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Analysis of Microbiological Air Quality Based on Fungal Count as Parameter in Working Rooms of "X" Hospital in Balikpapan

Khusnul Khotimah* and Dwi Nur Aini Dahlan

Lecturer Staff, Teacher Training Science Program, Samarinda 75251,
East Kalimantan, Indonesia
*Corresponding author:

A B S T R A C T

Air quality in hospital working room has to be paid attention to because patients are prone to disease, in addition to avoid cross contamination. One of air pollution indicators in room is fungi. This study aimed to determine air quality based on fungal count in working rooms of "X" hospital and correlate it with air environment factor values (Total Suspended Particles/TSP, temperature, and humidity). Fungal sampling from the air was carried out using Midget Impinger containing 0.9% NaCl with three (3) replications, prior to planting in PDA media and colony counting using Colony Counter. The result indicated that the physical air quality relatively belonged to high category with the highest TSP 0.78 mg/m^3 (RD) (50.35%), the highest temperature 28°C (RD) (22.31%), and the highest humidity 95% (RR). According to Decree of the Ministry of Health of the Republic of Indonesia No.1405/ MENKES/SK/XI/2002, fungal count in the working rooms met the standard<700 CFU/m^3, meaning that there was no correlation between fungal count and temperature, humidity, and TSP. However, fungal exposure in the air of "X" hospital rooms is to be paid attention to, i.e. by keeping humidity maximum 45-60% and pay attention to people density in the working room.

Introduction

Hospital is a whole part, integrity of organizational and medical aspects, serving comprehensive health service to community, both curative and rehabilitative, where the output of the service covers family, environment, and hospital also training center for health officers and biosocial study (WHO, 2009).

One of the causes for cross contamination in hospital building is air. According to Wijayanti (2007), the source of pollution affecting air quality relates to the building construction, temperature, humidity, air exchange and human activity. According to Miller *et al.,* (2005), microbiological air pollution consists of fungi and bacteria. Fungi are the most important indoor air pollutant, however they are less understood. Fungi exist in nature and the spores of which are abundant in air, dust, and water. According to Cabral (2010), fungi are also indoor air bio-indicator. Fungi can lead to diseases in human and very important as pathogen sources. Spengler *et al.,* (2001) stated that according to laboratory study, biotic and abiotic factors are capable of affecting the growth and reproduction of fungi. Abiotic factors are

among other water, temperature, nutrients (carbon, nitrogen, sulfur, and various macro- and micro-elements), pH, light, carbohydrate, and oxygen pressure; while biotic factors cover interaction between other organisms that relate to fungi community, such as antagonism, competition, predation, and parasitism.

Health effects from fungi air pollution are among other allergy reaction, irritation, and infection. Risk from particular exposure can be significant in long term, especially individuals with prone health condition, such as having asthma, immune system, or allergy (Eduard, 2009). This statement is in line with Haisley and Wong (2002) who stated that factors for possible fungal exposure in an individual indoor are the nature of the fungi (allergy, intoxication, or infection), level of exposure (amount and duration), community vulnerability that varies according to genetic, age, health condition, time of exposure, and sensitivity tendencies. According to the abovementioned rationales, it is important to carry out study on microbiological air quality analysis based on fungal count in working rooms of "X" hospital. This study is very important because air is one of transmission media for microbes responsible for human infection.

Materials and Methods

Population and sample

Population in this study is air composition of "X" hospital working rooms. Air samples were taken in five (5) points, i.e. waiting room, inpatient room, kitchen, recovery room, and meeting room, each with four (4) replications. Total samples acquired were 24.

Air microbe sampling

Impinger was filled with 10 mL 0.9% NaCl and covered tight, leaving no bubble, prior to sterilization at 121 °C for 15 minutes. Impinger was then put in Impinger body and attached to flow meter (speed 2 L per minute) for 30 minutes prior to laboratory analysis.

Laboratory analysis

A total of five (5) petri dishes were prepared; 1 ml sample (a, b, c, and d) was added into four (4) petri dishes with the exception of 5th petri dish (e = control). Into each petri dish, 1 ml 0.9% sterile NaCl and 10-15 ml PDA media were added prior to incubation for 48 hours at 35 °C using incubator. Growing colony was then counted using colony counter.

$$R \text{ (Colony/ml)} = \frac{(a-e)+(b-e)+(c-e)+(d-e)}{4}$$

$$JK = \frac{R \times V \times 1000/M^3}{Q \times t}$$

Note:

JK	= Microbe count
R	= mean of colony count
V	= saline solution (ml)
Q	= air flow discharge (L/minute)
t	= sampling duration (minute)
a-d	= microbe count in petri dish 1st-4th, containing sample a, b, c, and d
e	= microbe count in petri dish 5th (control, e)

Measurement of Total Suspended Particles (TSP)

Filter paper was heated in oven at 100 °C for ±60 minutes and put in desiccator (±10 minutes). After cooling down, the paper was taken out and immediately weighed (initial weight). The filter paper was then put in filter holder for 30 minutes and the air flow speed was set using flow meter. The paper with sample was then heated again in oven at

100°C for ±60 minutes and cooled down in desiccator for ±10 minutes prior to weighing with the filter paper (final weight)

Suspended Particles =

$$\frac{filter\ final\ weight - filter\ initial\ weight}{Q\ x\ t} = .mg/m^3$$

Note:
Q   = mean of sucked air volume (L/ minute)
t   = sample time (minute)

Measurement of temperature and humidity

Temperature was measured using thermometer and humidity using hygrometer where both tools were put on the rooms' wall. The measurement was carried out until the figures showed stable figures. Direct data reading was employed.

Data analysis

Data analysis employed in this study was descriptive data analysis. Results of fungal colony counting in this study are presented in chart and table.

Results and Discussion

Air quality analysis based on TSP, temperature and humidity

Air physical quality can affect microbiological air quality through the growth factor and microbe movement pattern. Air physical quality is among others TSP, temperature and humidity. Table 1 and figure 1 show the result of indoor air quality measurement, including TSP, temperature and humidity parameters.

According to the results, among the five (5) sampling rooms the highest TSP was 0.78 mg/m^3 (RD) (50.35%), followed with 0.30

mg/m^3 (RRI) (21.58%), 0.21 mg/m^3 (RR) (15.10%), 0.14 mg/m^3 (RP) (10.79%), and 0.03 mg/m^3 (RT) (2.15%). According to Decree of the Ministry of Health of the Republic of Indonesia No.1405/ MENKES/SK/XI/2002, maximum allowed TSP in room is 0.15 mg/m^3, meaning that the TSP in the rooms of "X" hospital was relatively high. One of the factors influencing such high TSP is high human indoor activity. According to Obbard and Fang (2003), physical closeness and interaction between human and fungi in the air is higher than that of in soil and water. Therefore, high TSP leads to relatively high fungi amount found.

According to temperature, among the five (5) sampling rooms the highest temperature was 28°C (RD) (22.31%), followed with 26.5°C (RRI) (21.11%), 25°C (RT&RP) (19.92%), and 21°C (RR) (16.73%). According to Decree of the Ministry of Health of the Republic of Indonesia No.1405/ MENKES/SK/XI/2002, standard temperature in working room is 18-26°C, meaning that the temperature in the rooms of "X" hospital was relatively high. Naddafi *et al.,* (2011) reported that 25-28°C rooms have higher concentration of pathogenic fungi compared to <25°C room because the former is closer to human temperature. Fungi spores are more resistant against high temperature compared to mycelia and they generally survive at higher range temperature (Spengler *et al.,* 2001; Gutarwska and Piotrowska, 2007; Flannigan, 1997). Therefore, the ventilation system and air temperature control of rooms in "X" Hospital have to be paid attention to.

According to humidity, among the five (5) sampling rooms the highest humidity was 95% (RR), followed with 91% (RP), 88% (RRI), 84% (RD), and 83% (RT). According to Decree of the Ministry of Health of the Republic of Indonesia No.1405/ MENKES/SK/XI/2002, standard humidity in

working room is 40-60%, meaning that the humidity in the rooms of "X" hospital was ideal for fungi growth and this fact was one of the causes for high fungal concentration in the rooms of "X" hospital. Such result was in accordance with study conducted in 420 buildings in Sweden by Wessen *et al.,* (2002) who stated that 65% buildings that faced indoor humidity problems had microorganism emission in the air of the rooms. In addition, study by Flannigan *et al.,* (2001) showed that increase in air humidity increases fungal concentration in the air.

According to Mandal and Brandl (2011), the main factor for fungi growth and distribution in the rooms of a building is humidity because fungi can be transferred from a material surface into indoor air when the air reaches humidity needed by the fungi. Humidity in substrate, including in the air, is one of the main factors for fungi growth. In general, most of fungi are capable of growing in humid environmental condition. In addition, water is also the other important factor. Water makes up diffusion and digestion process. In addition, water also affects substrate pH and osmolarity and is the source of hydrogen and oxygen which are required during metabolism process. The growth of a fungi is determined by a_w, i.e. substrate's water content (Spengler *et al.,* 2001; Prescoot 2002; Miller, 2000).

Air quality analysis by fungal count

Indonesia has a regulation on indoor air quality, i.e. Decree of the Ministry of Health of the Republic of Indonesia No.1405/ MENKES/SK/XI/2002 stating that maximum allowed fungi and bacteria is 0 CFU/m^3, while allowed microbial count is less than 700 CFU/m^3. See Table 2 and Figure 2 for the fungal colony count in the working rooms of "X" hospital. According to fungal count, among the five (5) sampling rooms the highest fungal count was 250 CFU/m^3 (RT) (29%), followed with 166 CFU/m^3 (RR, RRI & RD) (19%), and 125 CFU/m^3 (RP) (14%). According to Decree of the Ministry of Health of the Republic of Indonesia No.1405/ MENKES/SK/XI/2002, the five (5) sampling rooms were still below the threshold, indicating that the air quality in the rooms of "X" hospital was good. However, such data had no correlation with humidity (>60%). According to Fabian *et al.,* (2005), literature and standard regulation on indoor bioaerosol (<700 CFU/m^3) are still limited and yet to be agreed upon together. For instance, American Conference of Governmental Industrial Hygienists (ACGIH) considers<100 CFU/m^3 is the threshold for fungi; while Health and Welfare Department in Canada considers 150 CFU/m^3 with many species is a normal condition and 50 CFU/m^3 in a fungi species is considered require immediate investigation.

Table.1 Air quality in working rooms based on TSP, temperature and humidity

Air Parameter	A	B	C	D	E	Standard
TSP	0.21 mg/m^3	0.03mg/ m^3	0.30 mg/m^3	0.78 8mg/m^3	0.14 mg/m^3	0.15 mg/m^3
Temperature	21°C	25°C	26.5°C	28°C	25°C	18-26°C
Humidity	95%	83%	88%	84%	91%	40- 60%

Note:A = meeting room (RR); B = waiting room (RT); C = inpatient room (RRI); D = kitchen (RD); and E = recovery room (RP)

Table.2 Total fungal colony in the working rooms of "X" hospital

No.	Treatment	∑ Fungal Colony Count	Fungi Species	Threshold CFU/m^3*
1	A	166 CFU/m^3	*Rhizopus* spp. *Aspergillus* spp.	700
2	B	250 CFU/m^3	*Rhizopus* spp. *Aspergillus* spp. *Cladosporium* spp. *Penicillium* spp.	700
3	C	166 CFU/m^3	*Rhizopus* spp. *Aspergillus* spp.	700
4	D	166 CFU/m^3	*Rhizopus* spp. *Aspergillus* spp. *Cladosporium* spp.	700
5	E	125 CFU/m^3	*Aspergillus* spp.	700

Note:

A = meeting room (RR); B = waiting room (RT); C = inpatient room (RRI); D = kitchen (RD); and E = recovery room (RP).

*: Standard According to Decree of the Ministry of Health of the Republic of Indonesia No.1405/ MENKES/SK/XI/2002

CFU: Colony Forming Unit

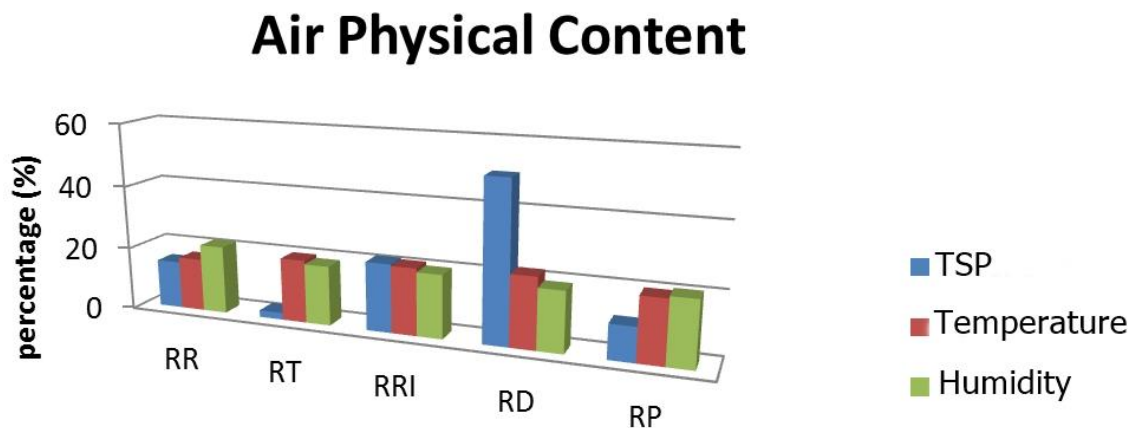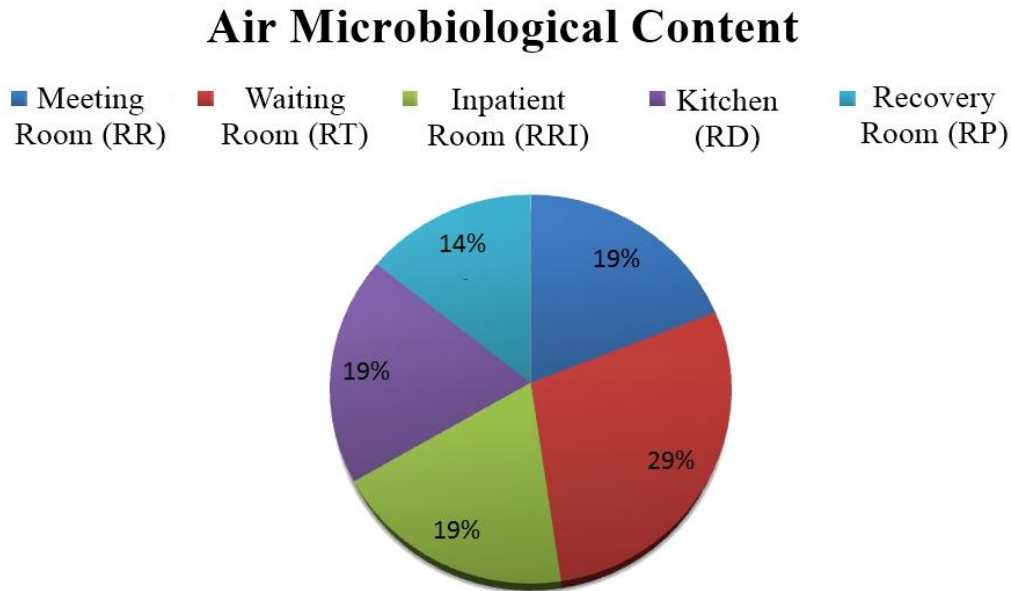**Fig.1** The percentage of TSP, temperature and humidity in rooms of "X" hospital

Fig.2 The Percentage of fungal colony count in the working rooms of "X" hospital

World Health Organization (WHO) considers 500 CFU/m^3 is an acceptable condition (Heseltiene and Rosen, 2009). Therefore, fungal concentration in the air of the working rooms of "X" hospital was of an acceptable condition by WHO, but not by ACGIH and Canada.

According to Grony and Dutkiewicz (2002), although microorganism concentration is still below the designated threshold, the presence of pathogenic microorganism in the air is something to be aware of because this will lead to health problem. This is in line with Yusup *et al.,* (2014) who stated that although bioaerosol is yet to belong to pollutant category, bioaerosol is an important air quality parameter indoor because it leads to contamination risk in human.

In conclusion, air quality in the working rooms of "X" hospital in Balikpapan based on TSP, temperature and humidity was relatively high in comparison with fungal count. In the five (5) sampling rooms, fungal count still met the standard <700 CFU/m^3, indicating that the fungal count had no correlation with temperature, humidity and TSP. However, the distribution of potential pathogenic fungi in the air of working rooms of "X" hospital in Balikpapan is something to be aware of to.

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