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A Review of the Bioaerosols in the Air-Conditioners Building

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ABSTRACT
Bioaerosol is one of the sources that influence poor indoor air quality. Most buildings have air-conditioners (A.C.) to cool down the indoor building. However, the microorganism tends to grow, especially on the air conditioner filter, which may cause health problems called sick building syndrome and other bacterial diseases. Besides, temperature variation, relative humidity, and human occupancy in the A.C. building can also influence bioaerosol growth. Staphylococcus and Micrococcus were the most dominant genera detected in the A.C. building worldwide. Therefore, A.C. buildings need periodic services to avoid the spread of bioaerosol growth as it leads to adverse indoor air quality and to maintain human health.

Keywords*: a.c. building, bioaerosol, filter, indoor building, sbs*

I. LITERATURE REVIEW

Bacteria and fungi were among the factors that were significant enough to increase the risk of sick building syndrome (SBS), acute allergies, infectious diseases, respiratory infections, bacterial disease (*i.e.*, Tuberculosis (T.B.), Leprosy, Legionellosis, and Anthrax), fungal disease (*i.e.*, Mycosis and Mycotoxicosis), and viral disease in the indoor air environment (Brągoszewska *et al*., 2018; Kumar *et al*., 2021; Passi *et al*., 2021). The indoor air environment typically consists of 50.5% bacteria and 49.5% fungi (Rajasekar & Balasubramanian, 2011). A bioaerosol is a colloidal suspension formed by liquid droplets and particles of solid matter in the air (Brągoszewska *et al*., 2018). According to Asism *et al*. (2022), the HVAC system needs to be improved as it functions as the respiratory system building in spreading microbial growth.

II. THE FACTORS INFLUENCED THE BIOAEROSOL GROWTH IN HVAC BUILDING

a) The Filter of Air-Conditioning System

It is known that some of the particles from the air cannot be removed by using the air-conditioning filter. The dust particle that has the smallest size from the filter can pass through unhindered. The proliferation of bacteria and moulds was increasingly lively, especially when the filters were excessively wet because it enhanced a conducive environment. Although nowadays, most the air conditioner building are installed the internal filter that can extract microorganisms, the microorganism can still distribute into the indoor air environment due to the in the lacking of operation, the maintenance period, and due temporary malfunctions (Al-Abdalla *et al*., 2019). Brągoszewska *et al*. (2018) found that indoor bioaerosol's indoor-to-outdoor (I/O) was 2.97 in the A.C. offices building. Figure 1 shows an example of the accumulated dust that contains the microorganism on discarded polyester filters before and after cleaning.

Figure 1: The accumulated dust that contains the microorganism on discarded polyester filters before and after cleaning (Al-Abdalla *et al*., 2019).

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(b) Temperature (T) and Relative Humidity (R.H.)

Besides, the variation of T and R.H. also contributed to the growth of bacteria and fungi inside the air conditioning building (Rasli *et al*., 2019). The dampness in the indoor building could cause the proliferation of mould (Zock et al. 2002), which would affect adult asthma. The T would control the rate of water vapour change, the exchange and the viability of the airborne bacteria (Mouli et al. 2005). Figure 2 shows the plot of regression analysis between T and R.H. vs. bacteria and fungi. The plots illustrated a robust positive relationship between T and R.H. vs bacteria and a moderate relationship between T and R.H. vs fungi in the air conditioning mosques (Rasli et al., 2019).

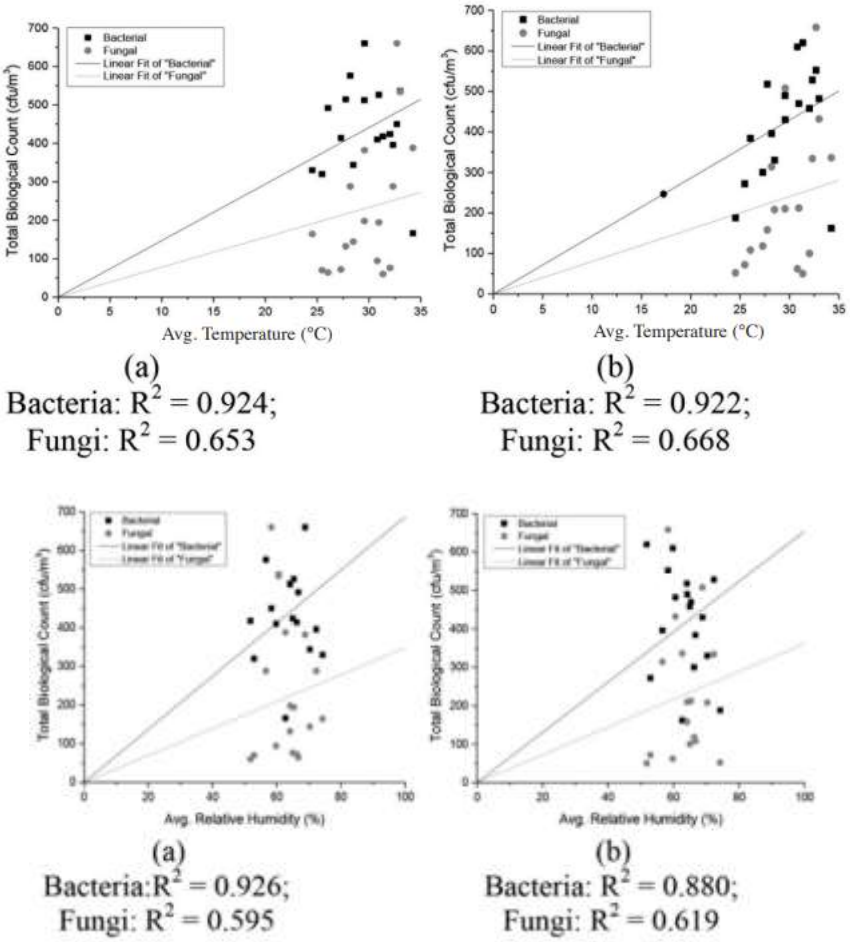

Figure 2: The plot of regression analysis between T and R.H. vs bacteria and fungi (a) before vacuum and (b) after vacuum (Rasli *et al*., 2019)..

(c) Human Activity/Occupancy

Human activity and occupancy can also contribute to bioaerosol emissions into the air (Engvall et al., 2005). The occupants can transport the bioaerosol to the air by the human skin cells, the microorganisms and particulates' ejection from the respiratory tract, and th

e suspended dust particles from the floor surfaces (Goh *et al*., 2000).

(d) The Cause of Bioaerosol Growth in The A.C. Building

Table 1 shows the genera and cause of bioaerosol growth in A.C. buildings worldwide (*i.e*., Italy, Singapore, Poland, Malaysia, South Africa, and Japan). Staphylococcus and Micrococcus were The most dominant bacteria in the A.C. building.

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Table 1: The genera and causes of bioaerosol in air conditioning building worldwide

No.	Genera and Concentration of Bioaerosol	Cause	Country	Author
1.	- Genera: *Staphylococcus* and *Micrococcus* - Concentration: A medium-low level of bacterial contamination (50–500 CFU/m^3)	Probably due to human presence	In the Italian HVAC office building	Bonetta *et al*., (2010)
2.	- Genera: *Staphylococcus, Pseudomonas, Alcaligens, and Corynebacterium, whereas Penicillium, Aspergillus* and *Cladosporium*	Indoor fungal concentration was positively correlated to relative humidity	The food stall in an A.C. student residence hall of the National University of Singapore	Rajasekar & Balasubramanian, (2011)
3.	- Genera: The most isolated bacteria were *Macrococcus equipercicus, Micrococcus luteus D,* and *Staphylococcus xylosus* - Concentration: Bacterial aerosol ranged from 102 to 103 CFU/m^3	Probably due to human activity	A.C. office rooms in the Upper Silesia region of Poland	Brągoszewska, *et al*., (2018)
4.	- Concentration: The bacterial contaminations at 10 out of 17 air conditioning mosques exceeded the limit recommended by Malaysian standards for indoor air quality (500 CFU/m^3).	Influenced by the T and RH (T= 92.3%; RH= 90.3%)	17 A.C. mosques in Pulau Pinang, Malaysia	Rasli *et al*. (2019)
5.	- Genera: *Mycobacterium, Bacillus,* and *Cupriavidus*	HVAC systems are the origin of airborne infections	Two HVAC buildings within the University of South Africa	Sibanda *et al*., (2021)
6.	- Concentration: The bacterial contaminations exceeded the ICOP limit (500 CFU/m^3) at 1000 CFU/m^3 (Point 1) and 1500 CFU/m^3 (Point 2).	Inadequate ventilation as the low air movement (restricted air circulation)	In the A.C. office of the University of Science, Malaysia	Rasli *et al*. (2021)
7.	- Genera: 10 genera of bacteria were detected on the filter surface; six genera were Gram-negative (Pseudomonas, Paracoccus, Acinetobacter, Methylobacterium, Enhydrobacter, and Sphingomonas), and 4 were Gram-positive (Staphylococcus, Corynebacterium, Streptococcus, and Actinotignum)	Influenced by the outside air, ventilation conditions, A.C. unit operating conditions, and occupant activity	In 17 units of AC Japanese Houses	Watanabe *et al*., (2022)

III. CONCLUSIONS

The spreading of bioaerosol into the air would harm indoor air quality in the air conditioning building and have adverse health effects. The factors that could affect microbial growth were included in the filter of the A.C. system, the variation of temperature and relative humidity, and the human occupancy in the A.C. building. Staphylococcus and Micrococcus were The most dominant bacteria in the A.C. building worldwide. Therefore, A.C. buildings need periodic services to maintain good indoor air quality.

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