

Assessment of Aerosols within Philippine Science  
High School - Central Luzon Campus  
via the Utilization of Light Sensors  
and Settling Plates

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## ABSTRACT

Aerosols are minuscule particles suspended in the air that can either be natural or human-made. In recent years, there has been an increase in the number of studies on aerosols due to the growing concerns about their implications on human health, the environment, and Earth's climate. This study aimed to quantify the number of aerosol particles in the Philippine Science High School - Central Luzon Campus (PSHS-CLC) with the use of settling plates. Five areas in PSHS-CLC served as data points for this study, and in each data point two Petri dishes containing unflavored gelatin where one served as the control were left for 21 hours. The mass of gelatin in each sample was measured before and after exposure to the air to determine the mass loss in each sample. Moreover, the settling plates were also observed before and after exposure to the air using a light sensor and their differences were calculated. Our study shows that the mass change of the settling plates had an average value of  $38.5183 \pm 15.5287$  g and the volume of the gelatin had an average of  $67486.98 \pm 23766.46$  mm<sup>3</sup> of volume loss. The mass loss with the most and least are the samples in the GRH (Residence Hall) and the library, respectively. In addition, all settling plates resulted in a lower value of relative light intensity which suggests its correlation with the mass of the air particulates. Factors such as elevation, air pressure, and air temperature affect the number of air particles that settle. Lastly, our findings show that the relative light intensity of the settling plates can be used to measure and monitor the amount of suspended particles in the air.

**Keywords:** aerosols, settling plates, light sensor, PSHS-CLC

## INTRODUCTION

Aerosols are small solid or liquid particles suspended in the air, typically with a diameter of less than 10 micrometers ( $\mu\text{m}$ ). They can be naturally-occurring or human-made and have significant impacts on air quality, climate change, and human health. They have the ability to absorb or scatter sunlight, which has an impact on the Earth's energy balance. These particles can have significant impacts on human health and the environment (WHO, 2021). Recent research indicates that aerosols can be quite important in the spread of respiratory illnesses and infections, such as COVID-19 (Morawska & Milton, 2020).

A crucial role in linking the Earth's four spheres of influence namely the atmosphere, hydrosphere, biosphere, and geosphere is constituted by aerosols (Cao, 2017). It impacts the key elements and systems of the planet such as the radioactive balance of the atmosphere and hydrologic and biogeochemical cycles. The scattering and absorption of solar radiation and heat by aerosols in a given region can have a notable impact on cloud optical properties, as well as the formation of clouds and precipitation. This influence is largely contingent upon the aerosols' composition within the specific area under consideration (Benedetti et al., 2021). According to a study by Calvoa et al. (2012), the history of aerosols is intricately associated with atmospheric pollution.

As evidenced in a study by Galvez et al. (2022), primary sources of aerosols are industrial and vehicular traffic emissions, aside from crustal and organic Liao et al. (2017) found that anthropogenic aerosol deposition has significantly increased trace metal concentration in the bodies of water around the Philippines, notably the West Philippine Sea. Aerosol research should be expanded since the Philippines is immensely exposed to the harmful effects of aerosols, particularly in the fisheries, agriculture, and health sectors (Beyersdorf et al., 2020).

In a research conducted by the Department of Science and Technology-Philippine Nuclear Research Institute (2018), it was revealed that there is a high presence of aerosols and heavy metals in the air of Clark, Pampanga. Another investigation by the University of the Philippines Los Banos (2020) revealed that the air in Clark, Pampanga has high concentrations of sulfur dioxide, nitrogen dioxide, and PM<sub>10</sub>. Due to the high concentrations of particulate matter and sulfur dioxide, the Environmental Management Bureau (EMB) Region III (2019) has also stated that the air quality in Clark, Pampanga, does not fulfill the requirements established by the Clean Air Act.

Given the multiple uses of Aerosols in the environment, especially in the atmosphere, the researchers were inspired to conduct a study on the aerosol content of their locality.

### **Research Questions**

1. How does the number of aerosols in the selected areas of PSHS-CLC differ from one another based on their amount, light intensity ratio, and relative intensity ratio?
2. Which among the selected areas in PSHS-CLC would have the most and least number of aerosols?

### **Research Objectives**

1. To quantify the amount of aerosols in selected areas of PSHS-CLC
2. To assess if light intensity could be used to measure suspended particles in the air
3. To investigate the differences in the amount of aerosols in the air of selected areas in PSHS-CLC

### **Scope and Limitations**

The study is preliminary research on the assessment of aerosols in PSHS-CLC via the utilization of settling plates and light sensors, as such, the research would not qualitatively classify the aerosols. Moreover, as the study locale is only limited to the area of PSHS-CLC, the results of this study may not provide substantial data that can be used to generalize the amount of aerosols to other locations.

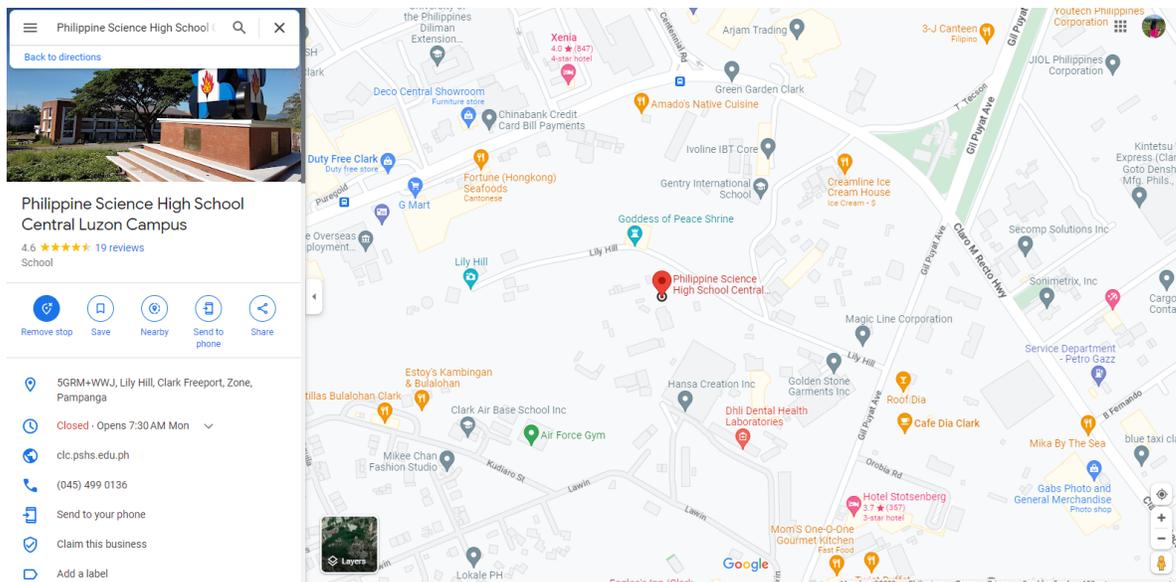
## **METHODS AND MATERIALS**

### *Time and Place of the Study*

The study was conducted initially on March 1, 2023, to March 2, 2023, and was repeated on March 7, 2023, to March 8, 2023, with a modified methodology. The location of the study is at Philippine Science High School-Central Luzon Campus (see Figure 1) in Clark, Pampanga, Philippines.

**Figure 1**

*Google Map of Philippine Science High School-Central Luzon Campus*



### *Acquisition of Materials*

The materials used for this study were the following: 12 g of unflavored gelatin, 700 ml distilled water, which was bought by the proponents, ten Petri dishes, one hot plate with an automatic magnetic stirrer, one stirring rod, 1 L beaker, analytical balance, two clamps, one forceps, one iron stand, digital caliper, red diode laser, and universal interface, which were all available in the Philippine Science High School-Central Luzon Campus laboratory.

### *Preparation of Settling Plates*

The settling plates were prepared by dissolving the 12 g of unflavored gelatin with 700 ml distilled water on a 1 L beaker and heated using the hot plate with an automatic stirrer. The heat was gradually increased while continuously stirring the mixture until it was observed clear. The mixture was then poured into the petri dish and left to cool down and settle. There were a total of ten Petri dishes per five locations in the school. It consisted of one control plate and one experimental plate (See figures 3, 4, 5, 6, and 7). The cover of the control plates was left slightly open to minimize evaporation.

Before exposing the settling plates, the mass of each petri dish without the gelatin mixture and the mass of each petri dish with the gelatin mixture were measured using an analytical balance. Additionally, the height of the gelatin mixture on each petri dish, the height of the petri dish itself, and its diameter were all measured using a digital caliper. The light intensity ratio and relative intensity ratio of all Petri dishes were recorded using a red diode laser, universal interface, and high-sensitivity light sensor. To calculate the average light intensity ratio and relative intensity ratio of each, there were five random points on the plate tested on the set-up shown below (see Figure 1). This setup was also done on a dark cabinet to ensure that no to minimal light can pass through the plates (see Figure 2).

The temperature before exposing the plates was also recorded using AccuWeather.com weather site during the experiment. The recorded air temperature was then submitted to the GLOBE Data Entry App and was visualized using the Visualization System of GLOBE.

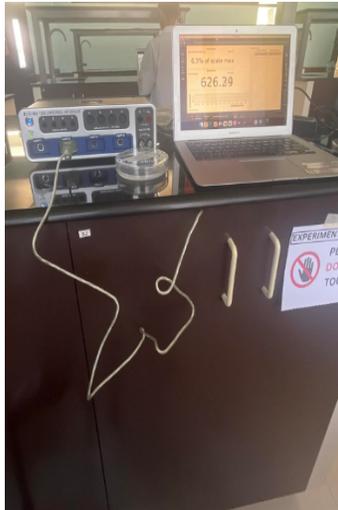
**Figure 2**

*Light sensor set-up before putting it inside the cabinet*



**Figure 3**

*Light sensor set-up inside the cabinet*



### *Exposing of Settling Plates*

The settling plates were then exposed to five locations in the school. The first set of settling plates was placed on the residence hall of the school. The second set of settling plates was placed in one of the classrooms in the school. The third set of settling plates was placed in one of the hallways in the school. The fourth set of settling plates was placed outside the library of the school. The fifth set of settling plates was placed on the gymnasium bleachers of the school. The settling plates were exposed for 21 hours.

### **Figure 4**

*First set of settling plates placed in the residence hall after exposure of 21 hours*

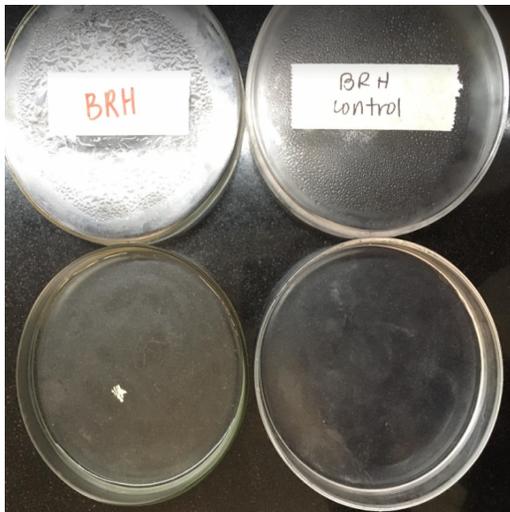


Figure 4A. Top view of the settling plates



Figure 4B. Height of gelatin after exposure in the residence hall

**Figure 5**

*Second set of settling plates placed in the classroom after exposure of 21 hours*



Figure 5A. Top view of the settling plates

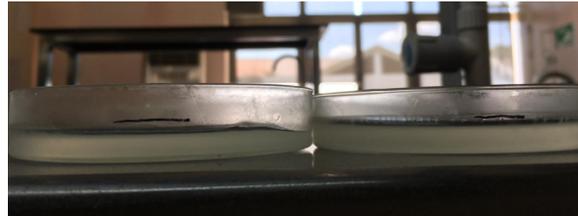


Figure 5B. Height of gelatin after exposure in the classroom

**Figure 6**

*Third set of settling plates placed in the hallway after exposure of 21 hours*



Figure 6A. Top view of the settling plates

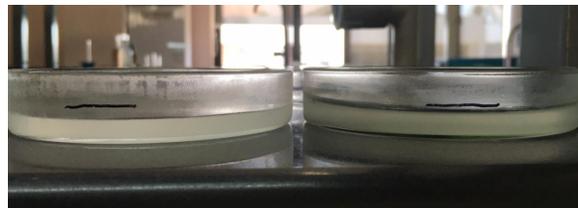


Figure 6B. Height of gelatin after exposure in the hallway

**Figure 7**

*Fourth set of settling plates placed in the library after exposure of 21 hours*

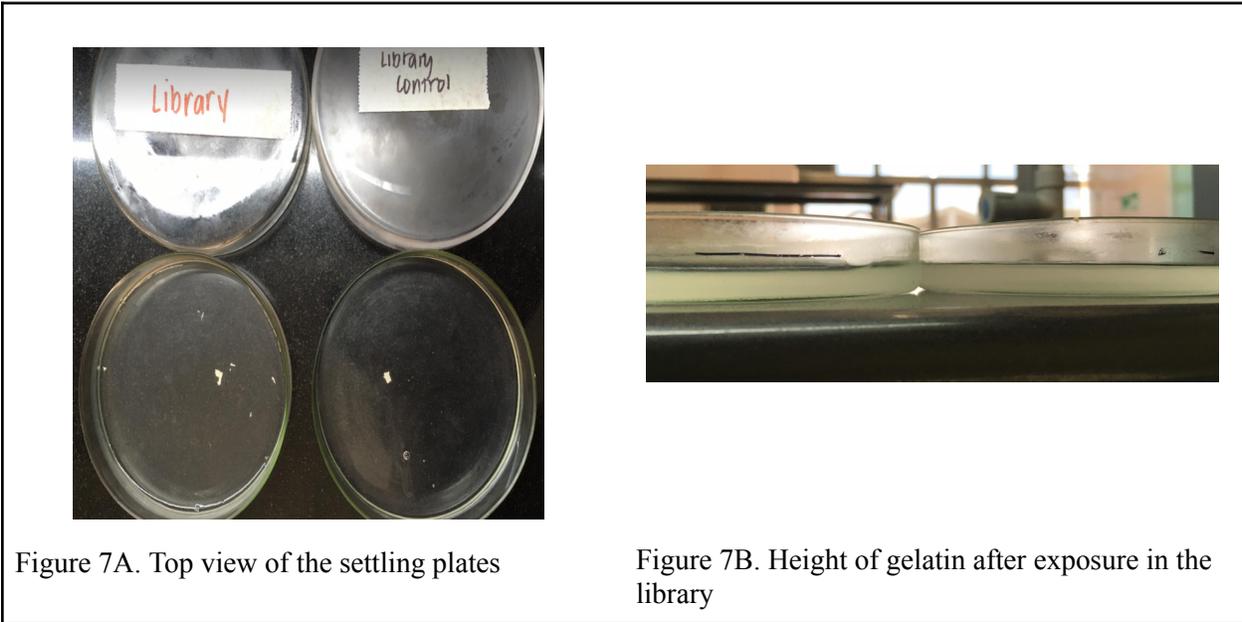


Figure 7A. Top view of the settling plates

Figure 7B. Height of gelatin after exposure in the library

**Figure 8**

*Fifth set of settling plates placed in the gymnasium after exposure of 21 hours*

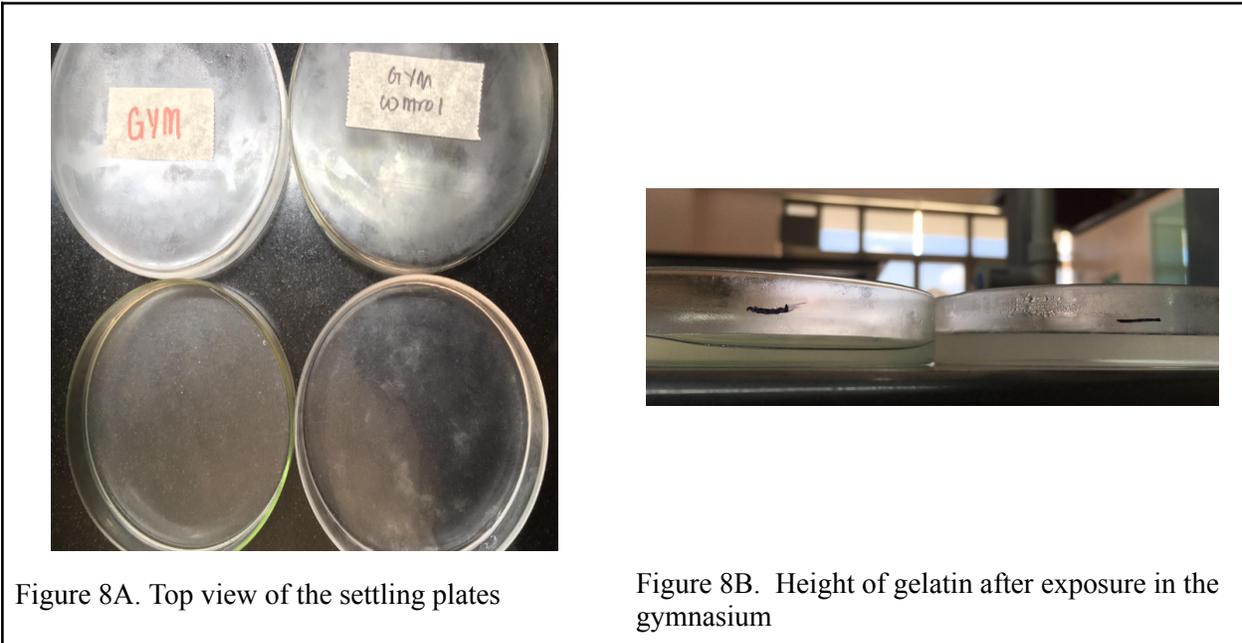


Figure 8A. Top view of the settling plates

Figure 8B. Height of gelatin after exposure in the gymnasium

*Characterization of Particulate Matter*

After exposing the settling plates for 21 hours, the mass of each exposed settling plate was measured again on the analytical balance. Consequently, the height of the gelatin mixture on each petri dish was also recorded again using a digital caliper. The light intensity ratio and relative intensity ratio of

each Petri dish were re-recorded using the set-up shown in figure 2, and five random points on the plate were again tested.

### *Analysis of Data*

The data that were used in this study included the density of the gelatin, the volume of the gelatin, the volume loss of the gelatin, the initial mass of the gelatin, the mass of gelatin on the petri dish, the mass of gelatin after exposure, mass loss of the gelatin, and mass of the particulates.

The final mass was calculated using the equation below:

$$\text{final mass} = \text{mass of gelatin after exposure} - \text{initial mass of the gelatin}$$

**Equation 1. Final Mass Formula**

The volume loss of the gelatin was calculated using the equation below:

$$\text{volume loss} = \pi r^2 (\text{initial height of gelatin} - \text{final height of gelatin})$$

**Equation 2. Volume Loss Formula**

The density of the gelatin was calculated using the equation below:

$$\text{density of gelatin} = \text{initial mass} / \text{initial volume of the gelatin}$$

**Equation 3. Density of Gelatin Formula**

To calculate the mass loss of the gelatin, the formula shown below was used:

$$\text{mass loss of the gelatin} = \text{volume loss} * \text{density}$$

**Equation 4. Mass loss of the gelatin Formula**

After calculating the mass loss, density, volume loss, and final mass of the gelatin, the mass of the particles was calculated using the shown formula:

$$\text{mass of the particulate} = (\text{final mass} - \text{mass loss of the gelatin}) - \text{initial mass}$$

**Equation 5. Mass of the particulate Formula**

## RESULTS AND DATA

**Table 1.**

*Data on the initial mass, mass after exposure, final mass, mass loss of the gelatin, and mass of the particulates per settling plate.*

Settling Plate	Initial Mass (g)	Mass of Gelatin After Exposure (g)	Final Mass (g)	Mass loss of the Gelatin (g)	Mass of the Particulate (g)
GRH (Residence Hall)	41.8788	76.4014	34.5226	16.7096	9.3534
GRH Control (Residence Hall Control)	50.3828	95.1814	44.7986	7.4062	1.8220
Classroom	39.8142	76.4675	36.6533	7.5629	4.4020
Classroom Control	32.7066	78.2273	45.5207	4.1417	16.9558
Hallway	50.0380	80.0300	29.9920	15.7929	-4.2530
Hallway Control	47.9709	92.4113	44.4404	2.8904	-0.6400
Library	42.0960	80.6778	38.5818	4.8433	1.3291
Library Control	48.2866	87.5269	39.2403	7.1055	-1.9407
Gymnasium	48.1767	80.0427	31.8660	14.9229	-1.3877
Gymnasium Control	49.6875	89.2551	39.5676	13.4841	3.3642

**Table 2.**

*Data on the initial height, final height, diameter, volume of gelatin, volume loss of the gelatin per settling plate, and the density of the gelatin*

Settling Plate	Initial Height (mm)	Final Height (mm)	Diameter (mm)	Volume of gelatin (mm <sup>3</sup> )	Volume Loss (mm <sup>3</sup> )	Density
GRH (Residence Hall)	10	6.01	94.32	69835.65	27864.42	0.00059
GRH Control (Residence Hall Control)	10	8.53	93.37	68435.96	10060.08638	0.00073
Classroom	9.16	7.42	94.97	64854.18	12319.46	0.00061
Classroom Control	9.95	8.69	94.82	70225.14	8892.83	0.00046
Hallway	9.22	6.31	94.95	65251.50	20594.56	0.00076
Hallway Control	9.46	8.89	95.7	68011.86	4097.96	0.00070
Library	9.3	8.23	96.98	67253.37	7737.75	0.00062
Library Control	9.31	7.94	94.67	65500.42	9638.62	0.00073
Gym	9.33	6.44	94.39	65253.41	20212.47	0.00073
Gym Control	9.76	7.11	95.73	70248.29	19063.89	0.00070

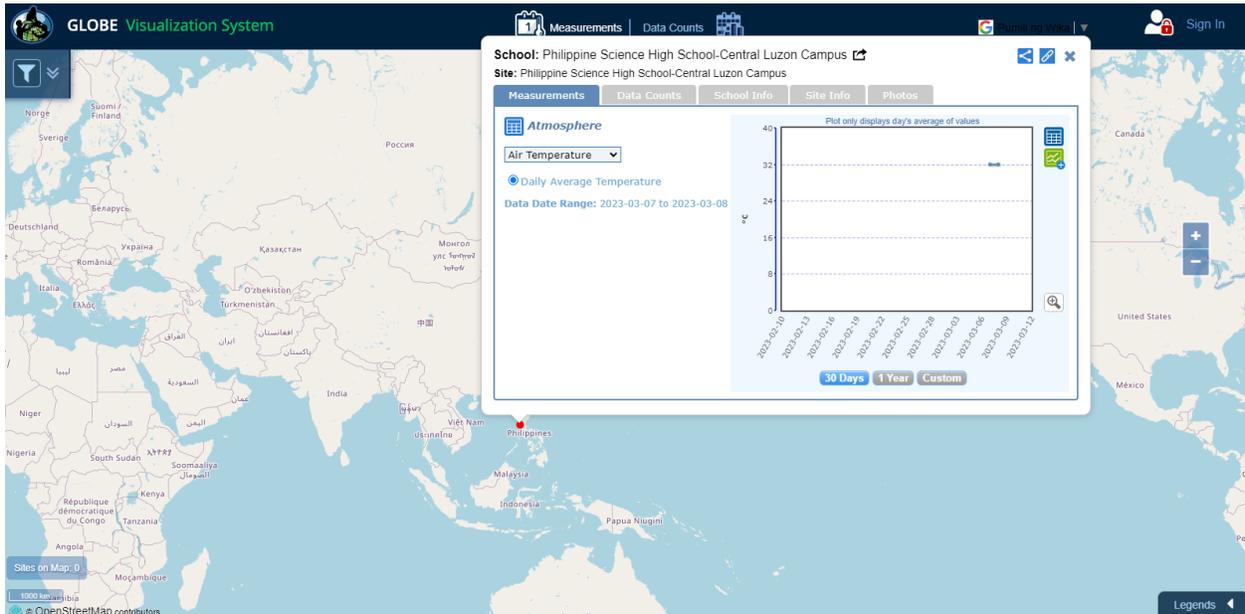
**Table 3.**

*Data on Initial and Final Relative Light Intensity (%) and Light Intensity of the gelatin and its change in Intensity*

Settling Plate	Initial Average Relative Intensity (%)	Final Average Relative Intensity (%)	Change in Relative Intensity (%)
GRH (Residence Hall)	83.31	72.90	89
GRH Control (Residence Hall Control)	87.75	72.90	82
Classroom	82.74	60.65	76
Classroom Control	85.47	66.45	80
Hallway	84.80	75.48	92
Hallway Control	76.33	79.03	107
Library	85.50	67.10	81
Library Control	81.21	86.45	111
Gym	79.81	53.23	69
Gym Control	83.94	71.94	87

**Figure 9**

*GLOBE Visualization System, Air Temperature from March 7, 2023 to March 8, 2023*



**Figure 10**

*Screenshots of the state or amount of aerosols at the study site retrieved from National Aeronautics and Space Administration's (NASA) Earth Observing System Data and Information System (EOSDIS) Worldview platform*

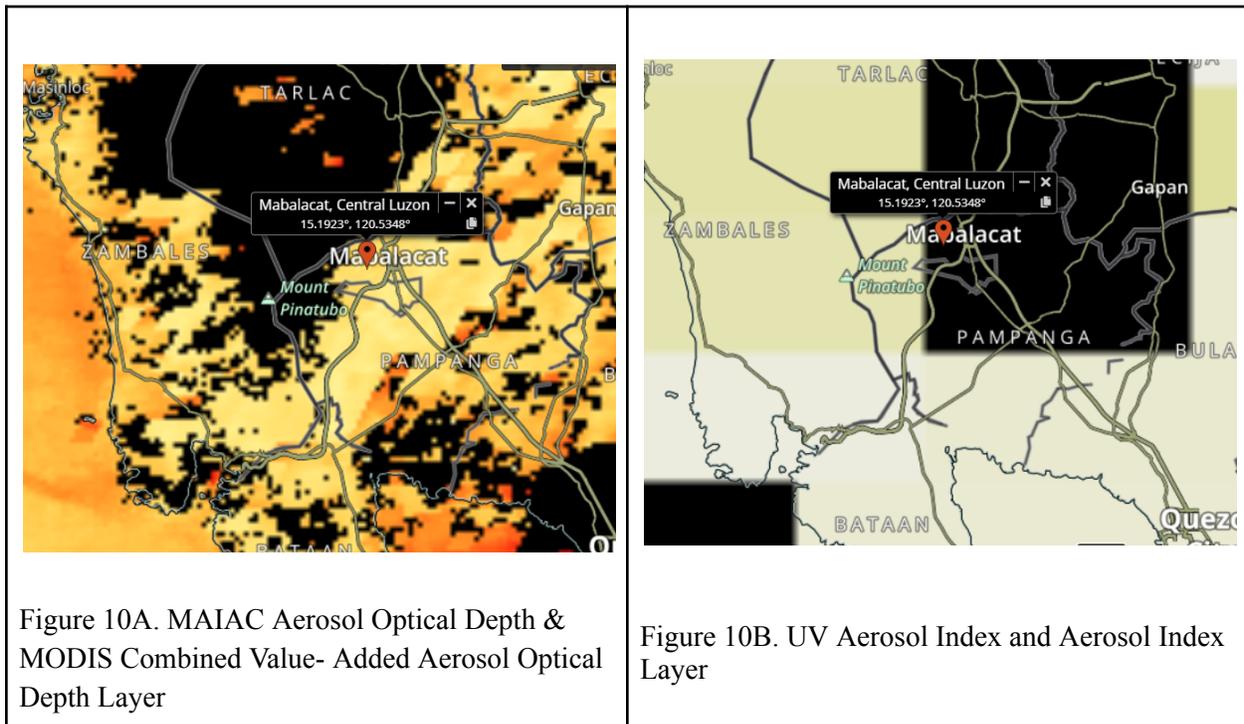


Figure 10A. MAIAC Aerosol Optical Depth & MODIS Combined Value- Added Aerosol Optical Depth Layer

Figure 10B. UV Aerosol Index and Aerosol Index Layer

## Figure 11

*EOSDIS Worldview Layers utilized*

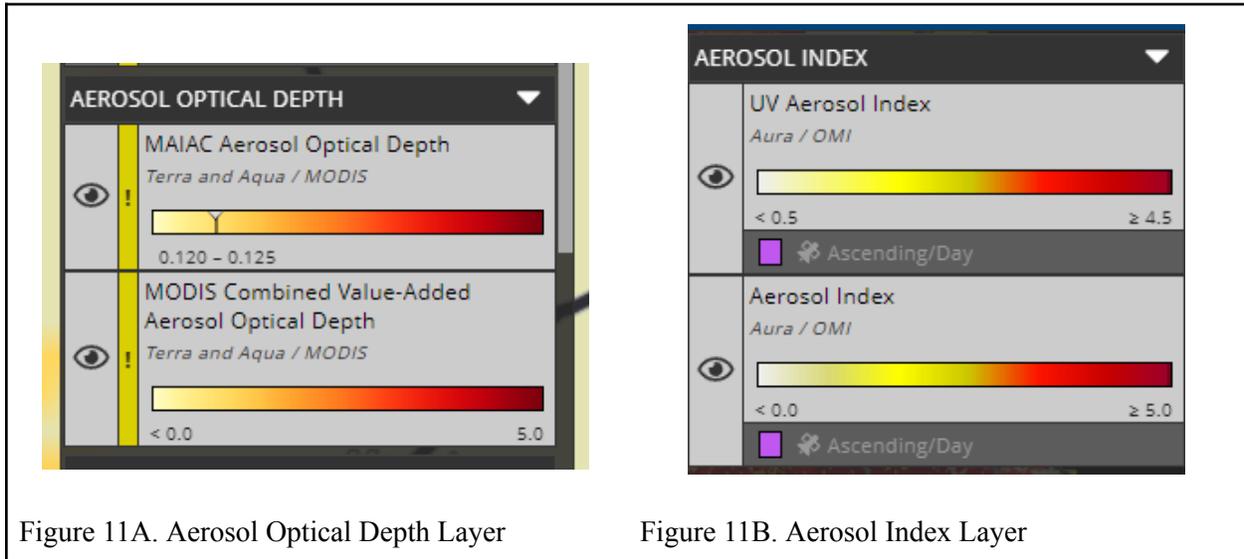


Figure 11A. Aerosol Optical Depth Layer

Figure 11B. Aerosol Index Layer

## DISCUSSION

### *Mass Loss of the Gelatin*

The initial mass is larger than that of the final mass. From the data above, the mass change had an average of  $38.5183 \pm 15.5287$  g. Moreover, there is also a change observed in terms of the volume of the gelatin. The volume of the gelatin had an average of  $67486.98 \pm 23766.46$  mm<sup>3</sup> of volume loss. This may be due to the air temperature affecting the evaporation rate of the gelatin on the settling plates. As reported by (Sandle, 2015), evaporation usually occurs on settling plates, and this is inevitable because of the direct relationship between evaporation with air temperature (Leso et al., 2021). Additionally, during the experiment, the recorded air temperature, using the AccuWeather.com Weather Site visualized with the Visualization System of GLOBE, was 32°C, and according to Lone et al. (2019), the networks of gelatin are easily broken with mild temperatures ranging from 30°C to 35°C. Furthermore, Luo (2018) stated that the range 32°C to 40°C is on the high level of environmental temperature which again adds to the explanation of why both the initial mass and volume of the gelatin were larger than that of the final mass and volume.

The highest calculated mass loss of gelatin was observed in the GRH (Residence hall). The GRH set-up was in an indoor glass-enclosed room. With that, the temperature might have been absorbed by the glass of the room which resulted in a higher temperature inside because as reported by Aklilu et al. (2018), the stiffness, interlaminar strength, and hybrid specimen of glass degrade with increasing temperature. To add to this, enclosed rooms have more chances of containing suspended air particles, which can vary from dust, pollen, fungi, bacteria, and viruses (Morawska et al. 2013). Consequently, the air also becomes more stagnant which results in trapping more heat and suspended particles (Byambaa et

al., 2019). In addition to that, the presence of aerosols has been also said to contribute to mass loss in the atmosphere (Chen et al., 2020).

Meanwhile, the second-highest mass loss of gelatin was calculated in the settling plate placed in the hallway. The set-up for this plate was outdoors, and according to the study of Yang et al. (2013), outdoor conditions have higher temperatures, which explains why it also lost a lot of gelatin. Although in terms of light intensity, the hallway set-up obtained a higher value of light intensity ratio, meaning it had lesser suspended particles, compared with the indoor set-up of the GRH. This may be because the aerosols were more suspended in the enclosed environment of the GRH in comparison to the open area of the hallway, as mentioned by the literature stated above.

The set-up that acquired the least amount of mass loss was the one stationed at the library. This can be attributed to the fact that out of all the set-ups, this was the only one located at a higher level being on the second floor of the building it was at. The correlation between temperature is well-known as temperature generally decreases as elevation increases. In fact, Allegretto (2020) also stated that an increase in elevation results in less air and pressure which means the air expands and so it decreases the temperature. Additionally, a study conducted by Li et al. (2020) found that “aerosol concentrations decrease with increasing elevation due to atmospheric dilution and mixing.” Consequently, it was observed that this set-up obtained an 81% change in relative light intensity, meaning more particles were suspended in the settling plate after 21 hours of exposure.

### *Mass of the Particulates*

In terms of the mass of the suspended particles, there were some that resulted in a negative value such as the hallway, hallway control, library control, and gymnasium settling plates. This may be due to the obtained maximum value for the relative light intensity after 21 hours of exposure. Furthermore, this may also be because of the evaporation of some particles from the settling plates. With this, however, the classroom control, despite being a control, gained the largest value of the mass of the suspended particles. It was mentioned in the methodology that all control set-ups were left slightly open and the windows in the classroom were also opened. These might have been caused by the placement of the plate. Although this was the case, under the analysis using light sensors, all plates still resulted in a lower value of relative light intensity which indicated the presence of suspended particles.

### *Relative Light Intensity Before and After 21 Hours of Exposure*

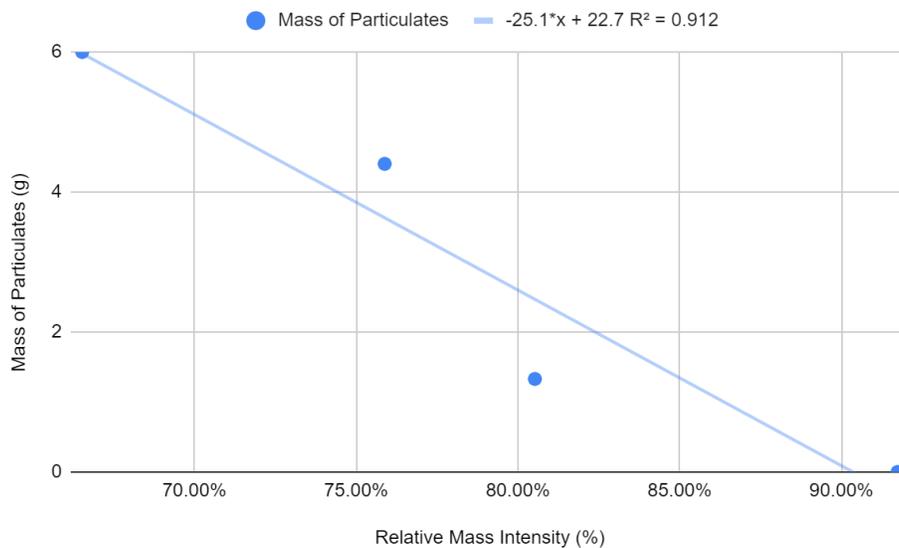
When a particle is exposed to a laser beam, the particle emits light in all directions and it is given that the scattering angle affects the intensity of the light that is dispersed (Shimadzu Europa, n.d.). To determine whether or not the measured parameters in this study, such as the relative intensity, can be used to measure the suspended particles in the air through settling plates, Figure 10 shows their correlation with the mass of the particulates. It may be concluded from the graph that the mass of the particulates and the relative mass intensity have a similar trend.

With that, the settling plate placed in the gymnasium obtained the lowest change in relative intensity which is 69%. Again, this indicates that among all the other settling plates, this specific plate

gathered the most suspended particles after 21 hours of exposure. Moreover, the set-up was also placed in the bleachers which are elevated, this explains why it also had a lot of suspended particles. Furthermore, the measured light intensity before and after the exposure of the plates are affected through the method of passive sampling, diffusion makes it possible for gas molecules to settle onto a sorbent medium in an enclosed space, which in this case are the settling plates, fully through their kinetic energy (Boston University School of Public Health, 2016). This is also observed from the data before and after exposure of the plates. For instance, the plates with the lowest light intensity (Gym, Classroom, Library) were all exposed to air in the surroundings whereas the plates with the highest light intensity were mostly control (Hallway Control and Library Control) and were only slightly exposed to air to minimize evaporation as mentioned in the methodology.

**Figure 12**

*Correlation of mass of particulates with the relative mass intensity*



*Data from NASA's EOSDIS Worldview*

According to NASA, their Earth Observing System Data and Information system serves as a platform for everyone to access Earth science data from their satellites, aircraft, field measurements, and is a part of their Earth Science Data Systems (ESDS) Program. This system was utilized to visualize the current data of aerosols within the study site. The layers that were applied depict the Aerosol Optical Depth and Aerosol Index, specifically the Multi-Angle Implementation of Atmospheric Correction (MAIAC) Aerosol Optical Depth layer Combined value-added aerosol optical depth, and the UV Aerosol Index layer. The MAIAC layer also comes from the Moderate Resolution Imaging Spectroradiometer (MODIS) combined Terra and together with the IV Aerosol Index layer gives the general level of solid particles in the atmosphere. It was also made sure that the data collected with these layers were at the exact duration of the experiment methodology. The exact coordinates of the school were imputed in the platform and the general observation with regard to the study site is that there is a relatively low level of aerosol within the area.

## CONCLUSION

The study quantified the aerosols in various areas in Philippine Science High School - Central Luzon campus after 21 hours through the use of settling plates and light sensor characterization. Based on the results, it can be concluded that due to the lack of air outflow, the amount of aerosols present is more significant in closed indoor areas. Additional factors such as heat and humidity in these closed areas contribute to the kinetic energy and circulation of the aerosols that are present. On the contrary, areas that are readily exposed to outdoor air have less particulate matter which is most likely due to the breeze that causes the outflow of aerosols. This is supported by the recorded aerosols from the NASA EOSDIS program, where the outside atmosphere aerosol index indicates that there is a relatively low level of aerosols in the area.

One advantage of the method that was used was its feasibility. The whole experiment could be done in two days. Additionally, the preparation and implementation of it is relatively easy to follow as using settling plates is the passive method of getting aerosols.

On the other hand, its limitations would include making sure that the settling plates are untouched and put in a place where minimal to no contamination could occur. The whole study was conducted only in one area of Clark, Pampanga which is the PSHS-CLC. It is recommended that the study could also be tested to more places within Clark, Pampanga for more variation and possible findings in the data. Improvement of preparation of plates is recommended. For example, more settling plates to be tested on different places with varying levels of gelatin. Exploring other settling materials with minimal evaporation rate to further analyze more suspended particles is suggested. Moreover, place equal volumes of settling materials into each plate using the appropriate equipment.

Working with a project mentor had advantages in devising the basic framework and procedure of the study. A structured flow of the methodology was easily followed by the proponents resulting in setbacks being resolved immediately. Beyond everything, there were also significant lessons learned from this project because of the guidance given by the mentor.

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