Jurnal Presipitasi
Media Komunikasi dan Pengembangan Teknik Lingkungan
e-ISSN: 2550-0023

Vol 20, No 3, 2023, 572-580
Article available at [homepage presipitasi]

Regional Case Study

Study of The Feasibility of Minimarkets in Pontianak Cities Based on the Microbiological Quality of Air In Relation to the Physical Condition of the Room

Siti Almira Rahminda[1], Jumiati[1*], Aini Sulastri[1]

[1] Department of Environmental Engineering, Faculty of Engineering, Universitas Tanjungpura, Jalan Prof. Dr. H. Hadari Nawawi, Pontianak, Indonesia 78124

* Corresponding Author, email : jumiati@untan.ac.id

Abstract

Indoor air quality affects human health and productivity. The presence of microorganisms in indoor air is influenced by physical parameters of the space, activities within the space, building factors, ventilation systems, and human maintenance and care. This study aims to assess air quality and analyze the difference in the number of bacteria between minimarkets and the relationship test with their influencing factors. The study used a cross sectional method with 4 minimarket samples, 2 AC and 2 non-AC. Airborne bacterial colony counts were measured using a passive method with blood agar media, a contact time of 15 minutes, and 3 days of repetition. The average value of airborne bacterial colony counts in non-air-conditioned minimarkets (294.3 CFU/m^3) was lower than in air-conditioned minimarkets (531.8 CFU/m^3). The Rank Spearman correlation test results indicated that there was no significant relationship between airborne bacterial colony counts and temperature (p=0.498), humidity (p=0.089), light intensity (p=0.948), and visitor count (p=0.481). All studied minimarkets met the microbiological air quality, population density, and air circulation standards, but not all met the standards for room temperature, humidity, and light intensity based on the quality standards of the Indonesian Ministry of Health Number 1405/MENKES/SK/XI/2002.

Keywoards: Air quality; airbone bacterial; minimarkets; physical condition

1. Introduction

The quality of indoor air is a crucial factor that affects human health, well-being, and productivity (Gita C. et al., 2022). According to the US Environmental Protection Agency (EPA) in (A'yun and Umaroh, 2023), indoor air quality is 2-5 times worse than outdoor air quality, where indoor pollution ranks 3rd in terms of health risks to humans. As people spend 80-90% of their time indoors spaces, such as in homes, offices, public restaurants, and other buildings (Arief Faturrahman and Kurniatuhadi, 2019). Factors such as building conditions, human activities, and maintenance and care of indoor spaces contribute to indoor air pollution (Cintya Dewi et al., 2021).

The air circulation system plays a role in exchanging indoor air, which is generally divided into two types: natural ventilation through windows and artificial ventilation with the help of air conditioners (ACs). The use of ACs can enhance indoor comfort and productivity, but when ACs are not regularly cleaned, they can become a breeding ground for microorganisms (Walid et al., 2019). In this study (Fajarwati, 2020), it was concluded that regularly cleaning the AC filter can maintain air quality in waiting rooms. The research results showed that fewer bacterial colonies were found on the cleaned AC filters.

Microorganisms in the air are a pollutant component that causes various diseases affecting the eyes, skin, and respiratory system. Especially indoor air in public places is unwittingly a shared consumption by many people, such as minimarkets. The presence of these microorganisms is affected by several factors such as indoor activities and the amount of dust and dirt (Putra1 et al., 2018). To maintain indoor air quality, the standard for indoor air microbiology should not exceed 700 colonies/m^3 of air and should be free from pathogenic bacteria (Menteri Kesehatan Republik Indonesia, 2002).

Recent studies suggest that there is a significant relationship between the concentration of bacteria and fungi in the air with temperature, humidity, and light intensity (Pudjadi et al., 2016). According to (Yusup et al., 2014), although not yet included in the criteria for pollutants, air microorganisms are important indoor air quality parameters as they cause a risk of contamination among humans. Therefore, indoor air quality in places or public enterprises such as minimarkets is one of the important factors of interest to look at. This study aims to analyze the differences in the number of air bacteria of air-conditioning and non-AC minimarkets and to determine their effect on the physical quality of space (temperature, humidity, light intensity, and number of visitors) and their feasibility in relation to development and maintenance factors in the minimarkets. The current research was conducted by comparing the physical parameters and activities of visitors in the minimarket.

2. Methods

This study uses the cross-sectional method to examine the correlation between independent and dependent variables simultaneously. The research population of 4 with sample locations in Pontianak is represented by 4 sub-districts with different ventilation systems, room wide, visitor density and minimarket operation time. The independent variables in the study are room temperature, room humidity, light intensity, and the number of visitors, while the dependent variable is the number of bacterial colonies in the room. The measurement of bacterial colonies using the passive method (contact plate method) with blood agar media for 15 minutes and repeated for three days, with a total of 36 samples.

The study samples were obtained from four minimarket locations with three points each and performed three repeats. In one repeat conducted at four research sites, 12 samples were produced. So that three repeats that were performed over the same time range were obtained totaling 36 research samples. Four research locations represent the number of sub-districts in Pontianak, the number of repeaters based on previous studies with point-setting using purposive sampling methods, and the time range of take-up is based on the time with the highest number of visitors in the minimarket studied.

The incubation process takes 24 hours to count the bacterial colonies, and 48 hours to identify the macroscopic morphology of the bacterial colonies. The number of bacterial colonies in the plates is calculated as the number of bacterial colonies in the room with the unit (CFU/m^3), using the following equation (1) m^3 (Dwi Astuti et al., 2022), (Sukmawaty et al., 2017), and (Cahyani, 2016):

$$x = \frac{\sum fx}{\sum f} \quad (1)$$

$$\sum y = x \times 35.32$$

Given that:

Convention : 1 CFU/m^3 colony = 35.32 CFU/m^3

X = Average result on bacterial colony

∑y = Total colonies in the room (CFU/m^3)

∑fx = Total bacterial colonies in petri dish

∑f = Total number of petri dish

The physical parameters of the room such as temperature, humidity, and light intensity were measured using a hygrometer and lux meter, as referred to in (Menteri Kesehatan Republik Indonesia, 2002). Meanwhile, the measurement of floor occupancy capacity and air circulation in the room was carried out in accordance with the Indonesian Ministry of Health Regulation No. 1335/MENKES/SK/X/2002. Based on the Permenkes RI No. 48 of 2016, the minimum floor occupancy density standard of 2.2 m^3/person can be calculated using the following equation (2):

$$\text{Floor Occupancy Density} = \frac{\text{Room Area}}{\text{Number of occupants in the room}} \quad (2)$$

The standard formula for minimum air circulation in the room is 10-15 m^3, and can be calculated using the following equation (3):

$$\text{Air Circulation Room} = \frac{\text{Room Volume}}{\text{Number of occupants in the room}} \quad (3)$$

In this study, normality test and Spearman Rank correlation test were conducted to analyze the statistical data, using SPSS 25.0 software, which was analyzed descriptively. The normality test was conducted using all measurement data to determine whether the data were normally distributed or not. Meanwhile, the data used in the Spearman Rank correlation test were the number of bacterial colonies in the minimarket and the physical parameters of the minimarket space. The supporting data sources include journals, organizational publications, and official materials.

3. Result and Discussion

3.1 Microbiological Quality of Indoor Air

The research data were collected from each minimarket at three points with repetition for three consecutive days. The number of bacterial colonies in each room was calculated by using the formula CFU/m^3 or colony/m^3 (Dwi Astuti et al., 2022). The average number of bacterial colonies in each minimarket can be seen in Figure 1, which shows the number of bacterial colonies in each minimarket.

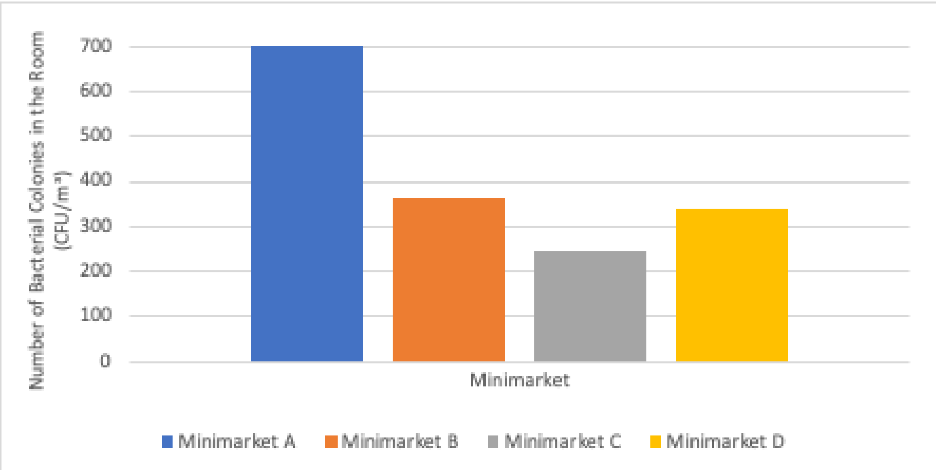

Figure 1. Graph of the number of bacterial colonies in minimarket rooms

Based on the standard quality benchmark referred to, all minimarkets have met the requirements with the number of bacterial colonies in the room less than 700 colonies/m^3. Referring to Figure 1, Minimarket A has the highest average number of bacterial colonies, which is 698.6 CFU/m^3, followed by Minimarket B with the second-highest value of 365 CFU/m^3. Minimarket D has a value of 341.4 CFU/m^3, and Minimarket C has the lowest number of bacterial colonies, which is 247.2 CFU/m^3.

In this study, the average number of bacterial colonies in minimarkets with AC facilities was 531.8 CFU/m^3, while minimarkets without AC facilities had an average of 294.3 CFU/m^3. This indicates that the use of AC affects the number of bacterial colonies in the room, with minimarkets with AC facilities having more bacterial colonies. This research is in line with the finding of another study (Fajarwati, 2020) that there is a difference in the number of bacteria between non-AC and AC classrooms, where the number of bacteria in non-AC rooms is 43 CFU/m^3 and the number of bacteria in AC rooms is approximately 55 CFU/m^3.

Artificial ventilation systems such as AC can be a breeding ground for bacteria and viruses if not maintained properly. Although AC filters are designed to prevent the spread of pollutants, closed AC rooms can also prevent pollutants from being expelled. Poor air microbiological quality in a minimarket with adequate ventilation is likely due to the cleanliness of the ventilation and the room, as well as the presence and activities of people. (Dwi Astuti et al., 2022) states that indoor air pollution is influenced by ventilation rates, crowd density, level of human activities, and room temperature and humidity conditions.

Based on research (Emdiyono and Triyantoro, 2018), maintenance and daily disinfectant cleaning can reduce air pollution and eliminate disease-causing microorganisms. Effective disinfectants should be used during room disinfection to reduce or kill bacteria (Lestari et al., 2019). Minimarket A and B have similar routine maintenance procedures, but the use of AC in minimarket B is not optimal. Minimarket A has higher visitor numbers and operating time, which affects the number of visitors and activities in the room.

According to a study (Afla, 2019), each room has a different concentration of bacteria depending on the number of people and the level of activity inside and outside the room. Healthy humans can also carry pathogenic bacterial contaminants, and suboptimal environmental conditions can potentially encourage bacterial growth (Mayasari et al., 2019). Minimarket D has a higher colony count of airborne bacteria compared to minimarket C due to the lack of air circulation and less frequent cleaning. Room sanitation also affects the amount of bacteria, including dust accumulation in corners (Prajawanti et al., 2019).

Observation of Macroscopic Morphology: The characteristics of bacteria based on size, optical characteristics, shape, elevation, surface, edge, color, and hemolysis zone were examined through observation of macroscopic morphology. The following is a representative example of a petri dish from an AC minimarket:

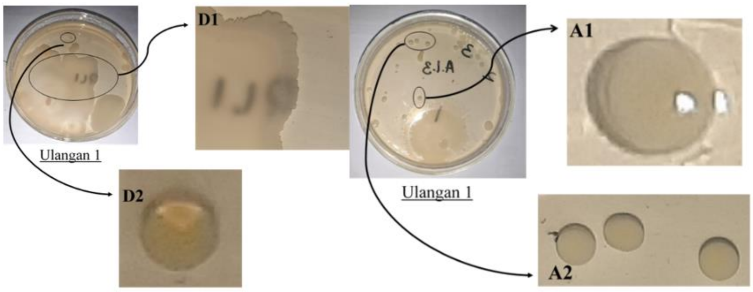

Figure 2. Sample Petri Dishes in Minimarket

Figure 2 shows the diversity of observations, with one of the sample cups displaying the following characteristics: Colony A1 has a round, convex morphology, whitish-gray color, and shiny surface. Colony A2 has a round, flat edge, convex morphology, shiny surface, and whitish-grayish color. Bacterial colony with code D1 has an irregular shape, dry surface, uneven edge, and white color, while the colony with code D2 has a round shape, golden yellow color, convex morphology, and shiny surface. One of the morphological features discovered by the researcher is a statement in (Thoyib 2007), which mentions round, yellow, convex morphological features, rough granular inner structures, and 2–3 mm in size indicating the morphology of microbial species. This species of bacteria is harmless to the human skin and can be found in areas with high occupancy or in areas with poor ventilation. The characteristics of infection are seen in the appearance of internal skin or organ lesions followed by decreased appetite (Ayden et al., 2005). To clearly know what species of bacteria it contains, further testing is needed in the study.

3.2 Relationship Between The Physical Indoor Air Quality and the Number of Bacterial Colonies

Minimarket A and Minimarket B utilized artificial ventilation systems with AC, Minimarket C used natural ventilation with open walls and a fan, while Minimarket D used natural ventilation with open walls. The measurement results of temperature, humidity, and light intensity can be seen in Table 1:

Table 1. Average result of physical air parameter measurements

The Standard of KEMENKES RI Number 1405/MENKES/SK/XI/2002	**Temperature**	**Humidity**	**Light Intensity**
	18-28°C	**40% - 60%**	**minimal 100 lux**
Minimarket A	25.4	67.8	479.7
Minimarket B	29.2	62.2	225.8
Minimarket C	28.8	82.3	61.8
Minimarket D	28.4	81.3	133.9

The difference between AC and non-AC facilities within a room significantly affects the room temperature. In minimarket A, all ACs are turned on, while in minimarket B, only one unit is activated. Minimarket C uses only two of its five available fans, and minimarket D relies solely on an open wall. Based on the measurements in Table 1, only minimarket A meets the standard temperature parameters and almost all measured minimarkets fail to meet the standard humidity. Indoor air movement maintains a comfortable and safe air temperature, and can also increase humidity.

Lighting can influence the number of bacteria in a room, as ultraviolet rays act as a disinfectant for microorganisms in the air. This is supported by a study by (Ariyadi, 2009) that examined the effect of ultraviolet rays on bacteria. The results of the study showed that the control medium without ultraviolet disinfection was filled with colonies of uncountable bacteria, while the medium with bacteria illuminated with 38 watts of ultraviolet rays for 1 minute, 5 minutes, and 10 minutes showed bacterial colony counts of 18, 5, and none, respectively. Based on Table 1, only Minimarket C did not meet the standard for light intensity, indicating suboptimal indoor lighting and requiring additional lighting in the room. The average calculation results of the room occupancy capacity and air circulation are presented in Table 2 below:

Table 2. Calculation of room occupancy capacity and air circulation

	Number of Occupants and Visitors (people)	**Floor Occupancy Density ($m^2/orang$)**	**Air Circulation Room ($m^3/orang$)**
Minimarket A	12	14.71	44.14
Minimarket B	8.67	12.18	36.54
Minimarket C	19.33	6.25	20
Minimarket D	10.67	14.27	45.66

All of the minimarkets evaluated met quality standards as shown in Table 2. Building size impacts floor occupancy density and room air circulation. The internal arrangement of minimarket goods affects customer movement flexibility, with a higher number of occupants resulting in hotter air. Such findings were highlighted in a study by (Ningtyas, 2019), which noted that high bacterial concentrations are affected by human populations and activities near the sampling location and may impact bacterial transmission in the air.

The research data were collected from each minimarket at three points with repetition for three consecutive days. The number of bacterial colonies in each room was calculated by using the formula CFU/m^3 or colony/m^3 (Dwi Astuti et al., 2022). The average number of bacterial colonies in each minimarket can be seen in Figure 1, which shows the number of bacterial colonies in each minimarket.

The results of the Rank Spearman correlation test conducted using SPSS 25.0 software are as follows:

Table 3. Table of correlation test results for physical parameters and the number of bacterial colonies in the room.

Physical Parameter	Significant Value	Correlation Coefficient	Conclusion
Temperature	0.498	- 0.217	There is no significant relationship and it has a weak correlation with a negative direction
Humidity	0.089	- 0.511	There is no significant relationship and it has a weak correlation with a negative direction
Light Intensity	0.948	0.021	There is no significant relationship and it has a less meaningful positive correlation
Number of Visitors and Occupants	0.481	- 0.225	There is no significant relationship and it has a weak correlation with a negative direction

Table 3 shows the non-significant relationship between physical parameters and the number of bacterial colonies in the room. The correlation coefficient between temperature and bacteria count indicates a weak negative relationship, meaning that as temperature increases, the number of airborne bacteria decreases. High temperature can cause bacteria to undergo protein denaturation and damage other important cellular components, leading to cell death. However, a previous study (Swandi, 2021) suggests that a relatively high and stable room temperature over a long period can be a trigger for bacterial growth.

The correlation coefficient between humidity and bacteria count shows a strong negative relationship, meaning that as humidity increases, the number of bacteria in the room decreases. In this study, the non-AC minimarket with a higher average humidity had a smaller average number of bacteria in the room at 294.3 CFU/m^3 compared to the AC minimarket at 531.8 CFU/m^3. In a study (Kusumawardhani et al., 2018) on the relationship between physical factors and airborne bacterial counts, the highest humidity level in the second-class ward was associated with a higher bacterial count of 2150 CFU/m^3 compared to the first-class ward at 2833.3 CFU/m^3, with the lowest humidity level among the wards being 54.17%.

The correlation coefficient between lighting and the number of bacteria has a less meaningful relationship with a positive correlation, indicating that as the light intensity in the room increases, the number of bacteria in the room also increases. A previous study (Cahyaningrum Amelia Yasmine, 2019) found that the number of microbes outside the room is less than inside the room because of the influence of UV light from the sun. The less meaningful relationship in the test is due to the minimarket's lighting being dominated by lamp lighting.

The correlation coefficient between the number of visitors and bacteria count indicates a weak relationship with a negative correlation, meaning that as the number of visitors increases, the number of airborne bacteria decreases. This phenomenon is attributed to the minimarket's excessive floor space, which renders the relationship between the number of visitors and the number of bacteria in the room insignificant. In a separate study (Sari, 2018), it was observed that the room with the highest number of occupants, comprising 51 persons, had a bacterial concentration of 2348 CFU/m^3, whereas the room with the least number of occupants, involving only 2 persons, recorded a bacterial concentration of 628 CFU/m^3. Therefore, as the number of persons in a room increases, the concentration of bacteria also increases. This can be attributed to the heightened level of human activity in a building, which results in increased air movement around the area.

3.3 Maintenance and Care of Minimarket

The Facility Ranking Assessment based on (Kepala Badan Pengawas Obat Dan Makanan, 2021) found minor issues the results of Facility Rating Assessment Based on the Regulation of the Indonesian Food and Drug Authority No. 21 of 2021, Regarding the Implementation of Food Safety and Quality Assurance System in Food Processing Facilities, Minor Findings Discovered:

Figure 3. Minor findings on infrastructure and buildings

According to (Kepala Badan Pengawas Obat Dan Makanan, 2021), facility rating values, the examination of minimarkets revealed minor non-compliance issues, ranging from 0-16 findings in all minimarkets. As a result, all minimarkets were rated A for their facilities. Figure 3 indicates that the minor deviations found are related to significant infrastructure and building deficiencies that do not have a direct impact on the minimarket products. All minimarkets had one minor finding related to display coolers. Although the display coolers have temperature indicators, they are not monitored. This can potentially affect product quality if the temperature is unsuitable for storage.

Minimarket C has cracks on the floor and a damp ceiling due to water leakage, while minimarket D experienced ceiling damage from rainwater, which could potentially pose a danger to visitors. Gaps and slopes on the floor can be a place for water to gather, which can become a breeding ground for bacteria and air contaminants. Figure 3 shows that minimarket B and C have cluttered and poorly arranged goods, which affect the cleanliness of the minimarket. Dust on furniture can make the air inside more humid, which allows microorganisms to grow (Lestiani and Tunggul Pawenang, 2018). The increase in the number of microorganisms in the room takes time, so good maintenance and care can prevent an increase in the number of microorganisms inside the room.

The impact of the study suggests that there is an influence on the number of airborne bacterial colonies in the room's activity and cleanliness. One of the efficient measures is to maintain cleanliness of the room and maintain air circulation of the room. Cleaning is a basic activity in handling surface contaminants. Indoor dust piles can increase the content of indoor bacteria, as microorganisms in the air will leave turbulence in the gas suspension and precipitate and stick to the surface (Pepper, Gerba, and Gentry, 2014). Examples of cleaning can be made using disinfectants in rinsing, mopping, and wiping on indoor furniture and floors, and regularly cleaning room air circulation support devices. Technical handlers from the research summary show that cleaning and maintenance routines and furniture can reduce bacterial colonies. Examples of handlers such as air conditioner cleaning or fan cleaning three times a month, floor cleaning, walls, and furniture can be done daily using disinfectants, and maintaining air circulation by opening windows or adding room air circulation support devices.

4. Conclusions

The bacterial colony count in AC minimarkets is found to be higher than in non-AC minimarkets. Correlation analysis between the bacterial colony count in the room and the factors affecting air quality indicates an insignificant relationship with p-values of temperature (0.498), humidity (0.089), light intensity (0.948), and the number of visitors (0.481). All of the studied minimarkets meet the microbiological quality, occupancy density, and air circulation requirements, but not all meet the standards for room temperature, humidity, and light intensity (Menteri Kesehatan Republik Indonesia, 2002). The bacterial concentration levels are $\bar{x}$ = 531.8 CFU/m^3 and $\bar{x}$ = 294.3 CFU/m^3, respectively.

References

Afla, R.A., 2019. Analisis Kualitas Udara Mikrobiologis Parameter Bakteri dan Jamur di Ruang Rawat Inap Rumah Sakit (Studi Kasus : Gedung A Rumah Sakit Umum Pusat Nasional (RSUPN) DR. Cipto Mangunkusumo). Universitas Indonesia, Depok.

Arief Faturrahman, M., Kurniatuhadi, R., 2019. Deteksi Keberadaan Bakteri Staphylococcus di Udara Dalam Ruangan Pasar Tradisional Kota Pontianak. Protobiot 8, 30–34.

Ariyadi, T., 2009. Pengaruh Sinar Ultra Violet Terhadap Pertumbuhan Bakteri Bacillus sp. Sebagai Bakteri Kontaminan. Kesehatan 2.

A'yun, I.Q., Umaroh, R., 2023. Polusi Udara dalam Ruangan dan Kondisi Kesehatan: Analisis Rumah Tangga Indonesia. Jurnal Ekonomi dan Pembangunan Indonesia 23, 16–26.

Cahyani, V.D., 2016. Kualitas Bakteriologis Udara Dalam Ruang Perawatan Inap Rsud H. Padjonga Dg. Ngalle Kab. Takalar.

Cahyaningrum Amelia Yasmine, 2019. Air Quality Analysis Of Microbiological Bacterial And Fungal Parameters In The Clinical Building (Case Study: Klinik Satelit Building, Universitas Indonesia). Depok.

Cintya Dewi, W., Raharjo, M., Endah Wahyuningsih, N., Kesehatan Masyarakat Universitas Diponegoro Jl Sudarto No, F., Kota Semarang Jawa Tengah Indonesia, T., 2021. Literature Review: Link Between Space Air Quality and Health In Terference In Workers. Jurnal Kesehatan Masyarakat 8.

Dwi Astuti, N., Hastutiningrum*, S., Sudarsono, S., 2022. Analisis Kualitas Udara Pada Rumah Warga Terhadap Parameter Bakteri dan Jamur. Jurnal Teknologi 15, 166–170.

Emdiyono, S.V., Triyantoro, B., 2018. Pengaruh Pemberian Karbol Sebagai Desinfektan Terhadap Jumlah Angka Kuman Pada Lantai Ruang Parikesit Kelas III Rumah Sakit TK III.04.06.1 Wijayakusuma Purwokerto Tahun 2017. Keslingmas 37, 405–534.

Fajarwati, D., 2020. Perhitungan Koloni Bakteri Pada Filter AC (Air Conditioner) dan Udara Dalam Ruang Tunggu Pelayanan Medis. Bandung.

Gita C., U., Vecky C., P., Abdul H., J.O., 2022. Indoor Air Quality Monitoring System. Teknik Informatika 17, 93–104.

KEPALA BADAN PENGAWAS OBAT DAN MAKANAN, 2021. Peraturan Badan Pengawas Obat dan Makanan Nomor 21 Tahun 2021 Tentang Penerapan Sistem Jaminan Keamanan dan Mutu Pangan Olahan Di Sarana Peredaran.

Kusumawardhani, C., Gunawan, A.T., Cahyono, T., Jurusan,), Lingkungan, K., Kesehatan, P., Semarang, K., 2018. Faktor Lingkungan Fisik yang Berhubungan Dengan Angka Kuman Udara di Ruang Rawat Inap Kelas I, II, dan III RST Wijayakusuma Purwokerto Tahun 2018. Keslingmas 38, 124–243.

Lestari, P.M., Supandi, Ani, P., 2019. Pembuatan Karbol Sebagai Desinfektan Lantai. SOLMA 8, 193.

Lestiani, D.P., Tunggul Pawenang, E., 2018. Lingungan Fisik yang Mempengaruhi Keberadaan Kapang Aspergillus sp dalam Ruang Perpustakaan. HIGEIA 2.

Mayasari, A., Zulkarnain, Agrina, S., 2019. Analisis Kualitas Fisik Udara Terhadap Kualitas Fisik Udara Rumah Sakit. Ilmu Lingkungan.

Menteri Kesehatan Republik Indonesia, 2002. Keputusan Menteri Kesehatan Republik Indonesia Nomor 1405/MENKES/SK/XI/2002 Tentang Persyaratan Kesehatan Lingkungan Kerja Perkantoran dan Industri.

Ningtyas, S.A., 2019. Analisis Kualitas Udara Mikrobiologis Dalam Ruang Perpustakaan Crystal Of Knowledge, Universitas Indonesia, Depok. Universitas Indonesia, Depok.

Prajawanti, N.L., Tri, C., Asep, T.G., 2019. Efektivitas Shokivi Desinfection Terhadap Penurunan Angka Kuman Udara Pada Ruang Kelas Gedung R2 Lantai 2 Kampus 7 Poltekkes Kemenkes Semarang Tahun 2018. Buletin Keslingmas 38, 17–28.

Pudjadi, E., Suciyani, R., Sahira, I.G., Pikoli, M.R., 2016. Kualitas Mikrobiologis Udara di Salah Satu Pusat Perbelanjaan di Jakarta Selatan. AL-Kauniyah: Jurnal Biologi 8.

Putra[1], I., Ikhtiar[2], M., Emelda[3], A., 2018. Analisis Mikroorganisme Udara terhadap Gangguan Kesehatan dalam Ruangan Administrasi Gedung Menara UMI Makassar. Windowof Health : Jurnal Kesehatan 1.

Sari, I.V., 2018. Analisis Kualitas Udara Mikrobiologis Pada Gedung S Fakultas Teknik Universitas Indonesia. Universitas Indonesia, Depok.

Sukmawaty, E., Manyullei, S., Dwi Cahyani, V., Biologi, J., Sains, F., Teknologi, D., Makassar, A., Masyarakat, F.K., 2017. Kualitas Bakteriologis Udara Dalam Ruang Perawatan VIP Anak RSUD H. Padjonga Daeng Ngalle Kabupaten Takalar. In: Seminar Nasional Biology for Life. Gowa, pp. 38–43.

Swandi, F., 2021. Analisis Kandungan Jumlah Bakteri di Udara dalam Ruang Kerja Institusi Pendidikan X di Kota Padang. Universitas Andalas, Padang.

Walid, A., Novitasari, N., Wardany, K., 2019. Studi Morfologi Koloni Bakteri Udara Di Lingkungan Fakultas Tarbiyah Dan Tadris Institut Agama Islam Negeri Bengkulu. Jurnal IPA & Pembelajaran IPA 3, 10–14.