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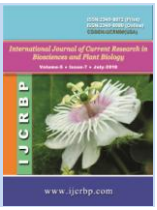

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Physical Condition and Air-Borne Bacterial Count in Air-Conditioned and Non-Air-Conditioned Work Rooms in Faculty of Tarbiyah and Teacher Training Science, IAIN Samarinda

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ABSTRACT

Bacteria are one of air-borne biological pollution sources in work room. Bacterial growth is influenced by various factors, e.g. temperature, humidity and ventilation. Ventilation system is categorized into two types, i.e. natural and artificial using air conditioner (AC). Unmaintained AC will become the source of bacterial growth. The present study aimed to determine the difference between bacterial count in AC room and non-AC rooms as well as to analyze the relation between temperature and humidity and bacterial count. Explanatory research with cross-sectional method was employed. The population of AC work rooms in IAIN's Faculty of Tarbiyah and Teacher Training Science (FTIK) were 9 rooms, while the non-AC 4 rooms. Independent variables in the study were temperature and humidity, while the dependent variable was bacterial count in the air. The results showed that mean bacterial count in AC rooms was 65.55 CFU/m^3, while in non-AC rooms 25.75 CFU/m^3. Temperature measurement showed that the mean temperature in AC rooms was 27.44°C, while in non-AC 31°C. Humidity measurement showed that the mean humidity in AC rooms was 68.78%, while in non-AC 67.25%. Bacterial difference testing in AC and non-AC rooms showed $P = 0.009$, temperature relation test $P = 0.006$, and humidity $P = 0.008$.In conclusion, bacterial count in AC and non-AC rooms is different and there is a significant correlation between temperature and humidity and bacterial count.

Introduction

The level of Indonesia's air pollution is extremely alarming. World Health Organization (WHO) estimates around 400-500 million people, particularly in developing countries, are facing indoor air pollution and it is estimated that around 3 million people die every year where 2.8 million of

which is due to indoor air pollution and the remaining 0.2 million due to outdoor air pollution. According to Egondi et al. (2013), air pollution is when other components, from nature and human activity, directly diffuse in the air and it increase chronic disease risks.

Indoor air quality highly impacts human health because nearly 90% human activities are indoor activities. According to Rosdiana and Hermawati (2015), decreasing indoor air quality is due to several factors, i.e. physical, chemical and biological quality. National Institution for Occupational Safety and Health (NIOSH) from United States of America found that microorganism (biological pollution) is a hazardous indoor pollution source. Schwartz (2006) stated that the pollution can impact on human health, i.e. change in lung function, cardiovascular and asthma attack. According to Hung et al. (2005), microbiological indoor air pollution consists of bacterial and fungal pollutions. Microorganisms or microbes are microscopic organisms that can only be seen under microscope. Microorganisms include bacteria, fungi, virus, protozoa and algae.

According to the Regulation of the Minister of Health of the Republic of Indonesia No. 1077 Year 2011 on Guidelines for Improving Indoor Air Quality, a healthy room is when its indoor air quality free of microorganisms such as pathogenic fungi and bacteria and maximum germ count in the air is <700 CFU/m^3. Microorganisms diffused in room are called bioaerosol. According to Eduart et al. (2012), bioaerosol is a biologically-sourced aerosol particle. The particles are from all organisms and can be diffused into the air through numerous abiotic and biotic mechanisms. In work environment, bioaerosols are mainly fungi and bacteria.

In general, the presence of indoor microorganisms is affected by temperature, humidity, ventilation system and residential density (Stryjakowska et al., 2007). Work rooms condition in IAIN Samarinda's FTIK is one of many rooms considered to be potentially polluted by indoor air pollutant, i.e. air-borne bacteria, due to the huge number of students in the faculty, meaning a lot of students come in and go out of the rooms every day. Therefore, it is very possible that the pollutions come from other places as well as from the room itself because of the building condition and position that make several rooms lack of sunrays and AC installation. Such arrangements lead to high air humidity and the rooms serve as good places for the growth of air-borne bacteria. As such, we were interested to assess the difference between bacterial count in AC and non-AC rooms as well as to analyze the correlation between temperature and humidity and bacterial count in work rooms of IAIN Samarinda's FTIK.

Materials and methods

Population and sample

Population of the study was work rooms in IAIN Samarinda's FTIK. Total population was 13 rooms that consisted of 9 AC rooms and 4 non-AC rooms. Air samples were taken from 4 points of each room, and as such 52 total samples were acquired.

Data collection technique

Data collection technique in this study consisted of temperature and humidity measurement and air sampling using Nutrient Agar (NA) media. Temperature was measured using thermometer and humidity using hygrometer placed in the room. Measurement until the figure shown was stable and direct reading of the scale were carried out.

Microbe sampling was carried out using NA media with settle plant method. Petri dishes containing NA media were placed at 4 spots of each room. The cover glass of the dish was opened for ± 15 minutes and closed again after. Incubation at 36°C for ± 24 hours was followed with laboratory analysis, i.e. counting bacterial colonies growing on the surface of the media.

Data processing and analysis

Data processing in the study was carried out in several steps, i.e., Editing, Coding, Entry,

Tabulating, and Cleaning, while univariate and bivariate analyses were employed as data analysis techniques. Univariate analysis is an analysis that uses variables studied and its data analysis uses minimum, maximum mean deviation and frequency distribution of each study subject that includes independent variables taking form of temperature air quality and air humidity as well as dependent variable taking form of indoor air-borne bacterial count. While bivariate analysis was used to assess the correlation and difference between independent and dependent variables.

Results and discussion

Based on univariate analysis: Physical quality examination of FTIK's staff rooms

Table 1 shows the results of work rooms temperature physical quality examination by AC utilization and mean temperature of AC rooms was 27.44°C while non-AC 31°C. As shown by Fig. 1, deputy head 1 of the faculty room had the lowest temperature (20°C), followed by language major and deputy head 3 of the faculty rooms (26°C), lecturer room (27°C), deputy head 2 of the faculty (28°C), head of the faculty room (29°C), general department, Madrasah Major and Quality control cluster rooms had the same temperature (30°C), library and academic room (31°C), and Islamic Education Major and International special classes (31°C).

Temperature is one of the parameters for bacterial growth. Each bacterium has optimum temperature during which it grows rapidly. Temperature affects bacterial cell regeneration and temperatures unsuitable for bacterial needs can damage the cells (Waluyo, 2009). Environmental temperature that is higher than temperature needed by the bacteria can results in denaturation of protein and other essential cell components, and eventually kills the cell. Similarly, environmental temperature that is below tolerance limit will hinder nutritional transportation because the cytoplasm membranes are no longer in liquid form, and eventually kills the cell's living process (Purnawijayanti, 2006).

Table 1. The results of room physical quality measurement.

No.	Staff room	AC utilization	Temperature (in °C)	Mean temperature	Humidity (in %)	Mean humidity
1	Head of Faculty	AC	29	27.44	69	68.78
2	Deputy Head 1 of Faculty	AC	20		72	
3	Deputy Head 2 of Faculty	AC	28		68	
4	Deputy Head 3 of Faculty	AC	26		67	
5	General Department	AC	30		66	
6	Academic	AC	31		65	
7	Lecturer	AC	27		76	
8	Madrasah Major	AC	30		66	
9	Language Major	AC	26		70	
10	Islamic Education Major	Non-AC	32	31.00	68	67.25
11	Library	Non-AC	31		66	
12	Quality control cluster	Non-AC	30		69	
13	International special classes	Non-AC	32		66	

Based on Table 1, mean humidity in AC rooms was 68.78%, while non-AC rooms 67.25%. As shown by Fig. 2, lecturer room had the highest humidity (76%), followed by deputy head 1 of the faculty room (76%), Language Major (70%), head of the faculty room and Quality control

cluster (69%), Islamic Education Major and deputy head 2 of the faculty (68%), deputy head 3 of the faculty rooms (67%), general department, library, International special classes and Madrasah Major had the same humidity (65%). Out of the 13 rooms examined, lecturer room had the highest humidity (76%) due to several factors, including a lot of furniture in the room such as cabinets containing stacks of books, refrigerator, and sofa, as well as the construction of the room that makes it lack of sunrays and carpet that easily becomes damp.

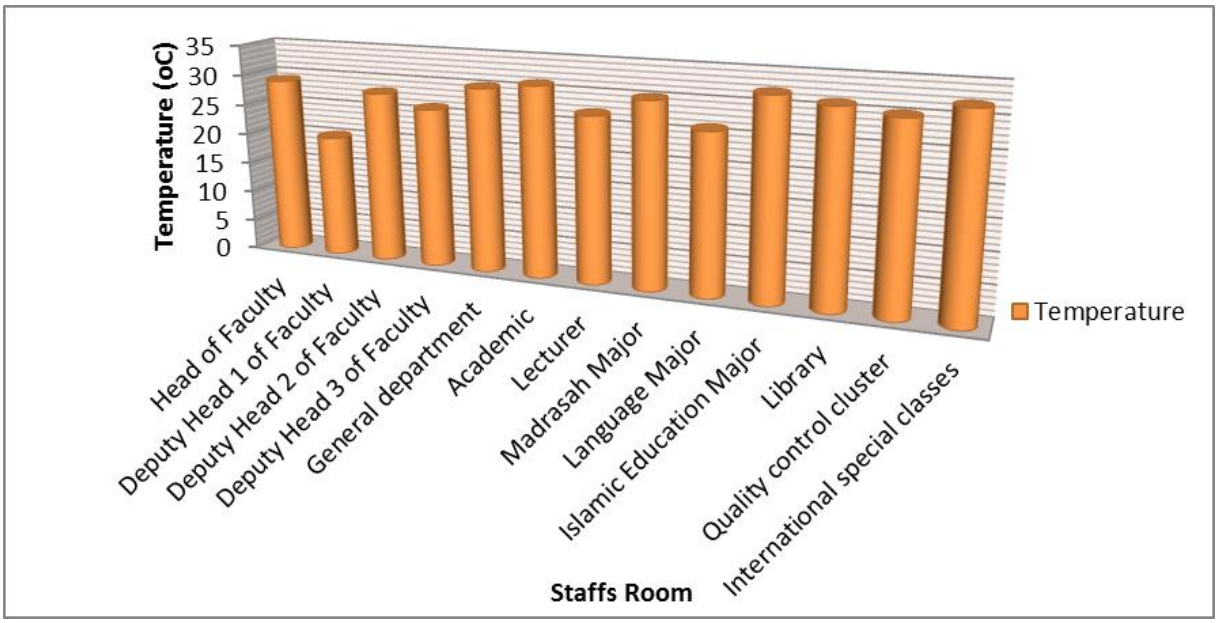

Fig. 1: Physical condition by FTIK work rooms' temperature.

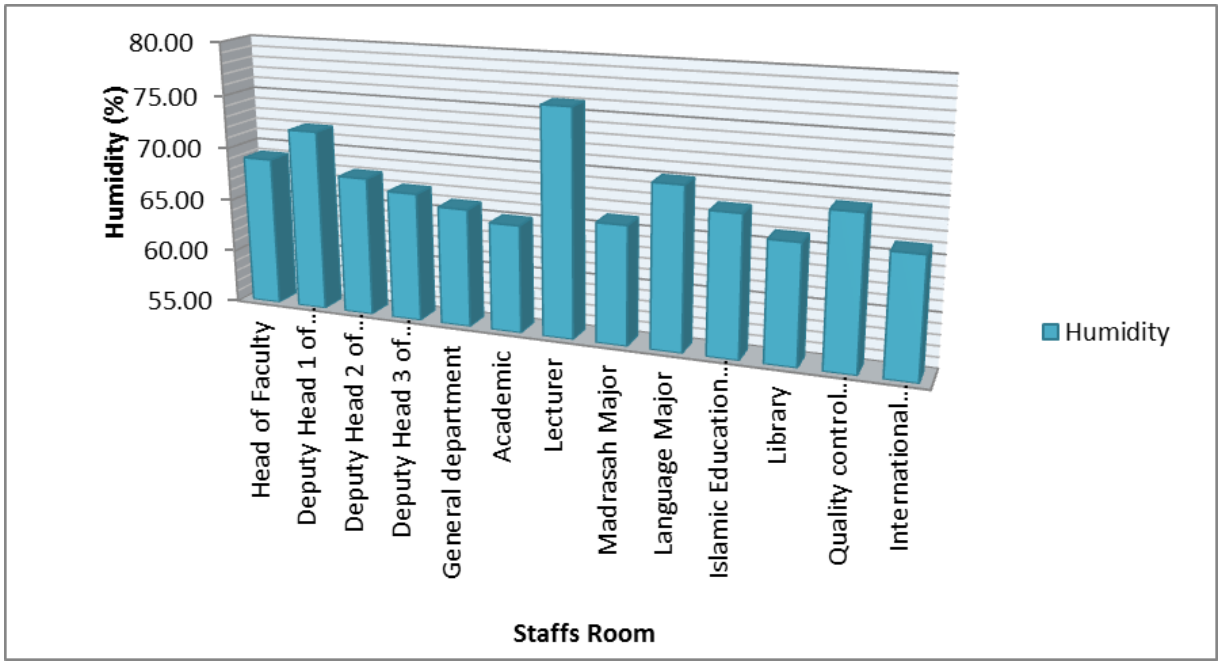

Fig. 2: Physical condition by FTIK work rooms' humidity.

In general, bacterial growth needs high humidity, and the needed humidity is above 85% (Prochazkova and Bezdeckova, 2008). According to Fitria (2008), high air relative humidity can

increase the growth of microorganisms. The low level of humidity may result in the reduction of moisture in the protoplasm that may stop the metabolic activity. Following the result of examination on physical quality of FTIK's work room, descriptive analysis was carried out, as shown in Table 2. Table 2 shows that minimum temperature of the examined room was 20°C and maximum temperature of which 31°C; and minimum humidity was 65% and maximum humidity 76%. Based on threshold values set in the Decree of the Minister of Health of the Republic of Indonesia No. 1405/Menkes/SK/ XI/2002 (Kepmenkes, 2002), 5 out of the 13 FTIK work rooms examined met temperature threshold, and the remaining 8 rooms had yet to meet temperature threshold; and all the 13 working rooms did not meet humidity threshold.

Table 2. Descriptive analysis on the result of rooms' physical quality measurement.

No.	Physical parameter	Minimum value	Maximum value	Mean	Threshold value	Note			
						Qualified		Unqualified	
						n	%	n	%
1	Temperature	20°C	32°C	28.61°C	18°C - 28°C	5	38.5	8	61.5
2	Humidity	65%	76%	68.30°C	40%-60%	-	0	13	100

Examination of bacterial colony count

Based on laboratory examination result, it was shown that bacterial count in AC rooms ranged from 34 CFU/m^3 to 128 CFU/m^3 with mean bacterial count 65.55 CFU/m^3, while non-AC rooms ranged from 18 CFU/m^3 to 36 CFU/m^3 with mean bacterial count 25.75 CFU/m^3 (Table 3).

Univariate analysis on the colony count examination showed that the minimum colony count was 18 CFU/m^3, and the maximum count was 128 CFU/m^3. Based on threshold values set in the Decree of the Minister of Health of the Republic of Indonesia No. 140/Menkes/SK/ XI/2002, maximum colony count in the rooms is 700 CFU/m^3 and it means that colony count of all 13 FTIK's work rooms met the threshold.

Table 3. The result of bacterial colony count examination in FTIK's work rooms.

No.	Staff rooms	AC utilization	Counting result	
			Mean colony count (CFU/m^3)	
			Each room	By AC utilization
1	Head of Faculty	AC	50	65.55
2	Deputy Head 1 of Faculty	AC	83	
3	Deputy Head 2 of Faculty	AC	64	
4	Deputy Head 3 of Faculty	AC	71	
5	General Department	AC	46	
6	Academic	AC	38	
7	Lecturer	AC	128	
8	Madrasah Major	AC	34	
9	Language Major	AC	76	
10	Islamic Education Major	Non-AC	28	25.75
11	Library	Non-AC	21	
12	Quality control cluster	Non-AC	36	
13	International special classes	Non-AC	18	

Based on bivariate analysis

Prior to being examined statistically, normality test was carried out on the data. The result of data normality test using Shapiro-Wilk is shown in Table 4. Based on the table above, the result of normality test for variable temperature showed *P*-value of 0.033 and for variable humidity *P*-value 0.037, and it was concluded that because *P*-value ≤ 0.05 for both variables, the distribution was abnormal; while bacterial count normality test showed *P*-value ≥ 0.05 (i.e., 0.159) and therefore normal distribution. According to bacterial counting result, mean bacterial count in AC room was 65.55 CFU/m^3 and in non-AC 25.75 CFU/m^3. The result of difference test using Mann-Whitney test showed *P*-value of 0.009 (< 0.05) and it was concluded that there is a difference between bacterial count in AC and non-AC rooms, and hypothesis was accepted.

Table 4. The result of normality test using Shapiro-Wilk.

No.	Variable	*P*-value	Conclusion
1	Temperature	0.033	Abnormal distribution
2	Humidity	0.037	Abnormal distribution
3	Bacterial count	0.159	Normal distribution

According to researcher, that was because in AC rooms there were several AC units that were not optimally working. This was also because the doors of several AC rooms were always left open and allowed air-borne contamination in from outside the room.

According to interview result with several FTIK staffs, it was revealed that AC unit cleaning in the rooms was not regularly carried out. AC unit cleaning and maintenance was carried out when there was a report of AC unit failure. Utilizing unmaintained AC unit in a room will make it a bacterial reproduction place because dirty AC filter makes the air from the room will be re-circulated into the room.

According to Chairinnisa (2010), there are lots of misconceptions that AC utilization is capable of generating air circulation in a room. However, the fact is AC unit only makes the indoor air become cooler. This statement was supported by Satwiko (2009) who stated that the air circulation in AC room tends to be closed circulation and such condition is capable of preventing pollutants from outside the room to enter in as well as preventing pollutants from inside the room to go out, and therefore it leads to unhealthy indoor air.

Correlation between temperature and bacterial count

Based on room temperature measurement, it was known that mean temperature in AC room was 27.44°C and in non-AC room 31°C. The result from Rank Spearman test showed that *P*-value was 0.006 (<0.05), meaning that there is a significant correlation between temperature and bacterial count. Correlation coefficient between room temperature and bacterial count was r = -0.714, meaning that the correlation is strong with negative correlation direction. This showed that the higher room temperature led to fewer bacterial counts in the room, and the hypothesis was accepted. The data is shown in the Fig. 3.

Fig. 3 shows the correlation between temperature and bacterial count. The result of IAIN Samarinda's FTIK work rooms' temperature measurement according to the figure was 20-32°C and based on the Decree of the Minister of Health of the Republic of Indonesia No. 1405/Menkes/SK/ XI/2002 the temperature was still an optimum temperature needed by bacteria. According to Waluyo (2009) each bacterium has optimum temperature during which bacteria grow rapidly. By optimum temperature, microorganisms are classed

into three groups, i.e., psychrophile (organisms whose optimum growth at 20°C), mesophile (organisms whose optimum growth at medium temperature 20-45°C), and thermophile (organisms whose optimum growth at above 45°C). Naddafi et al. (2011) reported that room with temperature of 25-28°C has higher concentration of pathogenic fungi compared to room with temperature of <25°C because the former is closer to human body temperature.

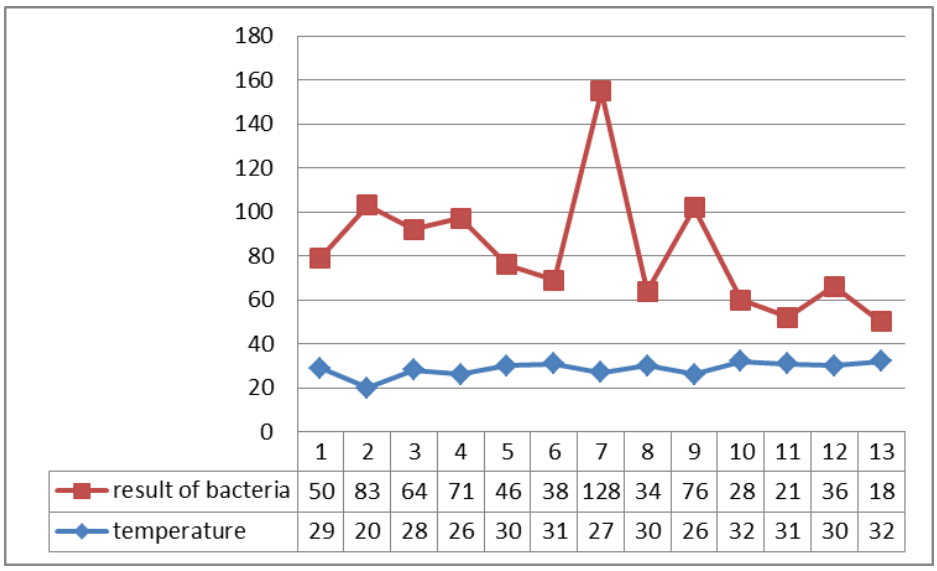

Fig. 3: Correlation between room temperature and bacterial count.

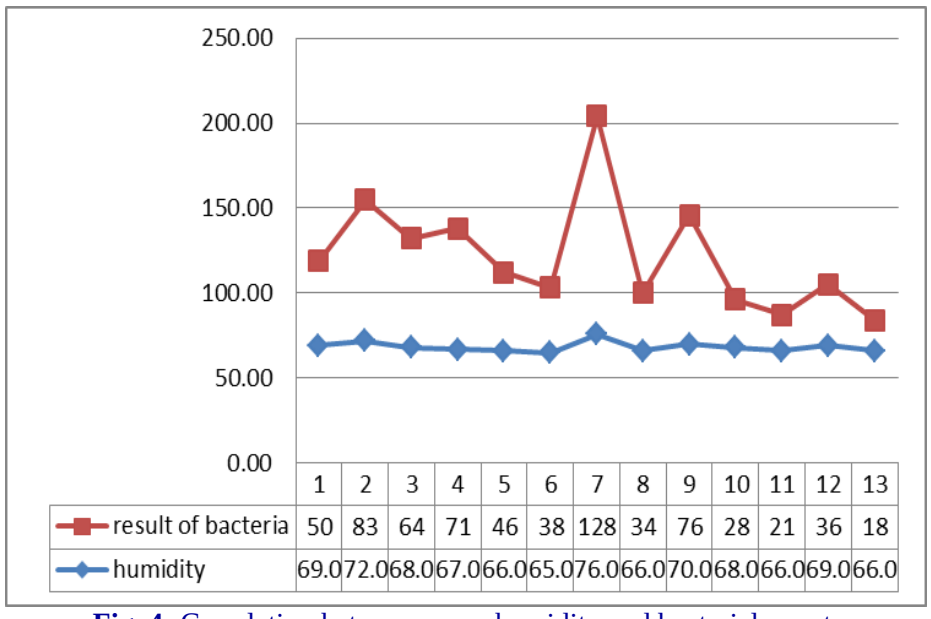

Fig. 4: Correlation between room humidity and bacterial count.

According to the researcher, there is a possibility that several other factors that weren't examined in this study can become the source of bacterial growth in IAIN FTIK work rooms, including room cleanliness, several book shelves and book stacks in the room, as well as rooms' curtain that makes it easier for the dust to stick and it is difficult to clean. According to Prasasti et al. (2005), bacteria in the rooms are generally carried out by the air alongside dusts, meaning that more furniture in the room more likely brings in more bacteria. There are six sources that affect room temperature, i.e. utilization of biomass

fuel, unqualified ventilation, settlement density, building's material and structure, geographical and topographical conditions (Frick et al., 2008).

Correlation between humidity and bacterial count

Based on humidity measurement, it was known that mean humidity of AC rooms was 68.78%, while non-AC was 67.25%. The result from Rank Spearman test showed that *P*-value was 0.008 (<0.05), meaning that there is a significant correlation between humidity and bacterial count. Correlation coefficient between room humidity and bacterial count was r = 0.701, meaning that the correlation is strong with positive correlation direction. This showed that the higher room humidity led to higher bacterial count in the room, and the hypothesis was accepted.

Fig. 4 shows that there is a relation between humidity and bacterial count. The result is in line with Vidyautami et al. (2013) who stated that in work room there is a significant correlation between humidity and bacterial count. Compared to temperature and light intensity parameters, the more affecting parameter against microbial count is humidity. According to researcher, the increasing humidity of FTIK work room was due to the carpet cleanliness and building construction. Carpet easily becomes damp and it can affect bacterial growth in the room. According to Fitria et al. (2008), humidity sources in a room includes bad building construction such as floor, wall that is not water resistant and lack of lighting, both artificial and natural lightings. Air's high relative humidity increases microorganism growth.

Conclusions

Based on the results of the research, following conclusions were drawn.

1. In 13 work rooms that consist of 9 AC rooms and 4 non-AC rooms, there is a different mean bacterial count between AC room (65.55 CFU/m^3) and non-AC (25.75 CFU/m^3).
2. There is a significant correlation between room temperature and bacterial count, i.e., higher room temperature leads to lower bacterial count in the room.
3. There is also a significant correlation between humidity and bacterial count, i.e., higher room humidity leads to higher bacterial count.

Conflict of interest statement

Authors declare that they have no conflict of interest.

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