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Preliminary Study of Indoor Bio-aerosol Evaluation in the Campus of Jinwen University of Science and Technology for Air Quality Management

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Abstract

A field study was carried out in a campus to present the quantitative results of indoor bio-aerosols. Four sites with distinct purpose of use were conducted in this study. The objective was to characterize microbial air quality in the campus of this university located in Taipei. The aerosol concentration of bacteria and fungi were collected and measured by methods of NIEA E301.10C and NIEA E401.10C for air quality management. Four stations, such as the classroom, elevator, meeting room, and toilet with the different activities in the school, were compared and analyzed with the spatial and temporal distribution of bio-aerosols. The bio-aerosol concentration is depended on the ventilation factor for different sites. The results reveal the violation of indoor air quality standards in some sites. It is suggested to conduct a control program to improve the indoor air quality and protect the health of students in the place of worse indoor air quality.

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I. Introduction

The indoor air quality of school campus is important for the public health. Among them the bio-aerosol is the most concerned air pollutant. Microorganisms contained in bio-aerosol, particularly fungi and bacteria, have been shown to be a risk of health for people [1]. Exposure to contaminated indoor air with fungi and bacteria may cause allergy, toxic, and disease [2-4]. Bio-aerosols exist in the limited space of a high-rise building where most people of the city lived in [2-4]. The climate of Taiwan is especially suitable for the production of health-related bio-aerosol as it is warm and humid. It is important to investigate the current conditions of micro-organisms concentration in a building. Environmental Protection Administration (EPA) in Taiwan has already suggested a concentration standard for fungi and bacteria in indoor air quality management. However, few quantitative field studies of ambient airborne microorganism populations have been reported after the announcement of indoor air quality standard by government office. The adequate data to evaluate the hygiene criteria in law is an imperative issue in Taiwan.

This study focuses on the indoor environments of a school campus. The university, Jinwen University of Science and Technology (JUST), is located in the south-eastern direction of Taipei city with about 10,000 students. The microbial background of air quality of four typical sites in the campus was analyzed with the microbial data, and evaluated in May 1, 2010. A pilot study was conducted to investigate the bio-aerosol concentration of JUST for environmental health.

II. Experimental Procedure

The investigating program was designed to determine the average and background levels of airborne particles of specific microbial groups suggest by Taiwan EPA. The effects of sampling location and human activity are the main topic of this study. The bio-aerosols were collected and statistically analyzed herein.

2.1 Air Sampling for Microorganisms The experiment was conducted in JUST. The air samples were collected with the BioStage bio-aerosol sampler. The aerosol concentration of bacteria and fungi were collected and measured by methods of NIEA E301.10C and NIEA E401.10C for air quality management [5]. A SureLock positive seal keeps the jet classification stage and agar plate securely in place and prevents leakage during sampling. The SureLock positive seal prevents air leaks to ensure complete sample integrity and does not depend on spring clamps that wear out or fail. The sampling is as simple as sealing an agar plate inside the BioStage, connecting the impact or to a pump operating at the given flow rate, sampling for two to four minutes, reveal the agar plate, and sending it to the laboratory for further analysis.

Two media, Tryptic Soy Agar (TSA) and Malt Extract Agar (MEA), was used in this study for sampling of bacteria and fungi. These samples were taken under the normal activity condition in four typical locations of this campus. For total bacteria, the cultures plates were incubated at 30˚C, after two days of incubation, plates was examined and the number of colony forming units per cubic meter (CFU/m^3) was calculated. For fungi, the incubation temperature was 20℃, with three days of incubation.

2.2 Material and Instruments A high volume air sampler with single stage impactor was used for sampling. The sampler, BioStage (SKC Inc, USA) applies the inertia impact theory to collect the microorganism in the indoor air, including bacteria, fungi, and actinomycetes.

BioStage was made by three aluminum component, an anti-oxidation inlet hole, impact plate, and jet classification stage. The impact plate consist 400 small precision-drilled holes with 0.22 diameters; the plastic incubation plate collected the air entering through the holes. A sample pump draws air through the sampler where multiple jets of air direct airborne particle toward the surface of the agar collection medium. Two models of BioStage Impactor are available to accommodate two different flow rates.

The air sampling system, QuickTake 30, is a portable air pump, suitable for the flow rate range from 10 to 30 liter per minute. The sampler consist a Li-ion rechargeable battery to ensure an effective operating period ranging from 1 to 999 minutes with eight-time period. This system equipped with the grab sample pump with constant flow from 10 to 30 liter per minute and gives the easy-to-use programmable timers for unattended sampling.

2.3 Quality Assurance and Bio-aerosols Assay UV sterilized the incubation plate, deionized water prior to each run for the purpose of quality assurance and quality control. The number of colonies was carefully counted for each agar plate. Colonies partially overlapped were counted as two separate colonies. The bio-aerosol concentration was calculated based on the sampling volume in CFU/m^3, colony forming units per cubic meter [6].

III. Results and Discussions

The measurement of indoor bacteria and fungi in air were conducted in 1, May 2010. The sampling was carried out sequentially in the four sites for four minutes. During the sampling period, the outdoor temperature range from 22 to 24℃ and relative humidity from 75 to 78 percentages.

The indoor air quality standards (IAQ standard) are suggested by Taiwan EPA [7]. The standards for bio-aerosol level are shown in the below: (1) The total bacteria count must be less than 500 and 1,000 CFU/m^3 for A class and B class, respectively; (2) The total fungi count must be less 1,000 CFU/m^3 only for A class. A class is a special requirement for indoor air quality such as the school, educational place, child recreational place for medical care, place for older people, and place for disabled person. B class is adopted for general public place and office building such as the commercial market, exchange market, exhibition place, office building, ground street market, public transportation, station.

3.1. Sampling Site Description Four sites in the school campus were chosen to be the sampling location of this experiment. At each site, the bio-aerosols were collected under two conditions, the empty space (un-used) and the space in used by students and staff. The surrounding environment and possible bio-aerosol source at each site are described as follows.

Classroom: The classroom with the capacity of 50 students in used is located in the fourth floor. Ventilation condition of this site is very good because it contain the window in both side.

Meeting room: A large meeting room was conducted in this study, and its capacity could be five hundred people to meet together in the same moment. The space is always closed except when there is a meeting held in this place.

Toilet: The toilet of capacity with ten people was conducted, and it’s also located in the fourth floor. Ventilation of this space mainly depends on the only one entrance and the small window in the upper wall.

Elevator: The bio-aerosol concentration in the elevator was measured for different conditions, with five people and without anyone here. The space is always closed except when the door opens for the other passengers to enter in. Thus, the ventilation of elevator is limited.

3.2 Effects of location and utilities The location effect was assessed by comparing data from individual stations. Table 1 lists the results of total bacteria concentration for the four sites. Most of observed results do not meet the indoor air quality standard suggested by Taiwan EPA when people exercised in this investigated place. The total bacteria concentrations of air in the four sites without people use in the spaces were also listed in Table 1. Particularly, the bacteria concentration in meeting room could meet the indoor air quality criteria because of its larger space.

Table 1 Bacteria aerosol counts

Location	Colonies	Filamentous colony	Big colony	Individual colony	Bio-aerosol Concentration CFU/m^3	Meet IAQ
Used (Person in this spaces)						
Classroom	8	9	0	15	1,281	No
Meeting room	50	6	0	53	4,536	No
Elevator	16	0	0	16	1,420	No
Toilet	40	43	0	42	3,571	No
Un-used						
Classroom	16	0	0	16	1,200	No
Meeting room	4	2	0	6	510	Yes
Elevator	8	7	0	15	1,274	No
Toilet	22	6	0	27	2,130	No

Table 2 lists the total fungi concentration in air for the four sites with or without people use. The results of air quality in used reveal that no site can meet the indoor air quality standard for fungal criteria. Except the classroom and toilet meet, the indoor air quality without people use also were disable to accord this criteria. Large meeting room present a low bacteria and high fungi background for air quality. The air conditioner in occupied room also is a possible factor to dominate the dramatic result. Otherwise, no strong associations were found between a station's bio-aerosol concentration and the ventilation of place for bacteria, but fungi. Therefore, the use frequency and behaviors in specific space could affect the local microbial ecology.

Table 2 Fungi aerosol counts

Location	Colonies	Filamentous colony	Big colony	Individual colony	Bio-aerosol Concentration CFU/m^3	Meet IAQ
Used (Person in this spaces)						
Classroom	60	4	1	66	5,524	No
Meeting room	120	0	0	120	10,114	No
Elevator	38	2	1	39	3,166	No
Toilet	140	9	0	140	1,182	No
Un-used						
Classroom	5	2	1	7	566	Yes
Meeting room	18	4	0	22	1,899	No
Elevator	17	1	0	19	1,528	No
Toilet	10	0	0	9	766	Yes

3.3 Effects of human activities In figure 1 and 2, the total bacteria and fungi concentration in air for the four sites were represented and compared, respectively. The human activity induces the rise of bio-aerosol concentration in both types of bacteria and fungi. The number of bacteria increases very rapidly when the meeting room was occupied by the students. The same phenomenon also occurs in the fungi production, included the migration of spore aerosol. It is obviously that the human activity in the room causes the bio-aerosol production in the space, particularly in fungi aerosol. The lower fungi aerosol concentrations of the background air (unused) were observed in both classroom and toilet. The use frequency and the ventilation state could provide a clear environment to avoid fungal contamination.

IV. Conclusion

The concentration of indoor bio-aerosol in the building of a university campus was determined in Taipei, May, 2010. Two types of microorganisms, bacteria and fungi, were distinguished on the bio-aerosols in this study. The space framework and human activities influence the indoor air quality on microbial aerosol were discussed and analyzed. The Indoor Air Quality Management Act will be carried out in Nov. 23, 2012 in Taiwan [8]. Our experimental results show that the most of indoor air quality of campus is not in accordance with the law criteria and the fungal contamination would be a serious problem in Taiwan. This issue would be highlighted for education units and official organizations since the preliminary study.

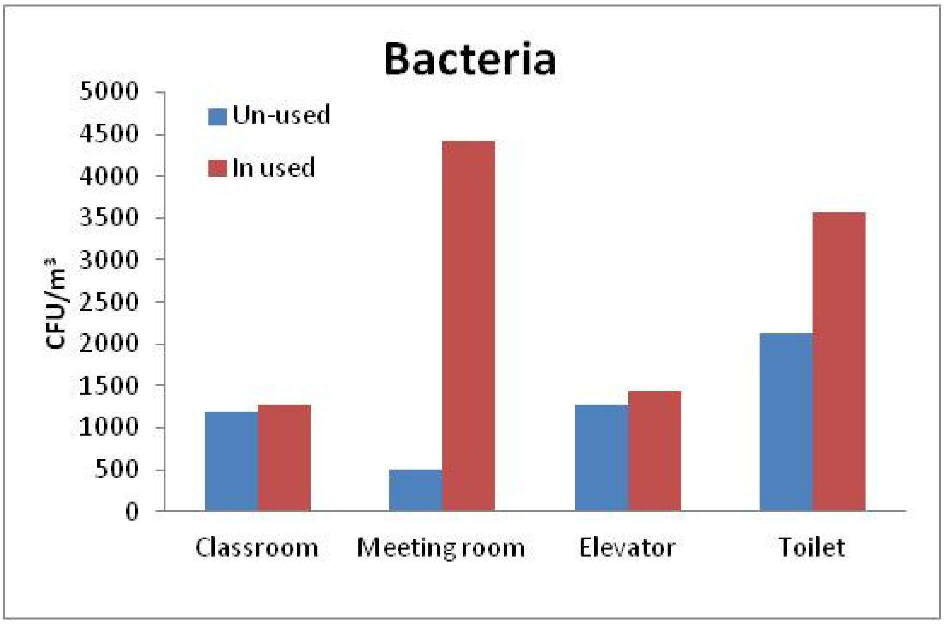

Figure 1 Comparison of total bacteria concentrations in four sites, grouped by the use situations in the space.

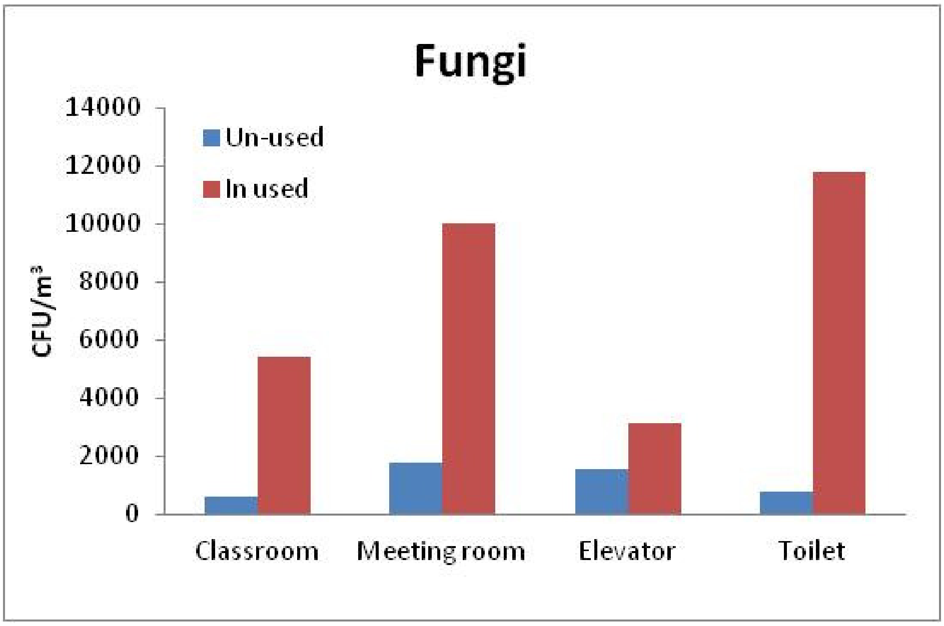

Figure 2 Comparison of total fungi concentrations in four sites, grouped by the use situations in the space.

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校園室內空氣品質管理之生物氣膠評量的初期研究

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摘 要

選擇位於新北市郊區的景文科技大學校園內四個不同標的場域,進行室內生物氣膠的檢測,藉此討論校園之室內空氣品質中的微生物特徵。以 NIEA E301.10C 及 NIEA E401.10C 方法檢測四個地區(分別為校園中的教室、電梯、會議室及廁所)的細菌和真菌之氣膠濃度,以作為空氣品質的管理方法。分析及比較此四個地區的生物氣膠,發現生物氣膠濃度取決於不同地點的通風因素及使用頻率。結果表明,部分空間違反室內環境品質標準。本實驗建議管理階層應正視校園室內之生物氣膠的管控,改善室內空氣品質較差的地區,增進校園室內空氣品質,以保護同學的健康。

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