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The Effect of *Sansevieria* Plant on Particulate Matter 2.5 Levels in Classroom

Sutrisno[1]✉, Guswan Wiwaha[2], Yulia Sofiatin[2]
[1]Public Health Study Program, Faculty of Medicine, Padjdjaran University, Indonesia
[2]Department of Public Health, Faculty of Medicine, Padjadjaran University, Indonesia

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Abstract

The Poor physical environment is the main cause of acute respiratory infections that result in death in school children aged 5 to 14 years due to exposure to PM2.5 at school. The improvement of the school's physical environment from high PM2.5 pollution is to involve the school community in planting Sansevieria Trifasciata as a solution to reducing PM2.5 pollution. This study aims to analyze the significance of differences in the physical environmental conditions of the Ciranjang 1 State Elementary School, Cianjur Regency, on the level of respiratory susceptibility of students seen from PM2.5 levels before and after the placement of Sansevieria Trifasciata. The study used 2 test classes and 1 control class. The study duration was 24 hours with two measurements, namely at the pretest and posttest. Data analysis used the Ancova one-way test followed by the Post-Hock test. The placement of 8 pots of Sansevieria Trifasciata was able to absorb PM2.5 compared to 6 pots of Sansevieria trifasciata. There is an effective and significant absorption of PM2.5 pollutants by placing 8 pots of Sansevieria trifasciata plants in a 49m2 classroom, which is 29µgr/m3 on the respiratory vulnerability level of Ciranjang 1 State Elementary School students, Cianjur Regency.

Introduction

Transportation has an important role as a source of air pollution. Commuters' exposure to concentrations of traffic-related air pollutants, including PM2.5, is generally higher due to their proximity to less dispersed emissions from mobile sources (Kumar et al., 2018). WHO estimates that 25% of all childhood diseases worldwide are caused by modifiable environmental factors (Cohen Hubal et al., 2020). The poor physical environment is the main cause of acute respiratory infections. Acute and chronic human exposure to ambient PM exposes receptors to high-risk diseases, including asthma, lung cancer, heart disease, stroke, type II diabetes, dementia, and loss of cognitive functions (Loxham and Nieuwenhuijsen, 2019). Pollutants produced by motorized vehicles are generally particulate matter (PM) (Tartakovsky et al., 2013). These particles can infiltrate the building even when the doors and windows are closed. Schoolchildren spend most of their time studying in the classroom. The air they breathe inside the school may be more polluted than the air outside. A contaminated school environment can cause or exacerbate health problems, including short-term health effects such as respiratory infections or asthma. It can reduce student attendance at school and learning abilities.

Research conducted in the Netherlands showed an increase in mortality associated with exposure to PM2.5 found indoors from vehicle emissions for people living at a distance of 50m from the main road or 100m from a highway (Hoek et al., 2002). Research in France proves a positive correlation between increasing respiratory problems in school children with high concentrations of PM2.5 in the classroom (Annesi-Maesano et al., 2012). Vehicle emissions were found to be higher in

✉ Correspondence Address:
Public Health Study Program, Faculty of Medicine, Padjdjaran University, Indonesia
Email : sutrisno20001@mail.unpad.ac.id

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schools located close to the highway than in schools located at a considerable distance from the highway (Kalaiarasan et al., 2017). Research conducted by Franklin (2007) stated that the concentration of indoor air pollution tends to be higher than outdoors. It is one of the causes of Acute Respiratory Infection (ARI) caused by exposure to PM2.5 in children (Franklin, 2007).

The school community should be aware of the environmental risks in schools and the importance of creating and maintaining a healthy physical school environment to protect the health of children and others who spend time in their schools. Thus, educators, planners, and school administrators must recognize ways to make the school environment safer. Improving children's environmental health can be realized by creating a healthy physical environment (Little et al., 2019). One of them is by engineering or modifying the physical environment in the classroom. Engineering or modification can be applied to create conditions for the school's physical environment to avoid high levels of PM2.5 pollution by involving the school community to plant that can absorb air pollution. Ornamental plants are one of the natural resources that exist in the community which can be used as a reliable and cost-effective solution to reduce pollution and improve air quality (Janhäll, 2015). In real situations, mixed pollutants pollute the indoor air, resulting in the application of technology phytoremediation to remove mixed pollutants requires further evaluation. A study of the efficacy of phytoremediation on air pollution mixture is needed to design a phytoremediation system appropriate and effective that can be used on an ongoing basis. Different plant species exhibit the ability to remove different air pollutants. Therefore, the selection of plant species can also be an vital factor for botanical biofilters (Irga et al., 2019).

A study to see the ability of Sansevieria Trifasciata to reduce PM2.5 concentrations was carried out by Siswanto et al (2020). Sansevieria Trifasciata can reduce PM2.5 concentrations in the room (Siswanto et al., 2020). Sansevieria plants don't need a lot of light or water to survive, so they can be used to filter out PM2.5 pollutants indoors (Kulkarni and Zambare, 2018). Sansevieria plant care is easy to make this plant suitable for school children to help reduce it in the classroom. Ciranjang 1 State Elementary School is an elementary school located on the edge of the highway, precisely on the Cianjur-Bandung national road, Cianjur Regency, with a fairly high level of vehicle density. This condition could make the condition of the physical environment of the classroom worse and can affect the level of respiratory vulnerability of students at school. Based on this background, the researcher intends to analyze the condition of the physical environment of the Ciranjang 1 State Elementary School, Cianjur Regency, on the level of respiratory susceptibility of students seen from PM2.5 levels before and after the placement of Sansevieria Trifasciata.

Method

The research design used in this study is quasi-experimental in the form of a nonequivalent control group design. In this design, the experimental and the control group was selected randomly. Two groups will be given a pretest, a treatment, and a post-test. The population in this study is an elementary school classroom located near a highway in the Cianjur Regency area. The sample used in this study was a classroom at Ciranjang 1 State Elementary School, Cianjur Regency. The sample was taken purposively by determining the elementary school that met the research criteria, namely the Ciranjang 1 State Elementary School, Cianjur District. The inclusion criteria in this study were: Classrooms in Ciranjang 1 State Elementary School, Cianjur Regency, permanent classroom walls are made of walls, the distance between the classroom and the road is less than 100 meters, and the classroom is used as a place for teaching and learning. The independent variable in this study is Sansevieria Trifasciata. The dependent variable in this study was the concentration of PM2.5 in the classrooms of the Ciranjang 1 State Elementary School, Cianjur Regency. The confounding variables in this study were temperature and humidity.

The planting media used in this study consisted of soil, manure, and rice husks with a ratio of 2:1:1. Planting media is placed in plastic pots with the same quantity of planting media in each pot. Sansevieria Trifasciata plants with 4 leaves and 50-100cm leaf size were placed in each plastic pot filled with planting media. Sansevieria plants were isolated for one week indoors to avoid contamination from pollutants before being used as samples. The research room prepared consisted of three classes, namely two classrooms for sample testing and one classroom for control. The area of the research sample testing room is 49m2. Each plastic pot containing planting media and Sansevieria trifasciata plants was placed on the floor of the classroom. The number in test room 1 was 8 pots, in test room 2 as many as 6 pots, and 6 pots containing only planting media without Sansevieria Trifasciata plants.

The research took duration for one day or 24 hours. Refers to the rules set by the Regulation of the Minister of Health of the Republic of Indonesia and WHO that the PM2.5 quality standard in the room is calculated on average per 24 hours (WHO, 2006). In carrying out the research, Sansevieria Trifasciata plants and planting media were placed on the research class floor. The number of Sansevieria plants in test room 1 was 8 pots, the test classroom 2 was 6 pots, and in the control room were 6 pots of growing media without Sansevieria Trifasciata. Measurements were made when teaching and learning activities took place, namely PM2.5 concentration, temperature, and humidity. During the research, 2 (two) measurements were taken, namely the initial measurement before placing the planting medium (for the control room) and before placing the Sansevieria Trifasciata plant sample (for the test class) and measuring at the end of the 24th hour. Initial measurements were carried out to determine PM2.5 pollutant levels in the control and experimental class before being influenced by the presence of planting media and Sansevieria Trifasciata plants. Measurements at the end of the 24th hour were carried out to see the effectiveness of Sansevieria Trifasciata in absorbing PM2.5 pollutants because the Botanic Filter's performance could effectively be seen after 24 hours (Siswanto et al., 2020). In addition, based on the rules set by the Regulation of the Minister of Health and WHO that the PM2.5 quality standard in the room is calculated on average per 24 hours. The measurement time duration is 119 seconds for each measurement point. Measurements were carried out at as many as 5 (five) points for each sample and control classroom at approximately 110 cm height from the floor with close consideration of the respiratory system when sitting (Siswanto et al., 2020). The data from the measurements and observations are then recorded in the format provided.

Analysis of the data to answer whether there is a significant difference between the physical environmental conditions of the Ciranjang 1 State Elementary School, Cianjur Regency, on the respiratory susceptibility of students seen from PM2.5 levels before and after the placement of Sansevieria Trifasciata using the one-way ANCOVA test. This one-way ANCOVA test was carried out because other variables could not be controlled. So it needed to be controlled statistically. Before the one-way ANCOVA test was carried out, the normality, homogeneity, and linearity were first tested. After the data were normal, homogeneous, and linear, the one-way ANCOVA test was carried out. Based on the results of the one-way ANCOVA test, there were significant differences in PM2.5 levels before and after placement of Sansevieria Trifasciata,

This research took place in Ciranjang 1 Public Elementary School, Cianjur Regency, using three classrooms, namely class 5 and class 6 as the test classroom and class 4 as the control classroom. Data collection began on July 18, 2022, while measurements of PM2.5 levels took time on July 26 and 27, 2022. This research has obtained research ethics permit from the Research Ethics Commission of Padjadjaran University Bandung with number 636/UN6. KEP/EC/2022. The prerequisite test was carried out before the Ancova test to see residual normality, homogeneity of variance, linearity of correlation between dependent variables, and homogeneity of regression coefficients. Based on the results of the residual normality test using SPSS 24, the following results were obtained:

Table 1. The Prerequisite Result was Carried Out Before Carrying Out the Ancova Test

1. Residual Normality

Kolmogorov-Smirnova			Shapiro-Wilk		
Statistics	df	Sig.	Statistics	df	Sig.
.195	15	.128	.939	15	.373

a. Lilliefors Significance Correction

2. Homogeneity of Variance

Dependent Variable: Post-test

F	df1	df2	Sig.
1.842	2	12	.201

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.
a. Design: Intercept + Pre + Class

3. Regression Coefficient Homogeneity

Dependent Variable: Post-test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2224,240a	5	444,848	73.201	.000	.976
Intercept	.986	1	.986	.162	.696	.018
Class	19,449	2	9.725	1,600	.254	.262
Pre	102,400	1	102,400	16,850	.003	.652
Class * Pre	15,860	2	7,930	1.305	.318	.225
Error	54,693	9	6.077			
Total	88767,000	15				
Corrected Total	2278,933	14				

a. R Squared = .976 (Adjusted R Squared = .963)

Based on the Residual Normality table, the significance value obtained from the results of the Kolmogorov-Smirnov test is 0.128, and based on the results of the Shapiro-Wilk test is 0.373. It exceeds the required significance level of more than 0.05. Thus, the concentration of PM2.5 is normally distributed. Based on the Homogeneity of Variance table, the significance value obtained from the results of Levene's Test to see residual normality is 0.201. It exceeds the required significance level of more than 0.05. Thus, the variances of the three groups (test class 1, test class 2, and control class) are homogeneous.

Based on the Regression Coefficient Homogeneity Table, regarding the results of the homogeneity of the regression coefficients, it is found that the interaction between class (test and control) and covariate (Class*Pre) has a significance value of 0.318 exceeding a significance level of 0.05. Thus, the H0 test decision is accepted with the conclusion that the regression coefficients of the three groups (test class 1, test class 2, and control) are homogeneous. The regression coefficient homogeneity is met. It means that if there is no significant interaction, then the pretest value can be used as a covariate in the study. The linearity of the covariate correlation to the dependent variable (PM2.5 levels in class) from test class 1, test class 2, and control class can be seen below:

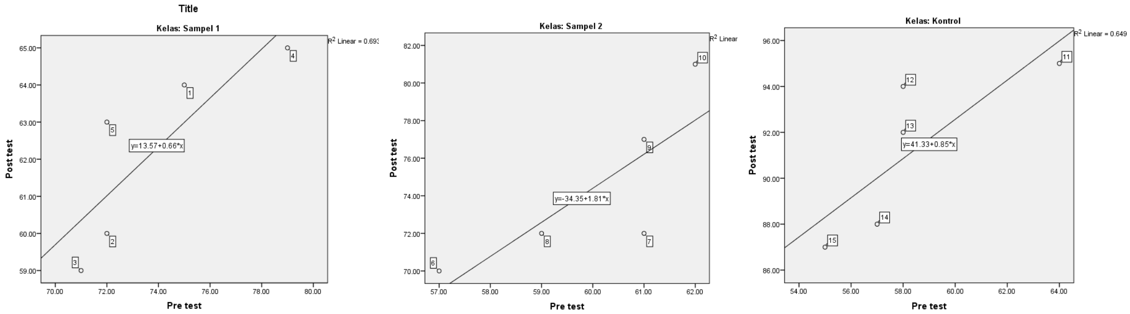

Figure 1. Scatter Plot Test The linearity of the covariate correlation

Based on Figure 1 regarding the Scatter Plot, the measurement results from a total of 15 points with each class carried out 5 measurement points, namely for test class 1, test class 2, and control class. The graph shows a straight line pattern to above. It can be concluded that the relationship or regression between the covariate (pretest) and the dependent variable (posttest) is linear.

Results and Discussion

The measurement of the research sample was carried out in test classroom 1, test classroom 2, and the control classroom. Each classroom was measured twice, at the pretest and posttest at the end of the 24th hour. Each measurement was carried out at 5 predetermined points for each test and control class. The results of measuring the concentration of PM2.5 in test classroom 1, test classroom 2, and control classroom are as follows:

Table 2 shows that before the intervention PM2.5 conditions, the temperature and humidity of the classrooms were different. PM2.5 was highest in test class 1 and lowest in the control class, the highest temperature in test class 2, lowest in test class 1, highest humidity in test class 1, and lowest in test class 2. After 24 hours of intervention, there was a change in PM2.5 conditions, temperature, and humidity. The highest PM2.5 was in the control class, the lowest was in test class 1, the highest temperature was in the control class, the lowest was in test class 1, the highest humidity was in test class 1, and the lowest was in the control class. As additional information, during the Post-test measurement, there were different situations in the school environment, namely more traffic jams than usual and cloudy weather. This test is carried out with the consideration that there is a possibility that the pretest results are influenced by variables that can affect the final or post-test results. Ancova's one-way test results can be seen in table 5 below:

Table 2. Results of Measurement of $PM_{2.5}$ Concentration, Temperature, and Humidity

Measuring Point	Measurement results								
	Control Class			Test Class 1			Test Class 2		
	$PM_{2.5}$	^oC	Rh	$PM_{2.5}$	^oC	Rh	$PM_{2.5}$	^oC	Rh
Pre-test									
Point 1	64	30.5	71	75	27	75.4	57	30.3	68.8
Point 2	58	29.4	70.3	72	27.5	74.3	61	30.6	67.4
Point 3	58	29.7	69.4	71	28.1	73.5	59	30.8	68.3
Point 4	57	30	69.2	79	28.6	71.9	61	31	66.5
Point 5	55	30.2	68.5	72	29.1	71.9	62	31.1	67.1
Average	58.4	29.96	69.68	73.8	28.06	73.4	60	30.3	68.8
Intervention	Planting media 6 pots			8 pots Test Plant			6 pots Test Plant		
Post-test									
Point 1	95	29.7	72.2	64	27.2	78.7	70	28.9	74
Point 2	94	29.8	71.8	60	27.6	78.1	72	29.1	73.3
Point 3	92	29.9	71.7	59	28	77.2	72	29.3	72.9
Point 4	88	30	71.8	65	28.4	75.8	77	29.5	73.2
Point 5	87	30	71.1	63	28.7	74.9	81	29.6	72.3
Average	91.2	29.88	71.72	62.2	27.98	76.94	74.4	29.28	73.14

Table 2 shows that before the intervention PM2.5 conditions, the temperature and humidity of the classrooms were different. PM2.5 was highest in test class 1 and lowest in the control class, the highest temperature in test class 2, lowest in test class 1, highest humidity in test class 1, and lowest in test class 2. After 24 hours of intervention, there was a change in PM2.5 conditions, temperature, and humidity. The highest PM2.5 was in the control class, the lowest was in test class 1, the highest temperature was in the control class, the lowest was in test class 1, the highest humidity was in test class 1, and the lowest was in the control class. As additional information, during the Post-test measurement, there were different situations in the school environment, namely more traffic jams than usual and cloudy weather. This test is carried out with the consideration that there is a possibility that the pretest results are influenced by variables that can affect the final or post-test results. Ancova's one-way test results can be seen in table 5 below:

Table 3. One-way ANCOVA Test Results

Tests of Between-Subjects Effects

Dependent Variable: Post-test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2208.380a	3	736,127	114.770	.000	.969
Intercept	7.240	1	7.240	1,129	.311	.093
Pre	88,247	1	88,247	13,759	.003	.556
Class	1052,931	2	526,466	82.081	.000	.937
Error	70,553	11	6.414			
Total	88767,000	15				
Corrected Total	2278,933	14				

a. R Squared = .969 (Adjusted R Squared = .961)

Based on the one-way ANCOVA test results table (Test of Between-Subjects Effects table) shows the significance level of the pretest covariate (covariate) of 0.003 less than 0.005. The significance level indicates that the pretest covariate (covariate) affects the posttest PM2.5 concentration. The class or independent variable (Sansevieria) was F=82,081 and =0,000. The significance level is less than 0.05, meaning that by controlling the pretest, there is a significant difference between the concentration of PM2.5 in test class 1 (8 pots of Sansevieria), test class 2 (6 pots of Sansevieria), and control class (6 pots of growing media). The results of the one-way ANCOVA test show a significant difference between the concentration of PM2.5 in test class 1 (8 pots of Sansevieria), test class 2 (6 pots of Sansevieria), and control class (6 pots of growing media). It is necessary to continue with the Post Hoc test to find out the different values of each sample to find which one is effective in reducing PM2.5 levels in the classroom. Post Hoc test results are in the following table:

Table 4. Post Hoc Test

Dependent Variable: Post-test

	(I) Class	(J) Class	Mean Difference (IJ)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Bonferroni	Sample 1	Sample 2	-12.20000*	2.30072	.001	-18.5948	-5.8052
		Control	-29,0000*	2.30072	.000	-35.3948	-22.6052
	Sample 2	Sample 1	12.20000*	2.30072	.001	5.8052	18.5948
		Control	-16.80000*	2.30072	.000	-23.1948	-10.4052
	Control	Sample 1	29,00000*	2.30072	.000	22.6052	35.3948
		Sample 2	16.80000*	2.30072	.000	10.4052	23.1948

*. The mean difference is significant at the 0.05 level.

Based on table 4, the Post-Hoc test results using the Bonferroni method show that the test class 1, test class 2, and control all have a significance value of less than 0.05. Thus, the sample and control have significant differences. Meanwhile, the difference in the mean levels of PM2.5 in the post-test measurement class in test room 1 decreased by 11.6μgr/m3 compared to the pretest measurement results. The results of post-test measurement in test room 2 experienced an increase in PM2.5 levels in the room by 14.4μgr/m3 compared to the pretest measurement results. Meanwhile, the results of post-test measurement in the control room experienced an increase in PM2.5 levels by 32.8μgr/m3 compared to the pretest measurement results.

The pretest measurement found that PM2.5 levels in test room 1 were the highest. Then the second order was in sample room 2, and the lowest PM2.5 levels were in the control room. This concentration difference is affected by the distance of the classroom from the highway. Test room 1 is 8m from it, test room 2 is 15m from it, and the control classroom is 22m from it. The concentration of PM2.5 in the school environment decreases with increasing distance between the measurement location point and the highway. Vehicle emissions were higher in schools located close to the highway than those at a considerable distance from the highway (Kalaiarasan et al., 2017).

Table 2 shows that between the control class and test class 2, there is a decrease in temperature in the room along with PM2.5 levels in the room. The result is per the theory which states that there is a positive relationship between temperature and the concentration of PM2.5. An increase in room temperature is proportional to straight with an increase in the concentration of PM2.5 (Wang and Ogawa, 2015). The decrease in room temperature, followed by an increase in PM2.5 in the control room and test room 2 was due to the density of vehicles on the highway and meteorological factors that occurred in the study area. At the time of the posttest measurement, the traffic flow was heavy and there was a traffic jam in front of the school, resulting in the temporal distribution of PM2.5 from the highway entering the classroom, while the weather during the posttest measurement was observed to be cloudy so that the temperature at that time was not too high. This condition is different when taking pretest measurements where traffic conditions were smooth and the weather was sunny.

Pollution caused by PM2.5 is closely related to spatial and temporal distribution as a component of air quality measurement. In a short time, the concentration of PM2.5 usually has a very large difference, but the difference may be insignificant. It is affected by the characteristics of different pollutant sources in each region and the climatic conditions. Meteorological conditions also play an important role in influencing the concentration of PM2.5 at any time. Meteorological factors affecting it include wind direction and speed (Wang and Ogawa, 2015). Meanwhile, different conditions occurred in test room 1, where the decrease in temperature that occurred in the room, followed by a decrease in PM2.5 levels. It was due to the role of 8 pots of Sansevieria Trifasciata plants able to reduce PM2.5 levels in test room 1, which was sufficient and statistically meaningful.

The value of humidity is inversely proportional to temperature. The higher the humidity, there is the tendency for PM2.5 levels in the room to decrease. The humidity value significantly affects the daily variation of PM2.5 (Zereini and Wiseman, 2010). High humidity can encourage the formation of secondary organic particulates through photochemical reactions (Yang et al., 2011). Humidity has a negative relationship with PM2.5 in summer. It can be seen from the increase in the concentration of particulate matter in the air as temperature increases, and humidity decreases (Zereini and Wiseman, 2010) .Very high humidity can make the particulates in the air freely combine, then the particulates cannot survive in the air and fall to the ground so that the concentration of PM2.5 decreases (Chen et al., 2016).

The results of humidity measurements in the posttest in the control room and test room 2 showed an increase in humidity in the room, followed by an increase in PM2.5 levels. This result is not by the theory stated previously that the humidity level is inversely proportional to the level of PM2.5. This incident is the same as what happened to the temperature indicator, that there is an influence of the temporal distribution of PM2.5 from the highway that enters the control room and test room and the weather factor is cloudy, causing humidity to increase.

Meanwhile, in test room 1, there was an increase in humidity followed by a decrease in the concentration of PM2,5. It is due to the role of 8 pots of Sansevieria Trifasciata plants, which can reduce PM2.5 levels in the room. The results of the One-way ANCOVA test showed that the significance level of the pretest covariate was 0.003 less than 0.005. The significance level indicates that the pretest covariate affects the posttest PM2.5 concentration. The class or independent variable (Sansevieria) has a level of F=82,081 and =0,000. The significance level is less than 0.05, which means that by controlling the pr test, there is a significant difference between the PM2.5 concentration in test class 1 (8 pots of Sansevieria). The significant differences obtained from the results of the One-way ANCOVA test need to be followed up with a post hoc follow-up test. It is done to find the value of the difference and whether it is positively or negatively correlated to the decrease in PM2.5 levels in each test room.

Overall, the study found that the placement of Sansevieria Trifasciata plants in the classroom had a positive impact on reducing PM2.5 levels in that class. However, the difference in traffic and weather conditions at the time of post-test measurement is very decisive for PM2.5 levels in the classroom. Vehicle pollutants from traffic jams contribute directly or indirectly due to the indirect role of fuel combustion in vehicles, including reactive gas emissions, both organic and inorganic, which can form secondary particulate matter through changes in the air. Vehicle speed on the highway includes the interaction of the vehicle with the road surface and the use of the brakes, which causes the release of particulate matter into the air. This category of emissions is known as non-exhaust emissions, which includes: tire wear, brake wear, road surface wear, and resuspension (Harrison et al., 2016). It occurs due to the process of mechanical aberration, grinding, crushing, and corrosion, while the latter is related to residual resuspension that collects around the road surface due to turbulence generated by vehicles due to congestion on the highway (Harrison et al., 2016). In Europe, 13% of all PM2.5 is transmitted to the air via motor vehicles, and this could increase to 40-50% (Harrison et al., 2016).

The cloudy weather during the post-test measurement made the temperature lower. It potentially reduces PM2.5 due to reduced photochemical reactions in the air because high temperatures contribute to photochemical activity in the air to produce more PM2.5 secondary particulates. Likewise, when it rains, Research (Gusnita and Cholianawati, 2019) says that PM2.5 concentrations are usually low. It is due to the presence of PM2.5 particulate washing process by rainwater (washing out) in the atmosphere. However, the high concentration of PM2.5 released by vehicles during traffic jams causes PM2.5 to be temporally distributed to spread larger to the surrounding area, including classrooms on the edge of the highway affected by wind direction and speed. Vehicle emissions were found to be higher in schools located close to the highway than in schools located at a considerable distance from it. Thus, although the temperature at the post-test time tends to be lower than the pre-test time due to cloudy weather, the congestion that occurred during the post-test measurement in a short time can increase the concentration of PM2.5 in the highway area temporally distributed in the classroom.

Based on statistical tests, the absorption ability of PM2.5 in test class 1 and test class 2 by the Sansevieria Trifasciata plant proved significant. The comparison of the ability of Sansevieria Trifasciata to absorb PM2.5 in test class 1 against the control class was 29µgr/m3. Meanwhile, the comparison of the absorption ability of Sansevieria Trifasciata in absorbing PM2.5 in the test class 2 to the control class was 16.6µgr/m3. The difference in the mean levels of PM2.5 in the post-test measurement class in test room 1 decreased by 11.6µgr/m3 compared to the pretest measurement results. The results of post-test measurements in test room 2 experienced an increase in PM2.5 levels in the room by 14.4 gr/m3 compared to the pretest measurements. While the results of post-test measurements in the control room experienced an increase in PM2.5 levels.

Based on the standards applied by WHO and the Ministry of Health, these results do not meet the requirements for PM2.5 levels in the room. Although it has not met the requirements set by WHO or the Ministry of Health, the placement of Sansevieria Trifasciata plants in the classroom is quite effective in reducing PM2.5 levels in that class. This conclusion was because achieving PM2.5 levels in school classrooms close to the highway to conform to standards in community or field research is quite difficult. This condition is highly dependent on various kinds of external variables that must be controlled such as vehicle density, meteorological factors, and others. It is different from laboratory research.

The explanation above concludes that the placement of Sansevieria Trifasciata plants in the classroom can reduce PM2.5 levels. Meanwhile, placing 8 pots of Sansevieria Trifasciata in a 49m2 classroom is more effective in reducing PM2.5 levels, compared to placing only 6 of Sansevieria Trifasciata in the same classroom area. The results of this study support the WHO statement that realistically considered environmental factors can be changed using available technology, policies, and public health precautions, including contaminated air, soil, and water (Cohen Hubal et al., 2020). One of the environmental changes referred to by WHO is engineering or modifying the physical environment in the classroom by placing 8 pots of Sansevieria trifasciata plants which are proven to reduce the level of respiratory susceptibility of students seen from the decrease in PM2.5 levels in the classroom.

The results of this study answer the research problem, as well as the research objective that there is a significant difference in the physical environment of the Ciranjang 1 Elementary School, Cianjur Regency, seen from PM2.5 levels before and after the placement of Sansevieria Trifasciata and the placement of 8 pots of Sansevieria Trifasciata plants, proved to be more effective in reducing levels PM2.5 in class. Maintenance Sansevieria Trifasciata proved to improve the condition of the physical environment of the Ciranjang 1 State Elementary School classroom, Cianjur Regency on PM2,5 levels. This is one form of effort to reduce environmental hazards that have an impact on health as outlined in the Sustainable Development Goals, including strengthening capacity in terms of early warning, risk reduction, and management of national and global health risks as well as supporting and strengthening local community participation in sanitation improvements.

Air pollution is associated with many respiratory diseases (Lorensia et al., 2022). Adverse effects include decreased lung function, increased infection, increased respiratory symptoms, and acute exacerbation of COPD (Kim et al., 2018). The impact of air pollution on health, in the end, will cause an economic burden that must be borne by the Public. The economic burden of disease includes three cost components, namely: costs direct costs, indirect costs (indirect costs), and costs that are not real (intangible costs) (Mursinto and Kusumawardani, 2016). Sansevieria plant maintenance is easy and inexpensive, making this plant suitable for school children to help reduce PM2.5 pollutants in the classroom. One pot of Sansevieria plants costs around Rp. 30,000.00. This fee is used to buy plants for Rp. 25,000.00 and flower pots for Rp. 5000.00. So the cost incurred to maintain 8 pots of Sansevieria plants in a class of 49m2 with 30 students is Rp. 240,000.00. The costs incurred in preventive efforts to reduce PM2.5 levels by maintaining Sansevieria plants in the classroom are much cheaper than the burden of medical costs incurred if students experience respiratory diseases due to PM2.5.

Based on the results of research conducted by Sabin, et al (2020) in Ecuador, the costs incurred for the treatment of one case of ARI in children are approximately Rp. 745.500.00 (Sabin et al., 2020). These costs include direct medical costs covering payments made for diagnostic tests, medicines, inpatient consultations, and equipment related to inpatient child health; non-medical costs include transportation, meals, and accommodation for companions and other family members during hospitalization, communication, and child care costs for children who stay at home while sick children are treated in health facilities; and indirect costs, i.e. taking into account lost wages and opportunity costs of lost time accompanying when a sick child is treated at a health facility. Based on the calculation of the cost of treatment above, if one student spends Rp. 745.500.00 for the treatment of ARI. The limitation of this study is that due to limited tools, researchers have not been able to identify and measure the temporal distribution that can affect PM2.5 levels in the room, such as wind direction and speed and vehicle density on the highway at the time of the study.

Conclusion

This study tested Sansevieria's ability to reduce PM2.5 pollutants in the classrooms of Ciranjang 1 State Elementary School, Cianjur Regency. Empirical equations were developed to measure the difference in PM2.5 pollutant levels in the classroom at SDN Ciranjang 1, Cianjur Regency, before and after the placement of Sansevieria Trifasciata. This study concludes that there is an effective and significant absorption of PM2.5 pollutants by placing 8 pots of Sansevieria trifasciata plants in a 49m2 classroom, which is 11.6μgr/m3 so that it can reduce the respiratory susceptibility of students at SDN Ciranjang 1, Cianjur District.

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