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Performance Comparison and Correction of Two PM_{10} Measuring Instruments for the Reduction of the Cost

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ABSTRACT

Millions of citizens in Seoul use the subway as a mean of transportation to go to work or move from someplace to the other per a day. There are high emissions of air pollutants from cars and some other air-pollutant resources in Seoul. Since many individuals usually spend most of their working hours indoors, the ambient air quality refers to indoor air quality. In particular, PM_{10} concentration in the underground areas should be monitored to preserve the health of commuters and workers in the subway system. Seoul Metro measures several air pollutants regularly. In this study, the possibility of the installing cost reduction will be shown through using the linear regression method to be improved in the accuracy between the measuring data of Airtest PM2500 and Grimm.

Keywords: *PM10 (Particle Matter 10), Linear regression analysis, Subway station, Air quality measurement*

1. INTRODUCTION

Millions of citizens in Seoul use the subway as a mean of transportation to go to work or move from someplace to the other per a day due to its high population density. There are high emissions of air pollutants from cars and some other air-pollutant resources in Seoul. Since many individuals usually spend most of their working hours indoors, the ambient air quality refers to indoor air quality. In particular, PM_{10} concentration in the underground areas should be monitored to preserve the health of commuters and workers in the subway system. Seoul Metro measures several air pollutants regularly. [1][2][3]

Among the various types of indoor environments, underground subway stations have especially unique features. The confined space occupied by the underground subway system can accumulate the pollutants entering from the outside in addition to those generated within the system. [4][5][6]

For the past 10 years, Platform Screen Doors (PSDs) have been installed in Seoul Subway stations to prevent suicide of people and the diffusion of air pollutants into the subway stations and ensure the safety of the public. [7][8]

In this study, the possibility of the installing cost reduction will be shown through using the linear regression method to be improved in the accuracy between the measuring data of Airtest PM2500 and Grimm.

II. PM_{10} Sensor Based Monitoring System

2.1 Light Scattering PM_{10} Instrument

Particulate matter with an aerodynamic diameter less than 10 μm (PM_{10}) is one of the major pollutants in subway environments. The PM_{10} concentration should be monitored to protect the health of the commuters and workers in subway system. Seoul Metro measures several air pollutants regularly. In order to keep the PM_{10} concentration below a healthy limit, the air quality in the underground platform and tunnels in subway should be monitored and controlled continuously, the PM_{10} instruments using light scattering method can measure the PM_{10} concentration in two minutes. However, the accuracy of the instruments using the light scattering method has still not been proven completely since they measure the particle number concentration rather than the mass concentration. Fig.1 shows the principle of the light scattering method for PM_{10} instruments. [9][10]

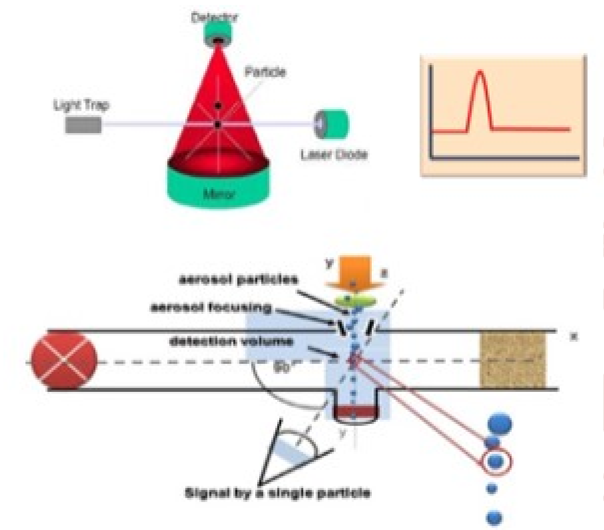

Fig. 1. Principle of a light scattering method

The measuring PM_{10} instrument of Airtest PM2500 in cost is much cheaper than the instrument of Grimm. The difference of the cost is about several tens of times.

Fig. 2. PM_{10} measuring of Airtest PM2500 and Grimm

Therefore, if the measuring performance of the Airtest PM2500 is similar to that of Grimm, the cost reduction of using Airtest PM2500 will be much greater than using Grimm when trying to measure PM_{10} in a broad area like an underground area of subway in Seoul. In this study, the possibility of that cost reduction will be shown through using the linear regression method to be improved in the accuracy between the measuring data of Airtest PM2500 and Grimm.

2.2 Performance Comparison and Analysis

Fig.3 shows a comparison of measuring PM 10 between a particle matter instrument of Airtest PM2500 and Grimm which were installed in a lab in University of Seoul. These instruments were measured in two minutes interval for two days. As shown in Fig.3, the measurement results of PM_{10} have a significant deviation between them.

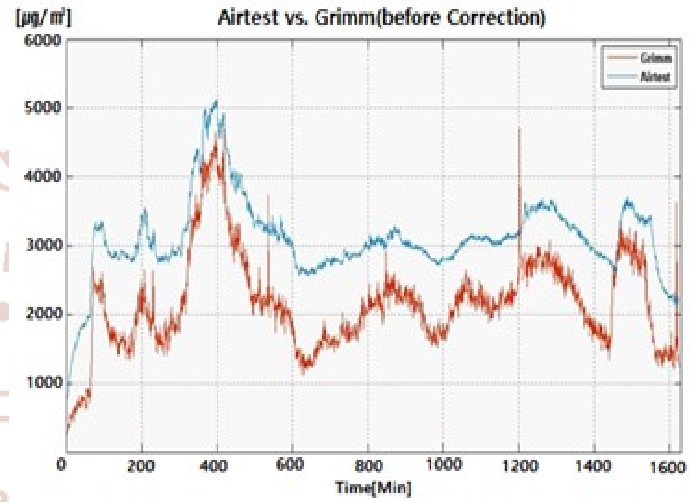

Fig.3. PM_{10} concentration of Airtest PM5200 and Grimm

Therefore, we analyzed a correlation between them and estimated a mathematical model with a slope and an intercept by using a scattering plot of two variables in Fig. 4.

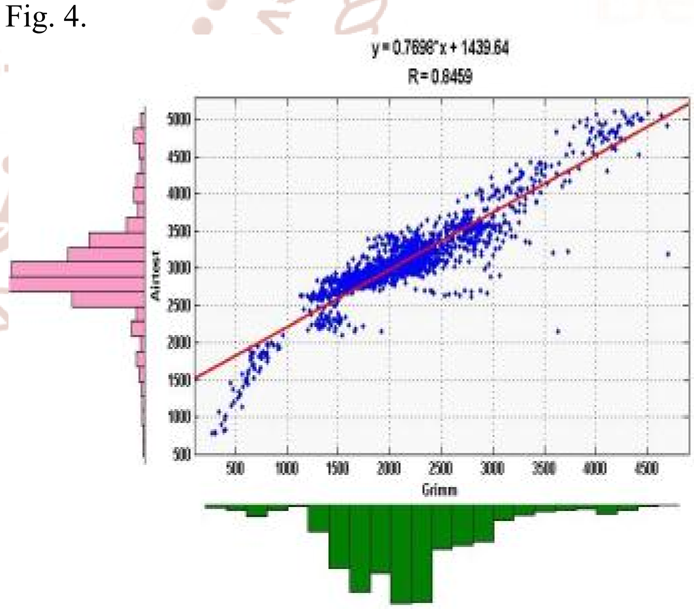

Fig. 4. Regression analysis result of Airtest PM2500 and Grimm

If comparing the measured particle matters of a distribution and deviation, we can take a close look of a correlation between two data in detail by adapting a regression analysis with a Histogram as shown in Fig. 4. The correlation coefficient of an estimated mathematical regression model in Fig. 4 is 0.919. They have a strong correlation between them, as the measure of fitness, R^2 is 0.8458, the estimated linear regression model is y = 0.7698x + 1239.64 which represents a variation in a model so well, and then this linear regression model is a reasonable model for correcting the measured two data.

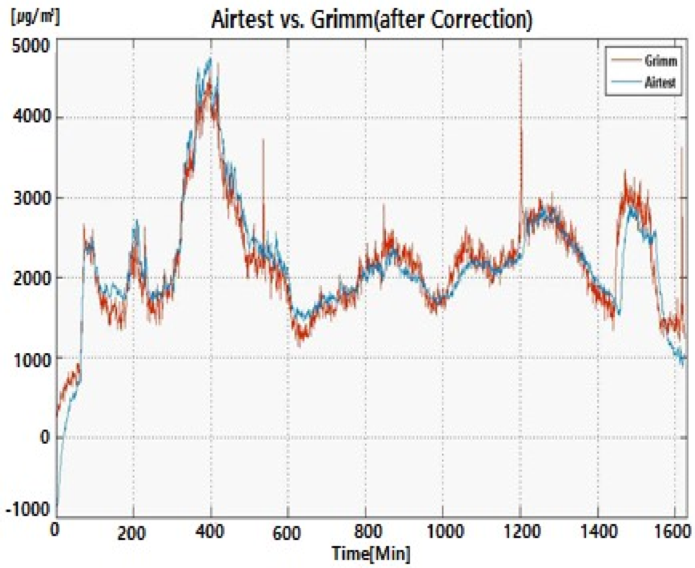

Fig. 5. Correction result of Airtest PM2500 and Grimm

If correcting the measurement difference of Airtest PM2500 into the measurement of Grimm by choosing the estimated regression model, Fig. 5 shows that the corrected results of two data are much similar than those before performing the correction. An appropriate model for a correction between the two measurements was made to improve the accuracy of Airtest PM2500.

In order to perform the verification of the model and try to find out the normalization of a distribution of two measured data in statistics, Fig. 6 shows a distribution of bivariate. Fig. 7 is a plot of a contour of two data. It is useful to predict and confirm the distribution and the information for a normalization and uniform of the data as well are taken easily. Linearity, independency, normalization and uniformity of two data by comparing the error of them are shown in Fig. 6 and 7.

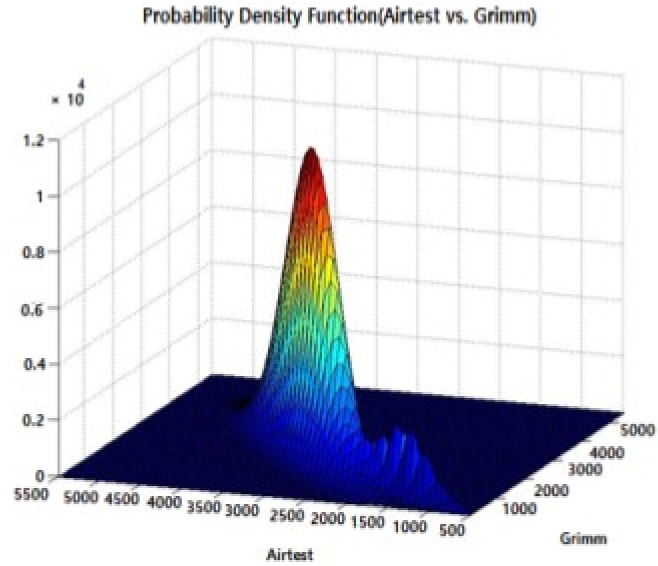

Fig. 6. Distribution of Airtest PM2500 and Grimm

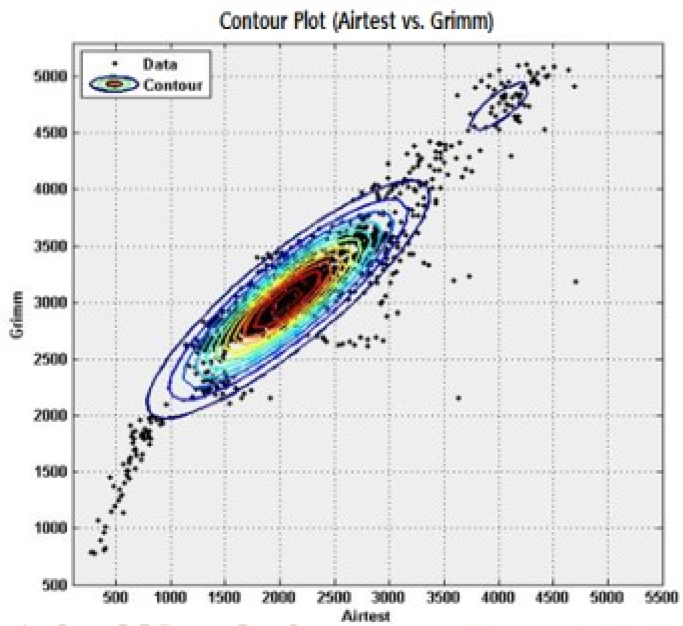

Fig.7. Data contours of Airtest PM2500 and Grimm

An amount of the error in Fig. 8 is varying randomly and it reflects dependency and uniformity of two data. It shows the correction model tracts the linear regression model assorting the data so well and the fitness of this model for the correction. Through the lower and upper interval of the error, a basis of determining the outlier is provided and we see that the outliers are occurred in Fig.8. If rejecting these outliers, we will be able to search for a better linear regression model for a correction.

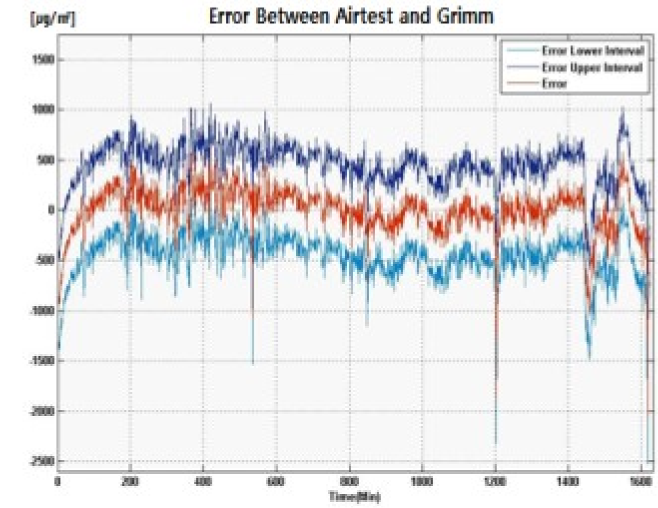

Fig. 8. Error of Airtest PM2500 and Grimm

III. Concluding Remarks

In this paper, the possibility of the installing cost reduction will be shown through using the linear regression method to be improved in the accuracy between the measuring data of Airtest PM2500 and Grimm. The accuracy of the PM measuring instruments using light scattering methods was improved with the help of a linear regression analysis technique to continuously measure the PM_{10} concentrations in the subway stations. Even though the accuracy was greatly improved, this approach had its demerits, such as the generation of very large measured data and the need to repeat the linear regression analysis every time the PM measuring instruments were moved to other places.

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References

1) Jihan Song, Heekwan Lee, Shin-Do Kim, and Dong-Sool Kim, "How about the IAQ in subway environment and its management," *Asian Journal of Atmospheric Environment,* vol.2, no.1, pp.60-67, June, 2008

2) Kyung Jin Ryu, MakhsudaJuraeva, Sang-Hyun Jeong, and Dong Joo Song, "Ventilation efficiency in the subway environment for the indoor air quality," *World Academy of Science, Engineering and Technology*, vol.63, pp.34-38, March, 2012

3) Youn-Suk Son, Trieu-Vuong Dinh, Sang-Gwi Chung, Jai-hyo Lee, and Jo-Chun Kim, "Removal of particulate matter emitted from a subway tunnel using magnetic filters," *Environmental Science & Technology,* vol.48, pp.2870-2876, Feb., 2014

4) Ki Youn Kim,, Yoon Shin Kim, Young Man Roh, Cheol Min Lee, Chi Nyon Kim, "Spatial distribution of particulate matter (PM_{10} and $PM_{2.5}$) in seoul metropolitan subway stations," *Journal of Hazardous Material,* vol.154, pp.440-443, June, 2008

5) Hae-Jin Jung, BoWha Kim, JiYeon Ryua, Shila Maskey, Jo-Chun Kim, Jongryeul Sohn, Chul-Un Ro, "Source identification of particulate matter collected at underground subway stations in Seoul, Korea using quantitative single-particle analysis," *Atmospheric Environment,* vol.44, pp.2287-2293, 2010

6) Ki-Hyun Kim, Duy Xuan Ho, Jae-Sik Jeon, Jo-Chun Kim, "A noticeable shift in particulate matter levels after platform screen door installation in a Korean subway station," *Atmospheric Environment,* vol.49, pp.219-223, 2012

7) Soon-Bark Kwon, Youngmin Cho, Duckshin Park, Eun-Young Park, "Study on the indoor air quality of seoul metropolitan subway during the rush hour," *Indoor Built Environment,* vol.17, no.4, pp.361-369, 2008

8) Harrison R.M., A.R. Deacon, and M.R. Jones, "Sources and processes affecting concentration of $PM_{2.5}$ and PM_{10} particulate matter in Birmingham (U.K.)," *Atmospheric Environment*, vol.31, no.24, pp.4103-4117, 1997

9) Aarnio, P., et al., "The concentrations and composition of exposure to fine particle ($PM_{2.5}$) in the Helsinki subway system," *Atmospheric Environment*, vol.39, pp.5059-5066, 2005

10) Branis, M., "The contribution of ambient sources to particulate pollution in spaces and trains of the Prague underground transport system," *Atmospheric Environment*, vol.40, pp.348-356, 2006