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Analysis of the Relationship between Physical Environmental Factors Air Temperature and Humidity with Airborne Germ Rates in Public Elementary Schools in the Territory Work Health Center Sumbang I, Banyumas Regency

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Abstract.State elementary schools play a vital role in shaping the educational environment for young children. Air quality is influenced by various physical factors, including air temperature, humidity, which can affect the presence of airborne microorganisms.

This research investigates the environmental factors, including air temperature, humidity, and airborne microorganism levels, and their potential impact on indoor air quality in public elementary schools within the working area of Puskesmas Sumbang I, Banyumas Regency. The research method used is an analytical observational study with a cross-sectional design. Sampling was conducted over a specific period to obtain a representative overview. Simple linear regression statistical analysis was used to identify the relationship between environmental factors and airborne microorganism levels. Sampling was conducted over a specific period to obtain a representative overview. The results of the analysis showed a significant relationship between air temperature and humidity with the number of airborne microorganisms in elementary schools. High air temperature and low humidity tends to be associated with an increase in airborne microorganisms. This emphasizes the importance of maintaining optimal air temperature and appropriate humidity levels in the school environment. The implications of this research highlight the need for prevention and control efforts related to physical environmental factors, such as ensuring proper air temperature regulation and humidity control, to improve air quality in elementary schools. Control measures may include the use of air conditioning systems and effective ventilation management. By maintaining good air quality, it is expected that student health and overall academic performance can be enhanced.

Keywords : air temperature; humidity; air germ count; Public Elementary School; Sumbang I Health Center; Banyumas Regency.

INTRODUCTION

Health development efforts are carried out as an effort to increase the degree of public health which is carried out in an integrated, comprehensive and directed manner. The goal of health development is to realize a level of awareness, willingness and ability to live a healthy life for everyone in order to achieve a high degree of public health as an investment in the development of socially and economically productive human resources. (Government Regulation No. 66, 2014 in Priyambodo et al., 2023) .

The World Health Organization, University of Cambridge, and King's College London conducted a health study and found that air pollution in nursery , *preschool,* kindergarten and elementary school classrooms is worse than on the road. The function of the school as a place of learning can be a threat of disease transmission for students if not properly controlled (Priyambodo et al., 2023) .

Indoor air pollution can cause Upper Respiratory Tract Infection (ARI), chronic obstructive pulmonary disease, lung cancer, nasopharyngeal and laryngeal cancer, asthma and tuberculosis (Smith et al., 2004). Types of indoor air pollution that are harmful to health are carbon monoxide (CO), volatile organic compounds (VOC), aerosols, particulates (PM), biological pollutants and others (A'yun & Umaroh, 2023).

Data from the Central Java Provincial Health Office stated that the number of ARI cases in March 2020 was 121,237 cases with a proportion of 49.40% in toddlers and 50.60% in adults while the number of pneumonia cases in March 2020 was 6,768 cases with a proportion of 23 .37% in toddlers and 76.63% in adults. In 2020, 3,831 cases of ISPA were found in Banyumas Regency and 1,208 cases of pneumonia (Health Pocket Book of Central Java

Health Office, 2021).

Sumbang I Health Center is a health service agency located in Sumbang Village, Sumbang District, Banyumas Regency. The working area of the Sumbang I Health Center is 11 villages. Based on data from the Sumbang I Community Health Center in 2022, it was found that diseases that were transmitted by air transmission included ISPA cases in September 2022 totaling 189 cases in the age range 6-12 years and increasing in October 2022 to 233 cases. The age range of 6-12 years is the age of elementary school children. Observations made by researchers on January 3, 2023 obtained data on the number of public elementary schools in the Sumbang District area of 37 schools with a total of 7,364 students while the number of public elementary schools in the Work Area of the Sumbang I Health Center is 18 schools with a total of students totaling 3,682 students.

ISPA disease can be caused by unfavorable air microbiological conditions in the form of bacteria, algae and fungi. Bacteria that cause ARI include those from the genera Streptococcus, Pneumococcus and Staphylococcus (Suharti et al., 2013). Based on the description above, the researcher is interested in conducting research with the title "Relationship between Physical Environmental Factors and PM 2.5 Dust with Airborne Germ Rates in Public Elementary Schools in the Work Area of the Sumbang I Health Center, Banyumas Regency in 2023".

METHOD

This type of research is an observational study with a cross sectional analytic approach. The population in this study were all classes in Public Elementary Schools in the Work Area of the Sumbang I Health Center with a total population of 135 classes, namely Silado State Elementary School (6 classes), Karangturi State Elementary School (6 classes), Karangcegak State Elementary School (6 classes), Negeri 1 Sumbang (12 classes), SD Negeri 2 Sumbang (6 classes), SD Negeri 1 Banteran (12 classes), SD Negeri 2 Banteran (7 classes), SD Negeri 3 Banteran (6 classes), SD Negeri Datar (6 classes), SD Negeri Kawungcarang (6 classes), SD Negeri 1 Karanggintung (8 classes), SD Negeri 2 Karanggintung (6 classes), SD Negeri Kedungmalang (6 classes), SD Negeri 1 Kebanggan (12 classes), SD Negeri 2 Pride (6 classes), SD Negeri 1 Tambaksogra (12 classes), SD Negeri 2 Tambaksogra (6 classes), and SD Negeri 3 Tambaksogra (6 classes).

The sampling technique used is purposive sampling. Purposive sampling is a sampling technique by setting certain considerations and criteria for the sample to be taken. The criteria for determining the sample are class samples with short learning time and classes with longer learning time. Sampling in class 1 as representative for classrooms with short study time and class 6 sampling as representative for classrooms with longer learning time. Sampling of 2 points in each school was carried out so that the analysis results obtained were more representative. The number of samples in this study were 36 class samples.

RESULTS AND DISCUSSION

Weather And Climate

Public health center Discordant I is at in region Subdistrict Discordant Which own temperature highest daily with average 31˚C And season hot going on on month February until May whereas season cold going onon month June until August. Weather bright in subdistrict discordant happen onMay to August and October to May the weather tends to be cloudy. Season Rain going on on month October until May Which lasts for 6.6 months while the dry season lasts on month May until October during 5,4 month. (Wheaters sparks, 2022).

Measurement Temperature, humidity, And Air Germ Figures Classroom

1. Temperature

Measurement temperature in whole School Base Country All Region Work Sumbang I Community Health Center, totaling 18 Public Elementary Schools with a total of a sample of 36 classes was measured using a digital thermometer and obtained result as following :

Table 1 Results Temperature Measurement SD All Working Areas Public health center Sumbangt I

No	School name Base	Class	Temperature (˚C)	Category
1	SD Country Silado	1	30.00	Fulfil Condition
		6	29.00	Fulfil Condition
2	SD Country Karangturi	1	31.00	No Fulfil Condition
		6	31.00	No Fulfil Condition
3	SD Karangcegak Country	1	29.00	Fulfil Condition
		6	28.00	Fulfil Condition
4	SD Country 1 Contribute	1	30.00	Fulfil Condition
		6	29.00	Fulfil Condition
5	SD Country 2 Donate	1	31.00	No Fulfil Condition
		6	31.00	No Fulfil Condition
6	SD Country 1 Banter	1	25.00	Fulfil Condition
		6	27.00	Fulfil Condition
7	SD Country 2 Banter	1	31.00	No Fulfil Condition
		6	31.00	No Fulfil Condition
8	SD Country 3 Banter	1	31.00	No Fulfil Condition
		6	30.00	Fulfil Condition
9	Flat State Elementary School	1	31.00	No Fulfil Condition
		6	31.00	No Fulfil Condition
10	SD Kawungcarang Country	1	31.00	No Fulfil Condition
		6	30.00	Fulfil Condition
11	SD Country 1 Karanggintung	1	31.00	No Fulfil Condition
		6	31.00	No Fulfil Condition
12	SD Country 2 Karanggintung	1	30.00	Fulfil Condition
		6	30.00	Fulfil Condition
13	SD Country Kedungmalang	1	32.00	No Fulfil Condition
		6	32.00	No Fulfil Condition
14	SD Country 1 Pride	1	32.00	No Fulfil Condition
		6	32.00	No Fulfil Condition
15	SD Country 2 Pride	1	29.00	Fulfil Condition
		6	30.00	Fulfil Condition
16	SD Country 1 Tambaksogra	1	31.00	No Fulfil Condition
		6	32.00	No Fulfil Condition
17	SD Country 2 Tambaksogra	1	29.00	Fulfil Condition
		6	30.00 _	Fulfil Condition
18	SD Country 3 Tambaksogra	1	32.00	No Fulfil Condition
		6	32.00	No Fulfil Condition

Results of temperature measurements in class 1 and class 6 throughout the school Based on the State of the Working Area of the Sumbang I Health Center, 16 classrooms were obtained (44,4 %) Which fulfil condition And 20 room class (55,6 %) Which No fulfil condition. The temperature of the classroom is declared to meet the requirements according to the Regulations Minister Health Number 2 Year 2023 that is range between 18-30˚C. Temperature measurement in grade 1 and grade 6 rooms in all public elementary schools The entire working area of the Sumbang I Health Center obtained measurement results with average as big 30.3˚C, median as big 31˚C, mode as big 31˚C, And standard error 0.25˚C. The lowest temperature measurement results are 25˚C and results measurement highest i.e. 32˚C.

2. Humidity

Measurement of humidity in all State Elementary Schools throughout the Region The work of the Sumbang I Health Center, which totals 18 Public Elementary Schools with amount sample as much 36 class be measured with use hygrometer digitalAnd the following results are obtained:

Table 2. SD Humidity Measurement Results The Health Center Work AreaSumbang I

No	School name Base	Class	Clamp father(%)	Category
1	SD Country Silado	1	66.00	No Fulfil Condition
		6	83.00	No Fulfil Condition
2	SD Karangturi Country	1	58.00	Fulfil Condition
		6	59.00	Fulfil Condition
3	SD Karangcegak Country	1	57.00	Fulfil Condition
		6	62.00	No Fulfil Condition
4	SD Country 1 Contribute	1	57.00	Fulfil Condition
		6	62.00	No Fulfil Condition
5	SD Country 2 Donate	1	66.00	No Fulfil Condition
		6	72.00	No Fulfil Condition
6	SD Country 1 Banter	1	63.00	No Fulfil Condition
		6	64.00	No Fulfil Condition
7	SD Country 2 Banter	1	44.00	Fulfil Condition
		6	44.00	Qualify
8	SD Negeri 3 Banteran	1	63.00	Not eligible
		6	44.00	Qualify
9	Flat State Elementary School	1	64.00	Not eligible
		6	63.00	Not eligible
10	Kawungcarang State Elementary School	1	52.00	Qualify
		6	50.00	Qualify
11	SD Negeri 1 Karanggintung	1	50.00	Qualify
		6	59.00	Qualify
12	SD Negeri 2 Karanggintung	1	61.00	Not eligible
		6	57.00	Qualify
13	SD Negeri Kedungmalang	1	62.00	Not eligible
		6	61.00	Not eligible
14	SD Negeri 1 Pride	1	64.00	Not eligible
		6	74.00	Not eligible
15	SD Negeri 2 Pride	1	60.00	Qualify
		6	61.00	Not eligible
16	SD Negeri 1 Tambaksogra	1	62.00	Not eligible
		6	64.00	Not eligible
17	SD Negeri 2 Tambaksogra	1	39.00	Not eligible
		6	39.00	Not eligible
18	SD Negeri 3 Tambaksogra	1	67.00	Not eligible
		6	66.00	Not eligible

The results of humidity measurements in class 1 and class 6 rooms throughout State Elementary Schools in the Work Area of the Sumbang I Health Center obtained 13 room class (13 %) Which fulfil condition And 23 room class (63.9%) Which No qualify. Classroom humidity is declared to meet the appropriate requirements with Regulation of the Minister of Health Number 2 of 2023, which ranges from 40-60%. Measurement humidity in room class 1 And class 6 in whole SchoolBase Country All Region Work Public health center Discordant I obtain results measurements with an average of 59.4%, a median of 61.5%, mode of 62%, and a standard error of 1.5%. Lowest humidity measurement results that is 39 % and measurement results highest that is 83 %.

3. Number of bacteria Air

Measurement of the number of airborne germs in all Public Elementary Schools throughout The working area of the Sumbang I Community Health Center, which consists of 18 Public Elementary Schools with amount sample as much 36 class be measured with use *Water Microbiology Samplers* and obtained results as follows :

Table 3. Results of Measurement of Elementary School Air Germs Numbers All Working Areas Public health center Sumbang I

No	School name Base	ExUS	NumberGerms Air(CFU/ m^3)	Category
1	SD Country Silado	1	505.00	Fulfil Condition
		6	731.00	No Fulfil Condition
2	SD Country Karangturi	1	391.00	Fulfil Condition
		6	537.00	Fulfil Condition
3	SD Karangcegak Country	1	571.00	Fulfil Condition
		6	708.00	No Fulfil Condition
4	SD Country 1 Contribute	1	556.00	Fulfil Condition
		6	610.00	Fulfil Condition
5	SD Country 2 Donate	1	401.00	Fulfil Condition
		6	588.00	Fulfil Condition
6	SD Country 1 Banter	1	727.00	No Fulfil Condition
		6	818.00	No Fulfil Condition
7	SD Country 2 Banter	1	665.00	Fulfil Condition
		6	699.00	Fulfil Condition
8	SD Country 3 Banter	1	803.00	No Fulfil Condition
		6	638.00	Fulfil Condition
9	Flat State Elementary School	1	708.00	No Fulfil Condition
		6	711.00	No Fulfil Condition
10	SD Country Kawungcarang	1	445.00	Fulfil Condition
		6	601.00	Fulfil Condition
11	SD Country 1 Karanggintung	1	97.00	Fulfil Condition
		6	209.00	Fulfil Condition
12	SD Country 2 Karanggintung	1	751.00	No Fulfil Condition
		6	418.00	Fulfil Condition
13	SD Country Kedungmalang	1	66.00	Fulfil Condition
		6	303.00	Fulfil Condition
14	SD Country 1 Pride	1	317.00	Fulfil Condition
		6	668.00	Fulfil Condition
15	SD Country 2 Pride	1	521.00	Fulfil Condition
		6	778.00	No Fulfil Condition
16	SD Country 1 Tambaksogra	1	289.00	Fulfil Condition
		6	593.00	Fulfil Condition
17	SD Country 2 Tambaksogra	1	71.00	Fulfil Condition
		6	118.00	Fulfil Condition
18	SD Country 3 Tambaksogra	1	515.00	Fulfil Condition
		6	401.00	Fulfil Condition

The results of measuring the number of air germs in class 1 and class 6 in whole School Base Country All Region Work Public health center Discordant I obtained27 room class (75 %) Which fulfil condition And 9 room class (25 %) Which does not meet the requirements. Classroom air germicidal numbers are declared eligible in accordance with Regulation of the Minister of Health Number 2 of 2023, which is equal to 700 CFU/m^3 . Measurement of airborne germ numbers in class 1 and class 6 at whole School Base Country All Region Work Public health center Discordant I obtained measurement results with an average of 514.67 CFU/m^3, the median 563.5 CFU/m^3, mode 401 CFU/m^3, and standard error 36.16 CFU/m^3. Results number germs air Lowest that is 66 CFU/ m^3 And results measurement highest i.e. 818 CFU/m^3.

Analysis Connection Temperature With Number Germs Air

The requirements of the simple linear regression statistical test are that the data must be distributed normal. Data results study tested normality For know that data fulfil condition. Results test normality temperature with number germs air obtained results 0.20 Which meaning that the significance value is > 0.05 and the data is normally distributed. Distributed data normal can next analysis test statistics regression linear simple with use software SPSS data processing version 26 that is as following:

Table 4. Relationship Analysis temperature with Number Germs Air

No	School name Base	Class	Temperature (˚C)	Air Germ Figures(CFU/m ^{3})
1	SD Country Silado	1	30.00	505.00
		6	29.00	731.00
2	SD Country Karangturi	1	31.00	391.00
		6	31.00	537.00
3	SD Karangcegak Country	1	29.00	571.00
		6	28.00	708.00
4	SD Country 1 Contribute	1	30.00	556.00
		6	29.00	610.00
5	SD Country 2 Donate	1	31.00	401.00
		6	31.00	588.00
6	SD Country 1 Banter	1	25.00	727.00
		6	27.00	818.00
7	SD Country 2 Banter	1	31.00	665.00
		6	31.00	699.00
8	SD Country 3 Banter	1	31.00	803.00
		6	30.00	638.00
9	Flat State Elementary School	1	31.00	708.00
		6	31.00	711.00
10	SD Country Kawungcarang	1	31.00	445.00
		6	30.00	601.00
11	SD Negeri 1 Karanggintung	1	31.00	97.00
		6	31.00	209.00
12	SD Negeri 2 Karanggintung	1	30.00	751.00
		6	30.00	418.00
13	SD Negeri Kedungmalang	1	32.00	66.00
		6	32.00	303.00
14	SD Negeri 1 Pride	1	32.00	317.00
		6	32.00	668.00
15	SD Negeri 2 Pride	1	29.00	521.00
		6	30.00	778.00
16	SD Negeri 1 Tambaksogra	1	31.00	289.00
		6	32.00	593.00
17	SD Negeri 2 Tambaksogra	1	29.00	71.00
		6	30.00	118.00
18	SD Negeri 3 Tambaksogra	1	32.00	515.00
		6	32.00	401.00

Table 5. Results Bivariate Analysis Temperature with Number Germs Air

R	R 2	Sig	Unstandardized B	
			Constant	Temperature
0.341	0.116	0.042	1999.483	-48.950

The results of the analysis of simple linear regression tests to analyze the temperature relationship with the number of airborne germs, the value of p = 0.042 is obtained, which means that the value of p <0.05 thenIt was stated that there was a significant relationship between temperature and the number of air germs. The R value was obtained at 0.341, which means the degree of relationship between temperature and numbers Airborne germs fall into the low relationship category. The value of R ^{2} is obtained by 0.116 which can be interpreted that the temperature contributed 11.6% and the remaining 88.4% was caused by other variables. Relationship line equation temperature with airborne germs that is Y = 1999,483+ (-48,950) X.

Analysis of the Relationship of Humidity with Air Germ Numbers

The requirements of the simple linear regression statistical test are that the data must be distributed normal. Data results study tested normality For know that data fulfilcondition. The results of the humidity normality test with airborne germ numbers obtained results 0.20 Which It means mark its significance > 0.05 And data distributed normal. Data distributed normal can next analysis test statistics regression linear simple with use software processing data SPSS version 26 that is as following:

Table 6. Analysis of the Relationship between Humidity and Air Germ Numbers

No	Elementary School Name	Class	humidity (%)	Air Germ Rate (CFU/m ^{3})
1	Silado State Elementary School	1	66.00	505.00
		6	83.00	731.00
2	Karangturi State Elementary School	1	58.00	391.00
		6	59.00	537.00
3	Karangcegak State Elementary School	1	57.00	571.00
		6	62.00	708.00
4	SD Negeri 1 Sumbang	1	57.00	556.00
		6	62.00	610.00
5	SD Negeri 2 Sumbang	1	66.00	401.00
		6	72.00	588.00
6	SD Negeri 1 Banteran	1	63.00	727.00
		6	64.00	818.00
7	SD Negeri 2 Banteran	1	44.00	665.00
		6	44.00	699.00
8	SD Negeri 3 Banteran	1	63.00	803.00
		6	44.00	638.00
9	Flat State Elementary School	1	64.00	708.00
		6	63.00	711.00
10	Kawungcarang State Elementary School	1	52.00	445.00
		6	50.00	601.00
11	SD Negeri 1 Karanggintung	1	50.00	97.00
		6	59.00	209.00
12	SD Negeri 2 Karanggintung	1	61.00	751.00
		6	57.00	418.00
13	SD Negeri Kedungmalang	1	62.00	66.00
		6	61.00	303.00
14	SD Negeri 1 Pride	1	64.00	317.00
		6	74.00	668.00
15	SD Negeri 2 Pride	1	60.00	521.00
		6	61.00	778.00
16	SD Negeri 1 Tambaksogra	1	62.00	289.00
		6	64.00	593.00
17	SD Negeri 2 Tambaksogra	1	39.00	71.00
		6	39.00	118.00
18	SD Negeri 3 Tambaksogra	1	67.00	515.00
		6	66.00	401.00

Table 7. Results Bivariate Analysis humidity with Number Germs Air

R	R 2	Sig	Unstandardized B	
			Constant	humidity
0.343	0.118	0.040	42.216	7.951

Results analysis test regression linear simple For analyze connectionhumidity with number germs air obtained mark p.s = 0.040 Which It means mark p.s < 0.05 so stated There is connection Which significant between humidity with airborne germs. The R value was obtained at 0.343 which means the level of relationship humidity with the number of air germs fall into the category of low relationship. Mark R^2 obtained as big 0.118 Which can interpreted that humidity give contribution of 11.8% and the remaining 88.2% caused by other variables.Equality line connection humidity with number germs air that is Y = 42,216 +7,951X.

Multivariate Relationship Analysis Between Temperature, Humidity, and Number Air Germs

Model 1 obtained the results of variable temperature, and humidity, namely with a significance value of 0.007 and an R-value of 0.733 which means that the level of relationship between temperature, humidity, and the number of air germs is included in the category of strong relationships. The R2 value is obtained at 0.537 which can be interpreted that temperature, and humidity, contribute 53.7% and the remaining 46.3% is caused by other variables. Equation of line Y = 1299.374 + (-47.580) X1 + 8.569 X2. This analysis suggests that both temperature and humidity have a substantial influence on the airborne germ count. The strong relationship between these variables indicates that changes in temperature and humidity are likely to have a noticeable impact on the level of airborne germs. However, it is important to note that there are other factors not included in this analysis that also contribute to the airborne germ count.

CONCLUSIONS

Research on the Relationship between Physical Environmental Factors and PM 2.5 Dust with Airborne Germ Rates in State Elementary Schools in the Working Area of the Sumbang I Health Center, Banyumas Regency 2023 which has been carried out, can be drawn the following conclusions:

Average temperature (30.3˚C); does not meet the requirements (55.6%), average humidity (59.42%); does not meet the requirements (63.9%), and the average number of airborne germs was (514.67 CFU/m3); qualified (75%). There is a significant relationship between temperature and the number of air germs. The p value is 0.042, the R value is 0.341 and the line equation for the relationship between temperature and the number of airborne germs is Y = 1999.483 + (-48.950) X. There is a significant relationship between humidity and the number of air germs. The p value is 0.040, the R value is 0.343 and the equation for the line between humidity and airborne germ numbers is Y = 42.216 + 7.951X. Multivariate analysis obtained results in model 1, namely the variables of temperature, humidity, lighting with a significance value of 0.007 and an R value of 0.733, which means the level the relationship between temperature, humidity with airborne germ rate is included in the category of strong relationship. The R2 value was obtained at 0.537 which could mean that temperature, humidity contributed 53.7% and the remaining 46.3%. caused by other variables. The equation for the line Y = 1299.374 + (- 47.580) X1 + 8.569 X2

REFERENCE

Maisuningtyas, PD, & Ratna, Y. (2021). Relationship Between Humidity Levels and Indicators of Air Germs in Al-Firdaus Elementary School Classrooms Samarinda. *Borneo Student Research* , *2* (2), 1145–1153.

Nurlaela, N., Rudijanto, H., & Yulianto, Y. (2022). Physical Environmental Factors Associated with Airborne Germ Rates at Uptd Puskesmas Bojongsari Purbalingga Regency in 2022. *Public Health Bulletin* , *41* (2), 92–99. https://doi.org/10.31983/keslingmas.v41i2.8691

Priyambodo, A., Health, P., Semarang, K., & Health. (2023). *The Relationship between Physical Environmental Factors and Airborne Germ Rates in State Elementary Schools in the Work Area of the Sumbang I Health Center, Banyumas Regency in 2023* . Semarang Ministry of Health Health Polytechnic .

Qin, L., Huang, CH, Liu, CQ, Zhao, CF, Li, PL, Tang, TS, Li, J., Xie, LN, Shao, B., Shao, J., Mao, L., Li , R., Zhang, L., & Zhu, BZ (2023). Molecular mechanism for the activation of the potent hepatotoxin acetylhydrazine: Identification of the initial N-centered radical and the secondary C-centered radical intermediates. *Free Radical Biology and Medicine* , *204* (April), 20–27. https://doi.org/10.1016/j.freeradbiomed.2023.04.010

Syamiyah, N., & Wahyuni, S. (2021). Indoor Air Pollution (Carbon Dioxide and Total Volatile Organic Compounds) and Lung Problems in Elementary School Students in Depok. *JOUBAHS Journal* , *1* (2), 126–140.

Visentin, M., Pagnoni, A., Sarti, E., & Pietrogrande, MC (2016). Urban PM2.5 oxidative potential: Importance of chemical species and comparison of two spectrophotometric cell-free assays. *Environmental Pollution* , *219* , 72–79. https://doi.org/10.1016/j.envpol.2016.09.047

Yu, SY, Liu, WJ, Xu, YS, Yi, K., Zhou, M., Tao, S., & Liu, WX (2019). Characteristics and oxidative potential of atmospheric PM2.5 in Beijing: Source apportionment and seasonal variation. *Science of the Total Environment* , *650* , 277–287. https://doi.org/10.1016/j.scitotenv.2018.09.021

Yuliarti, OA, Cahyono, T., & Mulyasari, TM (2020). Factors Associated with Airborne Germ Figures in Public Elementary Schools, Baturraden District. *Public Health Bulletin* , *39* (1), 13–22. https://doi.org/10.31983/keslingmas.v39i1.4537