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Bacteriological air quality at transfer station area (case study: Gegerkalong Transfer Station, Bandung City)

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Bacteriological air quality at transfer station area (case study: Gegerkalong Transfer Station, Bandung City)

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Abstract. This study aims to measure air bacteriological concentration, to determine the effect of temperature, humidity, and wind speed on bacteriological concentration, and to identify the genus of bacteria found around Gegerkalong waste transfer station. Sampling of air bacteria at stations was based on a radius of 0, 10, 30 and 60 meters East, West, South and North of the transfer station at 09:00, 12:00 and 18:30 with 3 replicates. The method used to measure the concentration of air bacteria was the settling plate method. The results showed that maximum concentration of air bacteria found around the transfer station area was 67626 cfu/m^3 and the minimum was 1153 cfu/m^3 for agar nutrient media. Referring to the quality standards of the UK Environmental Agency, bacterial concentration in Gegerkalong waste transfer station exceeds the bacterial concentration standard of 1000 cfu/m^3, whereas Coliform bacteria were below the standard. Bacteria found in the air around the transfer station are *Pseudomonas, Klebsiella, Shigella, Alcaligenes, Salmonella, Escherichia, Bacillus, Staphyloococcus* and *Coliform*. These can be concluded that a transfer station can be a source of airborne bacteria dispersion, which can have an impact on the surrounding community.

1. Introduction

City landfill is source of microbial air pollution [1] or main source of bioaerosol [2] therefore residents close to landfills are at high health risk [2].Waste is residu of human daily activities and/or solid natural processes [3]. Landfills collect large amounts of municipal waste supporting different bacterial multiplications mainly because of the organic material contained in the stored material. Over time, the waste can become a source of microorganism pollutants [4]. Typically urban waste is characterized by 15-40% of moisture content. However, in certain climatic conditions the water content can increase up to 60-70%. On dry season, urban waste daily water content is 63.37% whereas on holidays it reaches 66.75% [5]. Bandung city organic waste reached 712.23 tons/year, wich is 44.51% of the waste total wet weight [6]. The presence of water vapor in organic matter makes city waste a perfect environment for the development of various microorganisms including bacteria.

Analysis of municipal solid waste in landfills conducted by the US EPA (United States Environmental Protection Agency) in 1960-2007, showed that food waste contributed to 80.62% faecal coliform. Whereas, animal waste contributes to the presence of about 97.27% Salmonella, 94.88% human enterovirus and 97% protozoan parasites in municipal waste [7]. Dominant type of bacteria in open solid waste disposal sites identified mostly are the genera Bacillus, Staphylococcus, Streptococcus, Klebsiella and Escherichia [2]. The highest percentage of aerosol bacteria consists of Gram-positive Cocci and Gram-positive Basil [8,9]. Bioaerosol significantly influences air quality and public health [10]. Bioaerosol is a concept used to describe all biological substances suspended in the air, including bacteria, fungi, viruses, pollen, and their derivatives such as allergens, endotoxins, mycotoxins etc [11]. Factors that influence the survival of microbes in the air are relative humidity, temperature, radiation, oxygen, open air factors and ions [12]. Whilst factors that influence the dispersion of pollutants in the air are the characteristics of the source, the distance traveled by wind gusts, stability, wind speed and wind direction [13]. Therefore, this study aims to measure air bacteriological concentration, to determine the effect of temperature, humidity, and wind speed on bacteriological concentration, and to identify the genus of bacteria found around Gegerkalong waste transfer station. Research on bacteriological air quality in the area around waste transfer stations is important because transfer station in Indonesia is generally located close to residential areas and traditional market. This research can be used as input to prevent or reduce exposure of bacteria for the surrounding community.

2. Methodology

2.1. Measurement of air bacteriological amount at waste transfer station

Air microbial sampling was carried out using the settling plate's method. The air microbes observed in this study are bacteria that grow in agar media, namely Nutrient Agar (NA) and Endo Agar. NA was used as a general medium for bacterial growth while Endo Agar was used as a selective medium for the growth of Coliform bacteria. The number of microbes were measured by the total plate count method. Physical parameters measured were wind speed, humidity and temperature. Samples were taken at 09:00, 12:00 and 18:30. Sampling, temperature, humidity and wind speed were taken with 3 times repetition. Sampling was conducted on weekdays and weekends. Samples were taken at Gegerkalong waste transfer station area. The measurements carried out on radius of 0, 10, 30 and 60 meters from the transfer station. Total number of samples for NA were 117 samples and 36 samples for Endo Agar media. Bacteria identification conducted only on sample collected in the direction of the wind at the time of sampling, therefore the effect of temperature, humidity and wind speed analyzed only on the concentration of bacteria found on the waste transfer station and on the 36 samples of endo agar media.

Data obtained from air bacterial sampling was the total concentration of bacteria in the air. The initial value obtained was the number of bacteria read from the plates. Based on these data, calculation was made to obtain the average bacterial value in units (cfu/m^3) using formula 1.

$$X = \frac{A \; x \; 10000}{P \; x \; k} \tag{1}$$

X = Number of microorganisms in the air (CFU / m^3)
A = Average number of colonies counted
P = plate's area (cm^2)
K = Factor depends on plate's opening time (k = 1 for 5 minutes, k = 2 for 10 minutes, k = 3 for 15 minutes, k = 6 for 30 minutes)

2.2. Physical parameters (Temperature, Humidity and Wind Speed) analysis

Data on the physical parameters of the air (temperature, humidity, and wind speed) were analysed using statistical analysis linear regression. Correlation value (r) between the bacterial concentration and physical parameters of the air (humidity, temperature and wind speed) were calculated using formula 2.

$$\boldsymbol{r} = \frac{\mathbf{n\Sigma XiYi - (\Sigma Xi)(\Sigma Yi)}}{\sqrt{(\boldsymbol{n}\Sigma \boldsymbol{Xi}^2 - (\Sigma \boldsymbol{Xi})^2)\;(\boldsymbol{n}\Sigma \boldsymbol{Yi}^2 - (\Sigma \boldsymbol{Yi})^2)}} \tag{2}$$

2.3. Bacteria identification

Bacteria obtained from isolation were identified to determine the genus. The identification was morphological identification by looking at the colony morphological characteristics and physiological identification by conducting biochemical tests based on the results of gram staining. Test methods can be carried out using Benson's Microbiological Applications: Laboratory Manual in General Microbiology [12] such as motility tests, oxygen requirements, catalase, oxidase, citrate, methyl red

(MR), vogues proskauer (VP), urease, lactose and other tests according to the steps described by Brown and Smith [14].

3. Results and discussion

3.1. Analysis of bacterial concentration

Figure 1 and 2 show that sample collected at 09.00 west of the transfer station has the highest bacterial concentration. This sampling location is a traditional market. The high concentration of bacteria can also cause by the large potential of bacteria released from the waste container into the air during the morning garbage collection activities at the transfer station. The garbage disposal process at Gegerkalong transfer station is carried out by throwing trash into the container. The process of throwing garbage also causes the potential release of bio aerosol into the air. Organic waste will undergo a natural decomposition process during the garbage disposal time.

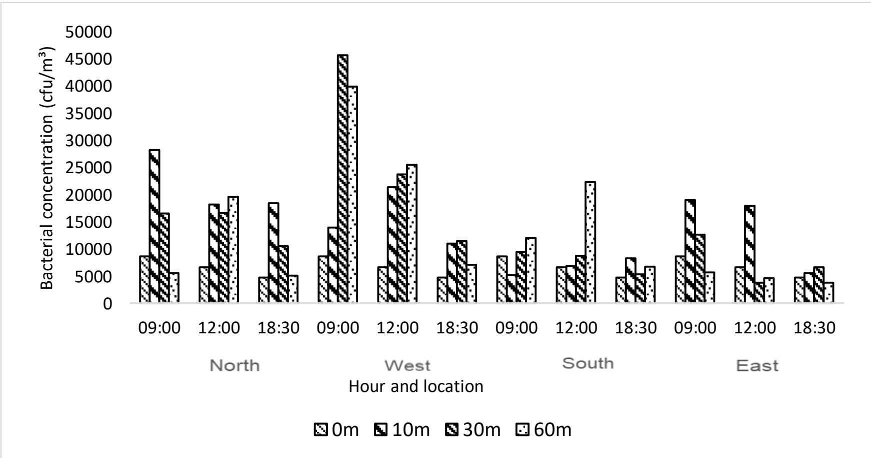

Figure 1. Bacterial concentration in NA media on weekdays.

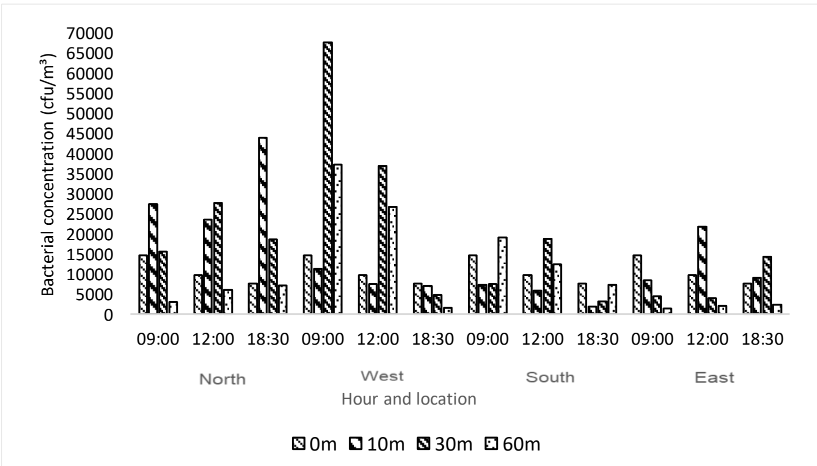

Figure 2. Bacterial concentration in NA media on weekends.

3.2. Analysis of temperature, humidity and wind speed effect on bacterial concentration

3.2.1. Temperature. Linear regression of temperature on bacterial concentrations calculated from Table 1 resulted the r value of 0.05 for bacterial concentration in NA and r value of 0.002 for Coliform bacteria

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in endo media. The r value illustrates the effect of temperatures on the concentration of bacteria in the air is low [15]. This shows that there is no correlation between temperature and bacterial concentration.

Table 1. Effect of temperature on bacterial concentrations on NA and endo media.

Temperature (^{o}C)	**Concentrations (NA) cfu/m^3**	**Concentrations (Endo agar) cfu/m^3**
20.00	14679	70
21.00	10275	891
22.00	8702	131
23.00	7706	35
23.00	20602	0
24.00	4771	35
24.00	6448	0
25.90	25478	0
29.00	6710	262
30.00	9698	280
30.60	7916	367
31.00	15360	79

3.2.2. Humidity. Linear regression of humidity on bacterial concentrations calculated from Table 2 resulted the r value of 0. 418 for bacterial concentration in NA and r value of 0. 178 for Coliform bacteria in endo media. The r value illustrates moderate effect of humidity on bacteria concentration in the air. As for the Coliform bacteria, the r value illustrates the effect of humidity on Coliform bacteria concentration in the air is low.

Table 2. Effect of humidity on bacterial concentrations on NA and endo media.

Humidity	**Concentrations (NA) cfu/m^3**	**Concentrations (Endo agar) cfu/m^3**
36%	9698	280
39%	7916	367
41%	15360	79
43%	6710	262
55%	4771	35
56%	7706	0
59%	6448	0
62%	10275	891
63%	25478	0
64%	14679	70
65%	8702	131
75%	20602	35

3.2.3. Wind speed. Linear regression of wind speed on bacterial concentrations calculated from Table 3 resulted the r value of 0.863 for bacterial concentration in NA and r value of 0.11 for Coliform bacteria in endo media. The r value illustrates the effect of wind speed on the concentration of bacteria in the air is strong. As for the Coliform bacteria, the r value illustrates the influence of wind speed is low.

Table 3. Effect of wind velocity on bacterial concentrations on NA and endo media.

Wind speed m/s	Concentrations (NA) cfu/m^3	Concentrations (Endo agar) cfu/m^3
0.90	4771	35
0.90	7706	0
1.20	6710	262
1.30	8702	131
1.30	6448	0
1.40	7916	367
1.40	9698	280
1.80	14679	70
1.90	10275	891
2.00	15360	79
2.10	25478	0
2.40	20602	35

In Indonesia there is no existing air quality standard reference on settling plate method, therefore this study used the UK Environmental Agency standard for acceptable bacteria of 1000 cfu/m^3 same as other studies in African countries such as Lagos Nigeria [16] which also used this standard. It can be seen that all sampling results indicate that the concentration of bacteria in the NA media exceed the bacterial concentration standards of the UK Environmental Agency for acceptable bacteria of 1000 cfu/m^3.

3.3. Genus of bacteria found around transfer station
The genus of bacteria found in the air around the transfer station were *Pseudomonas, Klebsiella, Shigella, Alcaligenes, Salmonella, Escherichia, Bacillus, Staphyloococcus* and *Coliform*.

4. Conclusion
Air bacteriological concentration found around Gegerkalong waste transfer station area exceeds the bacterial concentration standard of the UK Environmental Agency for acceptable bacteria of 1000 cfu/m^3. Whereas the *Coliform* bacteria is below the standard. Based on the linear regression test of physical factors, humidity and air temperature have a weak correlation value to bacterial concentration. However wind speed has very strong correlation with r values above 0.8. The genus of bacteria found in the air around Gegerkalong transfer station were *Pseudomonas, Klebsiella, Shigella, Alcaligenes, Salmonella, Escherichia, Bacillus, Staphyloococcus* and *Coliform.*

References
[1] Kazmierczuk M and Bablok A B 2014 Bioaerosol concentration in the air surrounding municipal solid waste landfill *Environmental Protection and Natural Resources* **25** 17-25
[2] Agarwal S, Manda P and Srivastava A 2016 Quantification and characterization of size segregated bioaerosols at municipal solid waste dumping site in Delhi *International Conference on Solid Waste Management* **35** 400-407
[3] The Law of the Republic of Indonesia Number 18 of 2008 *Waste Management* Jakarta
[4] Cyprowski M, Walczyk A L, Szymczak M G, Fraczek K, Kozdroj J and Gorny R L 2019 Bacterial aerosols in a municipal landfill environment *Science of the Total Environment* **660** 288-296
[5] Ozcan K H, Guvenc Y S, Guvence L and Demir G 2016 Municipal solid waste characterization according to different income levels: a case study *Sustainability MDPI* **8** 1044
[6] Regional Cleaning Company of the City of Bandung 2018
[7] Gerba P C, Tamimi H A, Pettigrew C, Weisbrod V A and Rajagopalan V 2011 Source of microbial pathogens in municipal solid waste landfills in the United States of America *Waste Management and Research* **29** 781-790

IOP Conf. Series: Earth and Environmental Science **737** (2021) 012066 doi:10.1088/1755-1315/737/1/012066

[8] Boruta B B 2012 Bioaerosols of the municipal waste landfill site as a source of microbiological air pollution and health hazard *Ecol. Chem. Eng. A* **19** 851-862
[9] Boruta B B 2016 The assessment of airbone bacterial and fungal contamination emitted by a municipal landfill site in Northern Poland *Atmospheric Pollution Research* **30** 1-10
[10] Xie Z, Li Y, Lu R, Li W, Fan C, Liu P, Wang J and Wang W 2018 Characteristics of total airbone microbes at various air quality levels *Journal of Aerosol Science* **116** 57-65
[11] Yao M 2018 Bioaerosol: a bridge and opportunity for many scientific research fields *Journal of Aerosol Science* **115** 108-112
[12] Pepper I L, Gerba C P and Gentry T J 2015 *Environmental Microbiology* Third Edition (United States of America: Academic Press) p 95-96
[13] Davis M L and Cornwell D A 2013 *Introduction to Environmental Engineering* fifth edition (United States of America: McGraw-Hill) p 631-632
[14] Brown A E and Smith H R 2017 Benson's Microbiological Applications: Laboratory Manual in General Microbiology fourteenth editon (New York: McGraw-Hill) p 241-279
[15] Sugiyono 2016 *Statistika untuk Penelitian* (Bandung: ALFABETA) p 228-231
[16] Akpeimeh G F, Fletcher L A ND Evans B E 2019 Exposure to bioaerosols at open dumpsites: a case study of bioaerosols exposure from at olusosun open dumpsites Lagos Nigeria *Waste Management* **89** 37-47