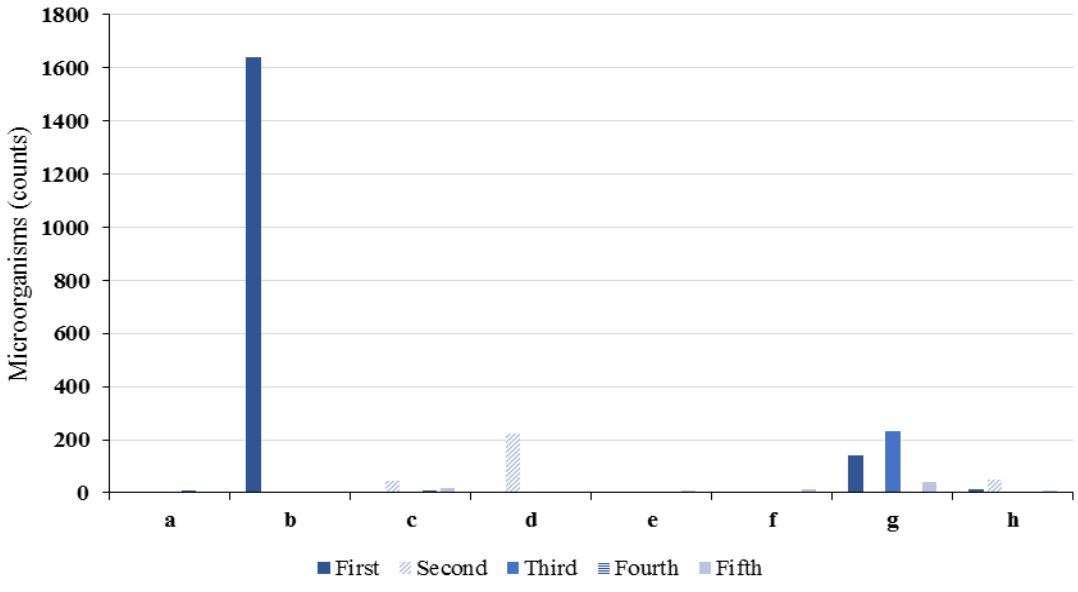

Fig. 5 Coliform bacteria counts on each floor

First, second, third, fourth, and fifth refer to the sampling times.

A-h refer to the sampling locations.

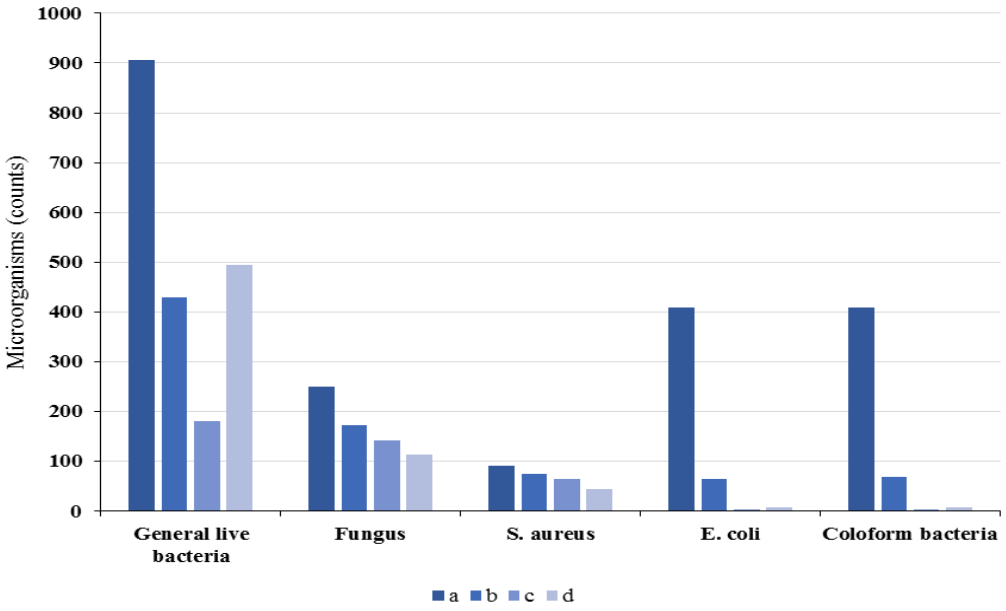

Fig. 6 Comparison by sampling date at A

A-d refers to the sampling locations

Shows the average number of microorganisms from 1st to the 5th time.

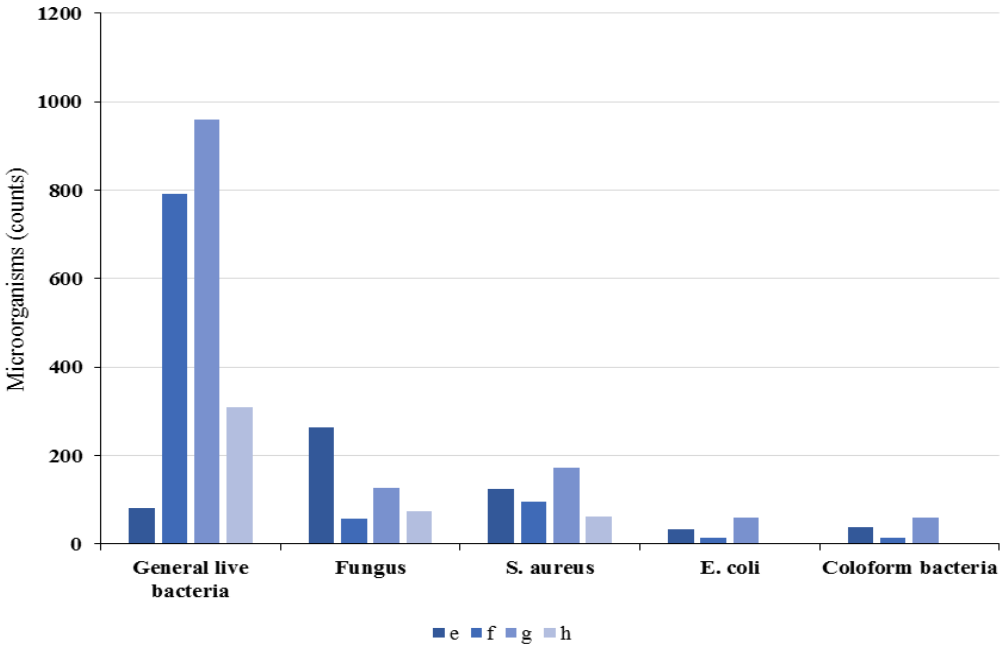

Fig. 7 Comparison by sampling date at B

E-h refer to the sampling locations

Shows the average number of microorganisms from 1st to the 5th time.

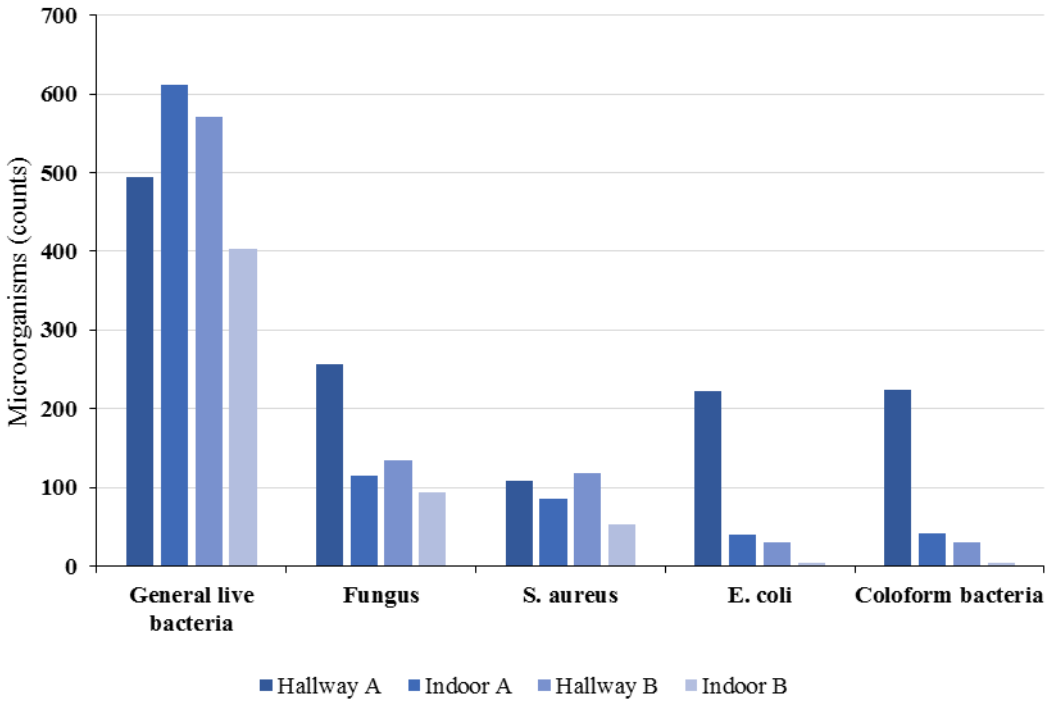

Fig. 8 Comparison of hallway and indoor floors

A and **B** indicate the type of room.

Shows the average number of microorganisms from 1st to the 5th time.

Table 1 Sampling location

Location	Room	Location details	Flooring	Doors and windows
a	A	Front hallway side	I	Door: Always open when in use (the main building is open longer than the common building) Window: Temporarily opened when in use
b		Front indoor side	II	
c		Rear hallway side	I	
d		Rear indoor side	II	
e	B	Front hallway side	I	
f		Front indoor side	II	
g		Rear hallway side	I	
h		Rear indoor side	II	

I, carpet; II, anti-slip vinyl chloride resin

Table 2 Number of students using each room for classes, etc.

Sampling No.	Sampling date	Users survey period	Users		Remarks
			A	B	
1st	June 6	May 2–June 5	555	960	Summer vacation period: August 9 to September 11. Period when hardly used in class: September 12 to October 2.
2nd	July 11	June 6–July 10	547	952	
3rd	August 15	July 11–August 14	449	761	
4th	September 21	August 15–September 20	195	0	
5th	October 24	September 21–October 23	519	177	

The number of users indicates the total number of students using the facility for classes and the number of users outside the class.

The number of students attending classes was calculated based on the list of students enrolled in the course; however, absentees were not included.

The number of users outside the classes was determined from a voluntary list created by the university administration.

As measurements were obtained at intervals of five weeks, the usage status of the classroom before the first measurement was obtained as the number of users for five weeks before the measurement.

Table 3 Temperature and humidity on the sampling day

Sampling No.	Weather at the time of sampling	Sampling location	Sampling order	Temperature (℃)	Humidity (%)
1st	Cloudy	A	1	24.9	60
		A	2	25.1	59
		B	4	24.2	62
		B	5	25.7	58
		Outdoor	3	23.9	64
2nd	Cloudy	A	4	28.4	73
		A	5	28.3	74
		B	1	28.4	72
		B	2	28.9	71
		Outdoor	3	29.7	71
3rd	Sunny	A	1	29.5	74
		A	2	29.8	69
		B	4	31.0	70
		B	5	31.4	68
		Outdoor	3	30.1	75
4th	Sunny	A	4	26.9	45
		A	5	26.9	41
		B	1	26.5	48
		B	2	27.6	42
		Outdoor	3	27.8	38
5th	Sunny	A	1	23.8	48
		A	2	23.7	46
		B	4	23.5	52
		B	5	24.8	43
		Outdoor	3	20.4	51