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Relationship between Particulate Matter and Population of Airborne Microorganism in Goat Farm: A case study at Ladang Pasir Akar, Terengganu

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Abstract. The aim of this study is to determine the concentration of particulate matter and airborne microorganism and to evaluate the relationship between particulate matter and airborne microorganism in goat farm of Pasir Akar, Terengganu, Malaysia. Aeroqual 500 series sensor was used to collect particulate matter, while DRF e-MAS was used to catch the airborne microorganism. The collected airborne microorganism was incubated in laboratory and the colony forming unit (cfu) of airborne microorganism was determined using Omeliansky's formula based on colonial observation formed after incubation. The data were analysed using descriptive analysis to gain parameter concentration and regression analysis to gain significance difference and correlation to assess the relationship between particulates and airborne microbes. As a result, any particulate matter changes will affect airborne microorganism population.

1. Introduction

Air around us is a combination of aerosols, primarily nitrogen and oxygen. Suspended particulate matter (dust), bioaerosols, and minerals are parts of air composition. These compositions are natural, biogenic, or anthropogenic. All these compositions have their own content limit to ensure that the surrounding air quality is clean. Poor air quality can infect human, animal, and environmental health. Other than aerosols' instability, bioaerosols can also give poor surrounding air quality. They may consist of bacteria, fungi, viruses, microbial toxins, pollen, plant fibres, etc. [1], [2].

In developing countries, demands for livestock production are increasing rapidly due to urbanisation and changing food habits. It will, however, affect the microbial content mostly from livestock manure. Without checking the air quality content, airborne microorganisms can be transmitted.

According to the United Nations [3], the population of the world is projected to grow from 7.7 billion in 2019 to 8.5 billion in 2030 (10% increase) and to 9.7 billion in 2050 (26%) and 10.9 billion in 2100 (42%). Growth, urbanisation and rising incomes in developing countries are the main driver of increased demand for livestock products [4]. When each farm operates wider, farm air composition that contains undesirable mixture may expose. Organic dust from bedding, faecal materials, animal skin or feedstuffs floats indoor air during cleaning or through animal activities such as feeding or feathering [5], [6], [7]. Airborne microorganism transmission may occur and may affect animals and



humans. In livestock production, airborne transmission is characterised as a whole transmission process involving pathogenic microorganisms released from the excretion or secretion of the infected animal into the air, carrying air, inhaling a healthy animal and eventually infecting the recipient [8].

A study of bacterial airborne and its relationship to particulate matter in a goat farm may assess the concentration and number of bacteria airborne matter in particulates. Determining bacterial load in the indoor environment is important to estimate the health hazard.

2. Methodology

2.1. Study Location

This study was conducted in goat farm building at Ladang UniSZA, Pasir Akar, Terengganu ($5^{\circ} 38' 00''$ N, $102^{\circ} 30' 00''$ E). Sampling activities took place January and February 2020. This farm has five pens: pen A, B, C, D and E with different building size and height. Pen A, C, D and E were used (goats). Pen B excluded due to contain sheep. 46, 90, 28 and 53 goats in pen A, C, D and E respectively. For purebred and crossbred, Saanen-Kajtang, Jamnapari-Katjang, Boer-Katjang and Saanen-British Alpine are the goat breeds that this farm raised. This farm's topography is quite hilly and the area is about 140,801 m². Farm location information is shown in Figure 1. Four pens are observed and data has been obtained in each pen. Each pen has two sampling points. The sampling was run four times between January 2020 and February 2020. Each sampling point was symbolised as KA1 and KA2 for pen A, KC1 and KC2 for pen C, KD1 and KD2 for pen D and KE1 and KE2. Inside the building, the devices were placed 1.5 metres from the floor at each sampling point, which is the average human breathing zone [9], [10].



Figure 1. Maps showed the sampling area

2.2. Sampling Methods

Aeroqual Series 500 was used to measure particulates matters (PM₁₀ and PM_{2.5}). Aeroqual Series 500 is an ultra-portable handheld air quality monitor that acts as a real-time air quality survey accurately. Data collected is stored in Series 500 and can be downloaded in Microsoft Excel. It also has a location ID feature that can be used to tag measurements to a particular location to enable tracking. Each sample was gathered 3 minutes. Meteorological parameters (air/humidity) shall be measured. Housing and animal activity management was also reported.

DRF e-MAS, as shown in Figure 2 (imitation MAS-100), was used to isolate airborne atmospheric cultural bacteria. DRF e-MAS use the standard method to assess biological pollutant according to USEPA CPSC # 425 during development of this system. DRF e-MAS, a cost-effective microbial air sampler, was designed as a 3-in-1 air sampler for biological sampling with a petri dish of 60 mm and 150 mm diameter and heavy metal sampling with 50 mm philtre paper. The open-source Arduino microcontroller is used to promote prototyping and wind speed algorithm integration and consistency control. For field sampling, two-type control, AC and DC from internal lithium polymer battery were used. Air was aspirated through a plate chamber flowing through the chamber at a maximum volume of 1.74 m³/min. Each sample obtained 30 seconds. To cultivate the collected bacterial samples, DRF eMAS was filled with nutrient-agar Petri dishes. Exposed culture dishes were then incubated 24-48 hours at 37 ° C. Colonial growth is called colony-forming unit (CFU). The result was then expressed

as colony-forming units per cubic metre (CFU m⁻³). CFU m⁻³ was estimated using formula Omeliansky (Eqn. 1) [11]:

$$N = 5a \times 10^4 / (b \times t) \quad (1)$$

Where, “N” represents microbial CFU/m³, “a” is the number of colonies forming units per Petri dish (CFU), “b” is dish surface area (cm²) and “t” is the exposure time (min).



Figure 2. Microbial Air Sampler (DRF e-MAS)

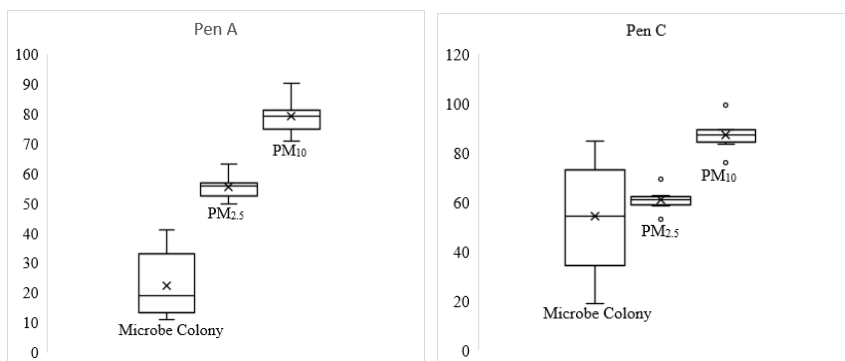
2.3. Statistical Analysis

Statistical analysis was performed using Microsoft Excel. Descriptive analysis was used to show results obtained through box plot of concentration of PM₁₀, PM_{2.5} and bacterial airborne found in each goat pen for highlighting the maximum, minimum and mean value. Linear regression applied to assess whether there are correlation and significant different between particulate matter and airborne microbe.

3. Results and discussion

3.1. Descriptive Analysis of Particulate Matter and Airborne Microorganism

In order to determine the concentration of particulate matter (PM₁₀ and PM_{2.5}) and microbial colony count in colony forming unit (cfu), descriptive analysis had been performed to summarize the raw data into mean, minimum and maximum value. Based on the result in Figure 3, the data for concentration of PM_{2.5} showed mean value for pen A, C, D and E were 55.38 mg/m³, 61.0225 mg/m³, 45.76 mg/m³ and 57.67 mg/m³ respectively. The data for concentration of PM₁₀ showed mean value for pen A, C, D and E were 79.04 mg/m³, 87.18 mg/m³, 65.38 mg/m³ and 82.4 mg/m³. The data for concentration of airborne microbes showed mean value for pen A, C, D and E were 22.21 cfu × 10³/m³, 54.26 cfu × 10³/m³, 13.38 cfu × 10³/m³ and 39.53 cfu × 10³/m³. Among those four pens in the goat farm, pen C had the highest value of concentration for each parameter, followed by pen E, pen A and pen D.



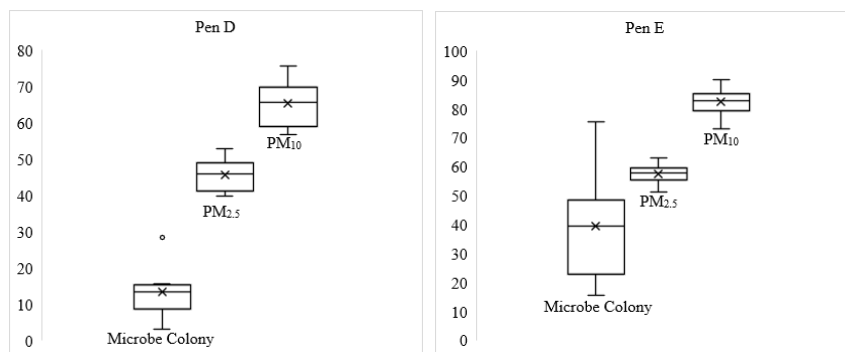


Figure 3. Result of concentration of microbial colony, $PM_{2.5}$ and PM_{10} in (a) pen A, (b) pen C, (c) pen D and (d) pen E

Factor influencing the value of the parameter's concentration were the number of goats, the height of pen building, activity around the pen, temperature and humidity. Pen C have 90 goats which is the highest number followed by pen E (53 goats), pen A (46 goats) and pen D (28 goat). Bernal [12] says that animal activity is a major factor causing high dust concentration. The time of sampling are from morning to afternoon, which is the time for goat to feed and required a lot of movement. When the number of goats is high, there is also high animal activity. For the height of the pen building, pen C, pen E and pen A have the same height about 1.5 meter from the ground and pen D is lower about a 0.5 meter from the ground. Higher building increase chance of natural air ventilation to flow inside the building. According to Tian [13], the increase the wind speed, the particulate matter and dust emission also increase. The wind speed could lead to either an increase or a decrease in the bacterial concentration depending on its direction, speed and site characteristics [14].

There are activities around the pen. Around pen A, the area was used as parking places for the lecturer, students and worker. Pen C has a huge grinder machine which use for process grass into total mixed ratio (TMR) as the feed for entire goat farm. Pen D does not have any routine event nearby. Pen E area is use as usual worker's parking site and during the sampling there is a construction of new pens about 70 meters from the pen E. Typically, machinery, transportation and construction emit high dust emissions. Temperature and humidity are observed within each goat pen using temperature and humidity detector (Fisher brand). Based on the result observed, the higher percentage of humidity is the higher value of the airborne microbes in the farm. Manyi-Loh et al. [15] have suggested that high moisture content in manure can serve as a reservoir for microorganisms. High temperatures are not a suitable condition for the development of microorganisms. In addition, some bacteria can die in high temperature environments [16]. The outcome of the sampling showed higher temperatures, lower airborne microbes in the goat farm.

3.2. Correlation of Particulate Matter and Airborne Microorganism by Regression

Regression analysis was run to find the correlation and significance difference of particulate matter in the goat farm. Table 2(a) to 2(d) show the correlation analysis by regression of particulate matters and airborne microorganism for each pen in goat farm.

Table 2. The correlation between particulate matters and airborne microorganism in (a) pen A, (b) pen C, (c) pen D and (d) pen E

(a)	$PM_{2.5}$	PM_{10}	(b)	$PM_{2.5}$	PM_{10}
Multiple R	0.806957	0.81661	Multiple R	0.77228	0.77228
R Square	0.651179	0.66686	R Square	0.596417	0.59642
Adjusted R Square	0.593042	0.61133	Adjusted R Square	0.529153	0.52915
Standard Error	6.966321	6.80797	Standard Error	15.39363	15.3936
Observations	8	8	Observations	8	8
(c)	$PM_{2.5}$	PM_{10}	(d)	$PM_{2.5}$	PM_{10}
Multiple R	0.736407	0.73641	Multiple R	0.809255	0.81012

R Square	0.542295	0.54229	R Square	0.654893	0.65629
Adjusted R Square	0.46601	0.46601	Adjusted R Square	0.597375	0.599
Standard Error	5.322169	5.32217	Standard Error	11.95559	11.9314
Observations	8	8	Observations	8	8

R^2 values are used to evaluate correlation and interpreting relationship efficiency. Based on the results, the R^2 value for correlation of $PM_{2.5}$ and airborne microorganism are 0.651179, 0.596417, 0.542295 and 0.654893 for pen A, C, D and E respectively. For correlation of PM_{10} and airborne microorganism, the R^2 are 0.66686, 0.59642, 0.54229 and 0.65629 for pen A, C, D and E respectively. Since all the R^2 values were above 0.5 for the pens, its show good strength of relationship between both particulate matters and airborne microorganism in the goat farm [17].

4. Conclusion

In this study, the concentration for particulate matter and microbial colonies were achieved. Pen C has the highest value of concentration for $PM_{2.5}$, PM_{10} and microbial colonies. It means that any changes in the number of particulate matter may affect the population of airborne microorganisms. For both particulate matters have correlation and significance difference with the colony of airborne microbes.

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