



Measures to Improve the Efficiency of the Portable Air Quality Measurement System

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Abstract

Purpose: In this study, pollutants generated in industrial areas were measured using a Portable Air Quality Measurement System(PAQMS). This study intends to examine in detail improvement measures and operational capabilities to operate a more efficient PAQMS. **Research design, data and methodology:** This study compares and analyzes the measurement values of the PAQMS and the measurement values of the national air quality measurement network. It is intended to develop a PAQMS corresponding to the data of the national measurement network by minimizing the errors that occur during comparative measurement and analysis and supplementing and improving the problems that occur during the current equipment calibration. **Results:** A PAQMS is an essential equipment for faster and more accurate measurement and analysis of pollutants in case of untimely measurement and civil complaints due to Micro Climate(local weather and environmental influences). Currently, there are many atmospheric measurement equipment in Korea, but only equipment for each item is produced and sold. Currently, these devices on the market must satisfy various conditions such as stable power, temperature, and humidity to calculate accurate measurement values. **Conclusions:** Therefore, there is no equipment that satisfies the conditions for performing detailed measurement in the field where accurate measurement is required. In this study, these field work conditions and contents for stable measurement were mentioned in the text.

Keywords : E-BAM , API T-SERIES, Particulate Matter, PAQMS, Air

JEL Classification Code : Q51, Q52, Q53, Q54, Q55

1. Introduction

In Korea, the state should clarify the rights and obligations of the people and the state's responsibilities

regarding clean air environmental conservation, and set basic environmental policies to prevent environmental pollution and damage, and to manage and preserve the environment appropriately and sustainably. In other words,

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the state enacted and managed the CLEAN AIR CONSERVATION ACT on August 1, 1980 to ensure that all citizens can enjoy a healthy and comfortable life. Among them, this Act establishes, stipulates, and manages Atmosphere Environment Standards(AES) items for air management. For the AES, a total of eight items were selected by dividing them into particulate matter and gaseous pollutant. Particulate matter was classified and managed as TSP, but was excluded in 1998 and managed as PM-10.

However, in Korea, as energy consumption rapidly increased due to industrial advancement, the impact and damage of PM-10, which is a general fine particle, and PM-2.5, which is a secondary order reaction, gradually increased. As the public's interest in fine particle and ultrafine particle has increased, the need for management of these substances has gradually emerged. In line with this situation, in January 2015, an atmosphere environmental policy to manage both PM-10 and PM-2.5 was operated.

The high-volume air assembler (HVAS) and the roll-volume air assembler (LVAS) method, which measure gravimetrically using a filter paper, are methods for measuring particulate pollutants. In these two methods, the filter paper is collected by the gravimetric method for 24 hours, and then the collected paper is stabilized and pre-treated in the laboratory, and the difference in weight is calculated and measured. These two methods of weight method have problems such as loss of samples and time, especially inability to check the results in the field. Therefore, the Light Scattering Method(LSM) and the Beta-Ray Method(BRM), which are automatic measurement methods in which measurements and results are directly derived in the field, have been commercialized.

The LSM has disadvantages in that there is a deviation in the accuracy and precision of data during long-term measurement and environmental impact at the time of measurement. Therefore, the BRM, which has been commercialized and used worldwide because it is more stable and can be measured for a long time, is specified as the domestic air pollution process test standard and environmental standard measurement method. In this study, a Portable Air Quality Measurement System(PAQMS) was constructed by applying the same equipment used by European and American EPAs and national measurement networks for the measurement method of particulate matter and gaseous pollutant. In this study, a method for improving

efficiency was studied by commissioning the configured PAQMS.

2. Research Methods

There are three items in the AES: fine particle (PM-10), ultrafine particle (PM-2.5), and heavy metal pollutants (pb). These are particulate contaminants, which are respiratory particles that affect the alveoli through respiration. Gaseous pollutants generated from industrial sites and energy production industries are additionally selected and operated and managed as benzene, which is a carcinogenic substance due to industrialization, in addition to the four items of SO₂, NO₂, CO, and O₃. For the target substances of this study, four items were selected among PM-10 and PM-2.5 and gaseous pollutants SO₂, NO₂, CO, and O₃ among particulate pollutants based on AES, and a total of 6 substances were studied.

2.1. Measuring areas & Atmospheric Environment Standards(AES)

Table 1: Sampling area

Points	Addresses	Latitude & Longitude	
		Latitude	Longitude
A-1	415(Doosan Venture Dime), Heungandaero, Dongan-gu, Anyang-si, Gyeonggi-do	37.232990	126.582279
A-2	235(Anyang City Hall), Shimindaero, Dongan-gu, Anyang-si, Gyeonggi-do	37.233988	126.572466
A-3	387(Ansan City Hall), Hwarang-ro, Danwon-gu, Ansan-si, Gyeonggi-do	37.192046	126.495544



Figure 1: Measurement location map

Table 2: Atmospheric Environment Standards [Attached Table of Enforcement Decree of Framework Act on Environmental Policy 1]

Items	Standards
Sulfur Dioxide (SO ₂)	Annual Average 0.002 ppm or less Average of 24 hours 0.05 ppm or less Average of 1 hour 0.15 ppm or less
Carbon Monoxide (CO)	Average of 8 hours 9 ppm or less Average of 1 hour 25 ppm or less
Nitrogen Dioxide (NO ₂)	Annual Average 0.03 ppm or less Average of 24 hours 0.06 ppm or less Average of 1 hour 0.10 ppm or less
Fine Particle (PM-10)	Annual Average 50µg/m ³ or less Average of 24 hours 100µg/m ³ or less
Ultrafine Particle (PM-2.5)	Annual Average 15µg/m ³ or less Average of 24 hours 35µg/m ³ or less
Ozone(O ₃)	Average of 8 hours 0.06 ppm or less Average of 1 hour 0.1 ppm or less
Lead (Pb)	Annual Average 0.5µg/m ³ or less
Benzene (Bz)	Annual Average 5µg/m ³ or less

Note:

1. For the 1-hour average, the 999th per mil value must not exceed the threshold, and for the 8-hour and 24-hour average, the 99th percentile value must not exceed the threshold.
2. Fine particle (PM-10) refers to dust with a particle size of 10µm or less.
3. Ultrafine particle (PM-2.5) refers to dust with a particle size of 2.5µm or less.

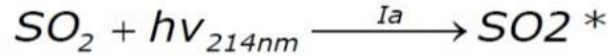
2.2. Principle and Specifications of Each Item of PAQMS

SO₂: Pulse U.V. Fluorescence Method

When ultraviolet light in the short wavelength region (200 ~ 230nm) reacts with SO₂ molecules in the atmospheric sample gas, the SO₂ molecules absorb the light

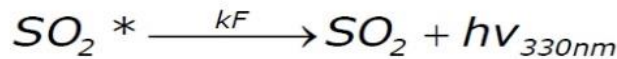
to generate SO₂* molecules in an excited state. Afterwards, the molecule returns to a stable state and secondary emission occurs. The intensity of the generated fluorescence radiation is proportional to the concentration of SO₂, using this principle, the concentration of sulfur dioxide contained in the atmosphere is measured. Table 3 as shown in below describes the principle of the UV fluorescence method.

Stage 1: This is the stage in which SO₂ molecules collide with ultraviolet photons at a wavelength of 190nm – 230 nm. The electrons of the SO₂ molecule are in a high energy state when SO₂ has excess energy. In the wavelength filter, the wavelength between the UV source and the SO₂ gas is about 214nm.



<mathematical notation 1>

Stage 2: This is the stage that appears after SO₂ reaches an excited (SO₂^{*}) state. The excited SO₂ emits surplus energy in the state of photons (hv) and then returns to a stable state rapidly since the system finds a stable state by minimizing the energy state. This fluorescent light is changed to a wavelength of 330 nm.



<mathematical notation 2>

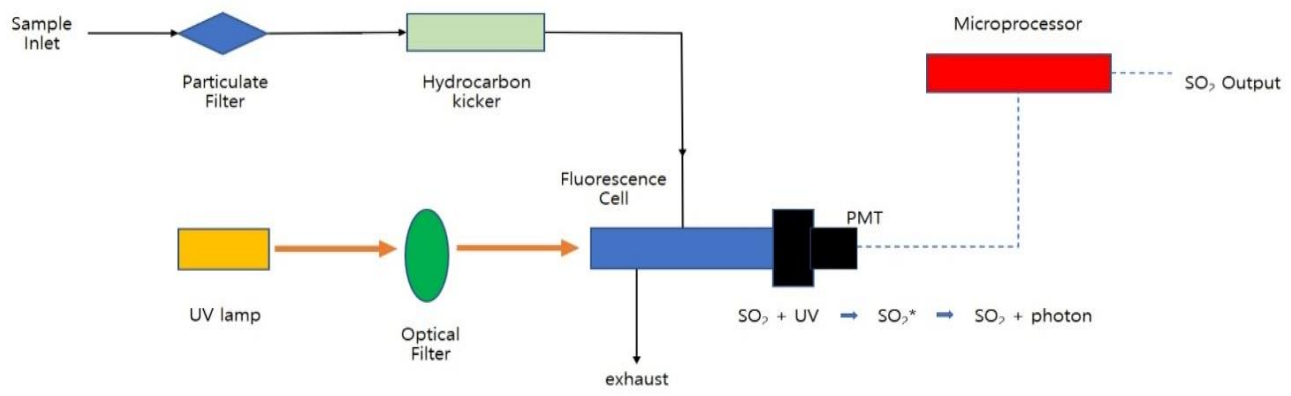


Figure 2: Ultraviolet Fluorescence Spectroscopy

Table 3: UV Fluorescence SO₂ Analyzer (Model T100)

Min/Max Range (Physical Analog Output)	Min: 0-50 ppb Full Scale Max: 0-20,000 ppb Full Scale	
Measurement Units	ppb, ppm, µg/m ³ , mg/m ³ (user selectable)	
Lower Detectable Limit	< 0.4 ppb	
Precision	0.5% of reading above 50 ppb	
Sample Flow Rate	650cc/min. ±10%	
Power Requirements	Power Rating 110-120 V~, 60 Hz 3.0A 220-240 V~, 50/60 Hz 3.0A	Typical Power Consumption 165W 140W
Analog Output Ranges	10 V, 5 V, 1 V, 0.1 V (selectable)	
Operating Temperature	5 - 40°C (with EPA Equivalency)	
Humidity Range	0 - 95% RH, non-condensing	

CO: Non-dispersive Infrared Method

The non-dispersive infrared method is a method of continuously measuring the concentration of carbon monoxide contained in the environmental atmosphere by measuring the change in the amount of infrared absorption by carbon monoxide with a selective detector. Molecules constituting a substance each have their own intermolecular vibrations, and absorb light of a wavelength according to the

frequency of the vibration mode, and in a gas with a constant pressure, absorption corresponding to the concentration is shown. The carbon monoxide analyzer by the non-dispersive infrared absorption method is a method of measuring the component concentration by measuring the infrared absorption in the vicinity of 4.7µm of carbon monoxide.

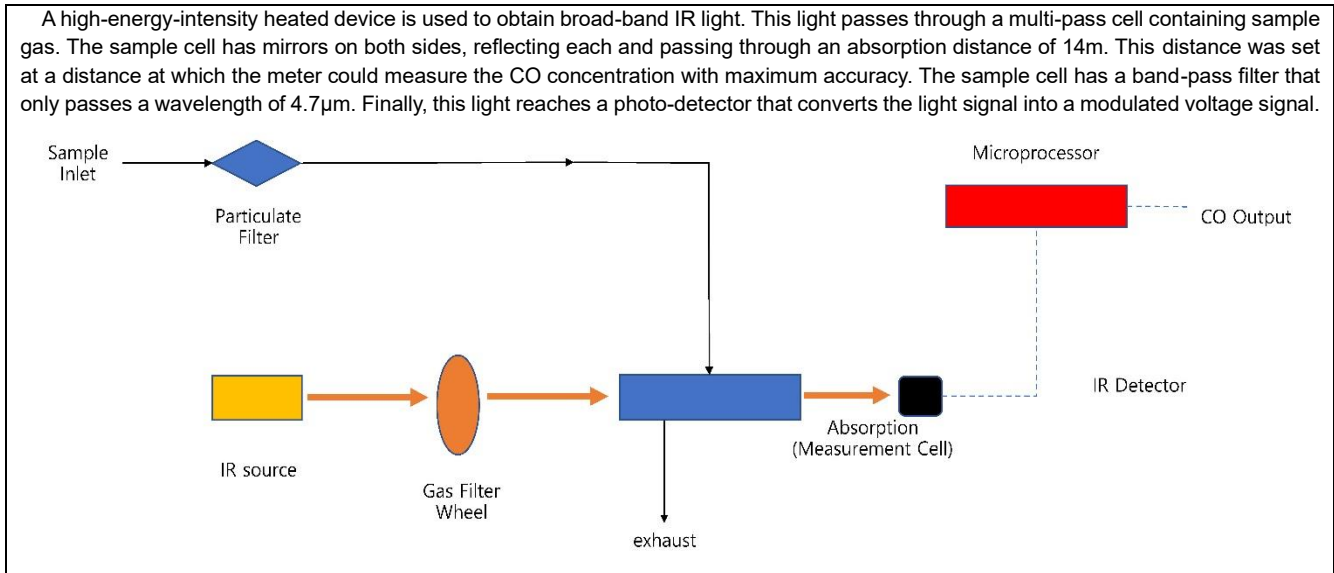


Figure 3: Non-Dispersive Infrared Spectroscopy

Table 4: Carbon Monoxide Analyzer (Model T300)

Min/Max Range (Physical Analog Output)	Min: 0-1 ppm Full scale Max: 0-1,000 ppm Full scale	
Measurement Units	ppb, ppm, μ g/m ³ , mg/m ³ (user selectable)	
Lower Detectable Limit	< 0.04 ppm	
Precision	The greater of 0.5% of reading or 0.2 ppm	
Sample Flow Rate	800 cm ³ /min. \pm 10%	
AC Power	Power Rating 110-120 V~, 60 Hz 3.0A 220-240 V~, 50/60 Hz 3.0A	Typical Power Consumption 155 W 160 W
Analog Output Ranges	All Outputs: 10V, 5V, 1V, 0.1V (selectable) Three outputs convertible to 4-20 mA isolated current loop. All Ranges with 5% under/over-range	
Operating Temperature	5 - 40°C operating, 10 - 40°C EPA Reference (T300 only)	
Humidity Range	0 - 95% RH, non-condensing	

NO₂: Chemiluminescent Method

When nitrogen monoxide in the sample atmosphere reacts with ozone, nitrogen dioxide is produced, which is in a photo-chemically excited state. These nitrogen dioxide molecules return to the ground state and generate light with a central wavelength near the near-infrared region (1,200 nm). The intensity of this light is proportional to the nitrogen monoxide content, and this is used to measure the nitrogen

monoxide concentration in the sample atmosphere. In the nitrogen oxide (NO+NO₂) measurement method, the nitrogen dioxide in the sample atmosphere is converted to nitrogen monoxide through a converter and measured in the same way as nitrogen monoxide, and the value obtained by subtracting nitrogen monoxide from nitrogen oxide becomes nitrogen dioxide.

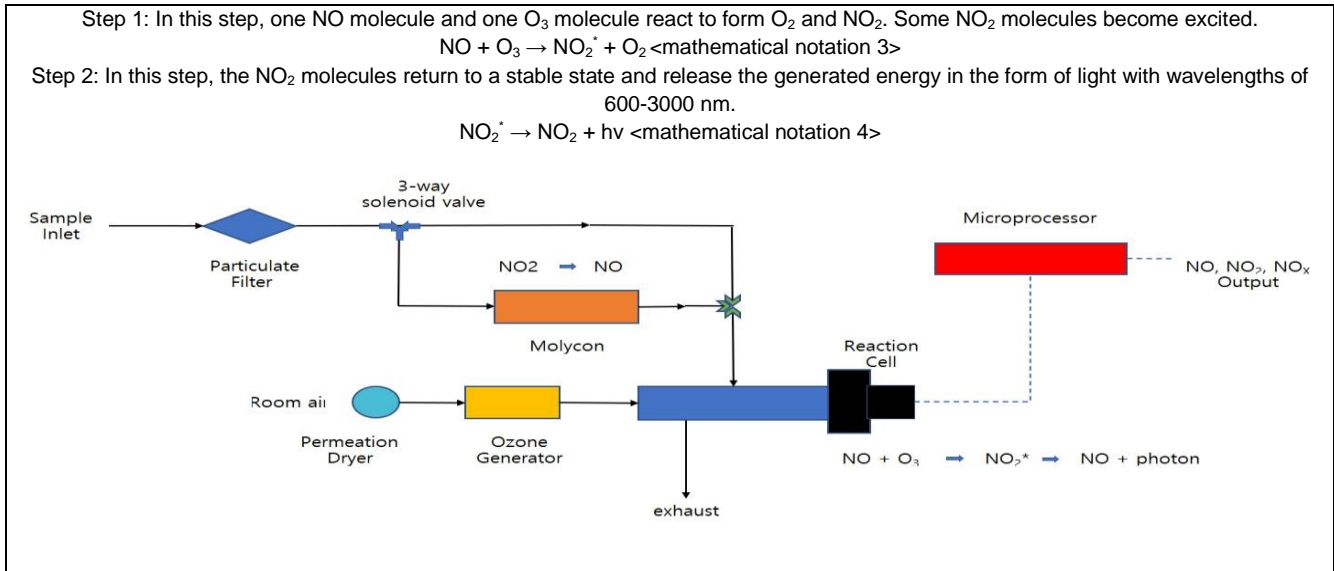


Figure 4: Chemiluminescence

Table 5: NO/NO₂/NO_x Analyzer (Model T200)

Min/Max Range (Physical Analog Output)	Min: 0-50 ppb Full Scale Max: 0-20,000 ppb Full Scale	
Measurement Units	ppb, ppm, μg/m ³ , mg/m ³ (user selectable)	
Lower Detectable Limit	< 0.4 ppb	
Precision	0.5% of reading above 50 ppb	
Sample Flow Rate	650cc/min. ±10%	
AC Power	Power Rating 110-120 V~, 60 Hz 3.0A 220-240 V~, 50/60 Hz 3.0A	Typical Power Consumption 100 W 110 W
Power, Ext Pump	100 V~, 50/60 Hz 3.25 A	115 V~, 60 Hz 3.0 A 220-240 V~, 50/60 Hz 2.5 A
Analog Output Ranges	10 V, 5 V, 1 V, 0.1 V (selectable) All Ranges with 5% Under/Over Range	
Operating Temperature	5 - 40 °C (with EPA Equivalency)	
Humidity Range	0 - 95% RH, non-condensing	

O₃: U.V Photometric Method

The 253.7nm ultraviolet rays emitted from the non-transferred low pressure mercury (Hg) discharge lamp are absorbed by ozone while passing through the optical absorption cell through which the sample air flows, and are measured with a discharge diode or a photo tube and converted into an electrical signal. Only ozone is selectively

removed from a part of the sample air collected using an ozone catalytic converter, and the UV intensity in the absence of ozone absorption is measured while flowing alternately with the sample through the sample absorption cell or through the double absorption cell. The ozone concentration obeys the Beer-Lambert law.

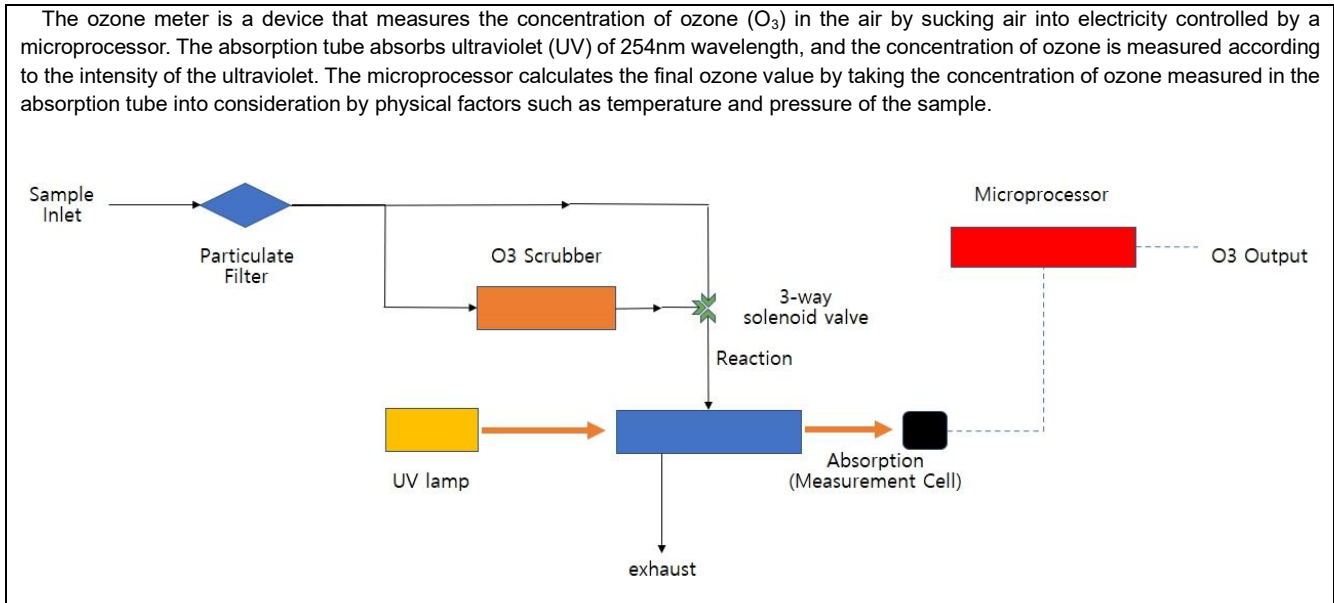


Figure 5: Ultraviolet Absorption Spectroscopy

Table 6: Photometric Ozone Analyzer (Model T400)

Min/Max Range (Physical Analog Output)	Min: 0-100 ppb Full scale Max: 0-10 ppm Full scale (selectable, dual ranges and auto-ranging supported)	
Measurement Units	ppb, ppm, $\mu\text{g}/\text{m}^3$, mg/m^3 (user selectable)	
Lower Detectable Limit	< 0.4 ppb (with 80 Sample Digital Filter)	
Precision	0.5% of reading above 100 ppb	
Sample Flow Rate	800cc/min. $\pm 10\%$	
Power Requirements	Power Rating	Typical Power Consumption
	110 - 120 V~ 60 Hz 3.0 A	110 W
	220 - 240 V~ 50 Hz 3.0 A	112 W
	220 - 240 V~ 60 Hz 3.0 A	112 W
Analog Output Ranges	10 V, 5 V, 1 V, 0.1 V (selectable)	
Operating Temperature	5 - 40 °C (with EPA Equivalency)	
Humidity Range	0 - 90% RH, non-condensing	

PM-2.5 / 10: Beta-Ray Absorption Method

The beta-ray absorption method compares and measures the intensity of beta-rays absorbed when beta-rays irradiated from a beta-ray light source emitting beta-rays pass through

the particle collected on the filter (particulate matter with an aerodynamic equivalent diameter of 2.5 μm or less than 10 μm).

E-BAME-BAM uses ¹⁴C, which naturally generates radioactive isotopes as beta particles, as a source of beta particles. ¹⁴C beta particles are electrons emitted from the nucleus of an atom as neutrons are split into photons and electrons. This electron is a smaller particle than an atom with a mass of 0.00054858 amu and an average energy of 49 KeV. Because of their very low mass and energy, beta particles can only travel 1-2 feet in the atmosphere, so they can be completely absorbed by a few sheets of paper. Because of the absorption properties of these beta particles, the mass can be measured.

E-BAM has a three-step particles weight measurement process. The first is the first count through the filter tape. The second is to pass particles -laden air through the filter, causing particles to build up on the filter. Finally, there is a second count that allows particles accumulated on the filter to pass through. The second count will have a lower value than the first count because the beta particles are absorbed by the particles accumulated on the filter. With a simple calculation, you can measure the weight of the particles that has accumulated on the filter. The weight of the particles is divided by the suction flow.

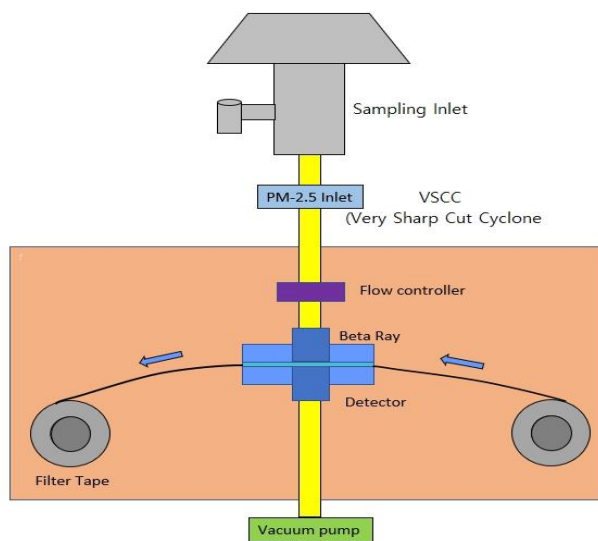


Figure 6: Beta-ray Absorption Method

Table 7: PM-2.5 / 10 Analyzer (MODEL E-BAM)

Measurement Principle	Particulate Concentration by Beta Attenuation
Measurement Range:	-0.005 to 65.530 mg/m ³ (-5 to 65,530 μg/m ³) 16 bit digital range
Accuracy	± 10% of indicated value for hourly measurements
Sample Time	Continuous air sampling with variable filter change periods
Measurement Cycles	Automatic hourly concentration measurements, with user selectable 1, 5, 10, 15, 30, or 60 minute quasi-real-time average output.
Flow Rate	16.7 liters/minute. Adjustable up to 17.5 liters/minute. Actual or Standardized flow modes.
Flow Accuracy	±2% of setpoint typical.
Filter Tape	Continuous glass fiber filter, 30mm x 21m roll. Up to 1 year operation per roll.
Beta Source:	¹⁴ C (carbon-14), 60 μCi ±15 μCi (< 2.22 X 10 ⁶ Bq), Half-Life 5730 years.
Beta Detector Type:	Photomultiplier tube with patented scintillator assembly
Operating Temp. Range	-25 to +50°C intermittent. -25 to +40°C continuous
Ambient Humidity Range	0 to 90% RH, non-condensing
Humidity Control	Automatic 15 Watt inlet heater module.
Analog Voltage Output	0-1, 0-2.5, or 0-5 volt DC output equals 0-1000 μg/m ³ . Selectable to represent the hourly or real-time concentration.
Power Supply	12 to 16 Volt DC input. 4.1 amps @12 VDC (50 Watts) max continuous draw

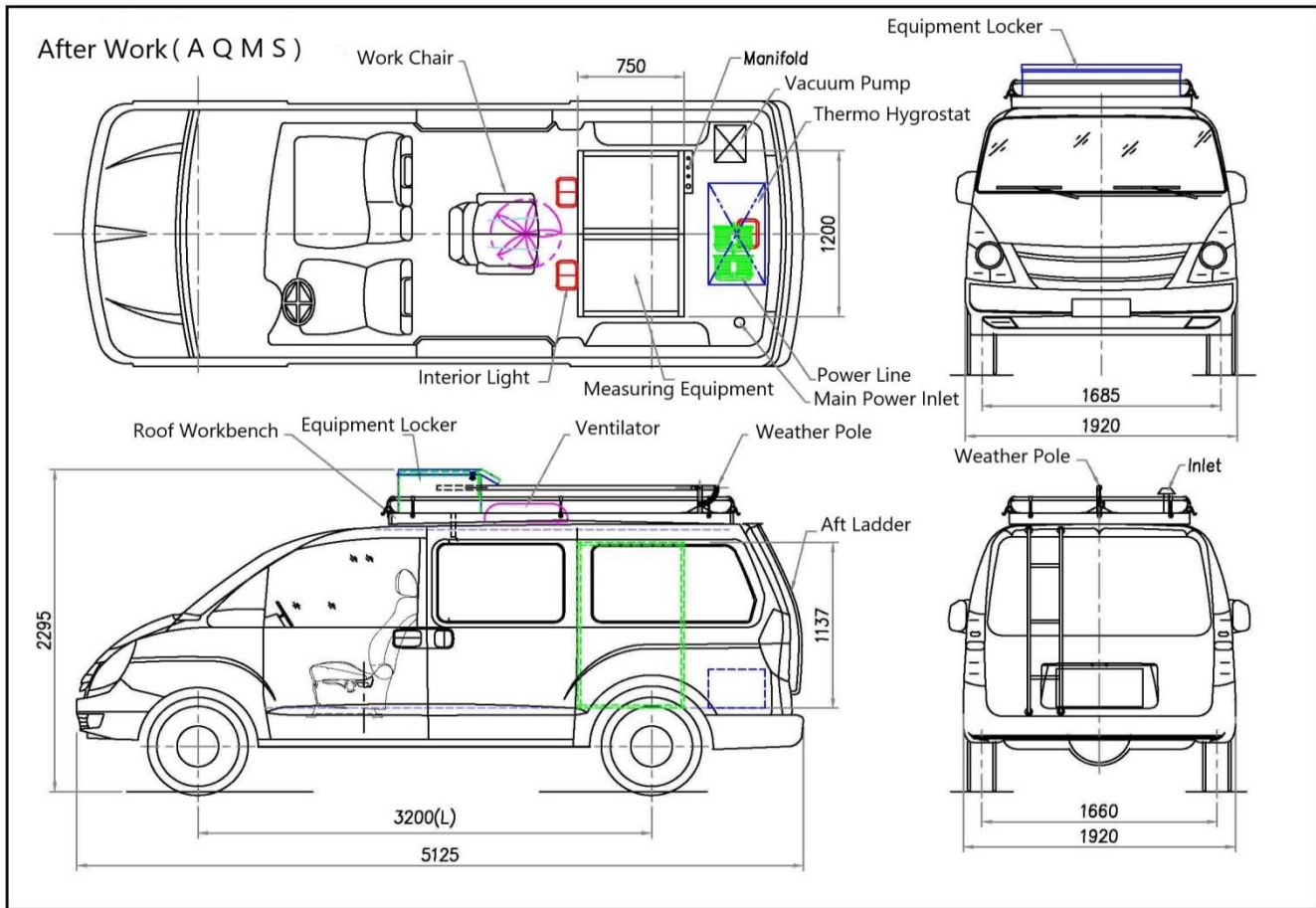


Figure 7: Portable Air Quality Sampling System Vehicle Drawing

3. Research Results and Discussions

Table 8: Weather Measured by the Local Meteorological Office -

Dates	Daily Climate	Average Temperature (°C)	Humidity (%)	Wind Direction (m/s)	Average Wind Speed (m/s)	Sea Level Pressure (hpa)	Amount of Precipitation (mm)
08/17/2022	a little cloud	25.3	81.9	W	1.4	1006.4	0
08/18/2022	more cloudy	25.1	78.4	WNW	1.5	1007.9	0
08/19/2022	cloudy	26.2	87.8	SW	2.4	1003.4	9
08/20/2022	a little cloud	27.3	84.5	W	2.1	1002.1	0
08/21/2022	a little cloud	27.4	80.9	WNW	1.3	1005.1	0
08/22/2022	more cloud	26.4	81.4	WSW	1.5	1004.8	2.2
08/23/2022	a little cloud	24.9	83.4	SWS	1.3	1005.9	6.1
08/24/2022	more cloudy	24.5	71.6	ENE	2.4	1008.2	0
08/25/2022	more cloudy	22.1	80.1	NNW	1.0	1008.1	0.4
08/26/2022	a little cloud	23.2	78.5	WSW	1.8	1007.9	0
08/27/2022	a little cloud	21.7	61.9	NW	2.6	1010.3	2.4
08/28/2022	clear	22.2	63.6	SSE	1.5	1014.8	0

Table 9: Weather Measured inside the Vehicle

Dates	Temperature (°C)	Humidity (%)
08/17/2022	25.8	60.7
08/18/2022	23.3	55.8
08/19/2022	24.6	67.1
08/20/2022	24.7	63.3
08/21/2022	23.3	65.2
08/22/2022	24.4	60.9
08/23/2022	24.7	61.1
08/24/2022	24.3	55.5
08/25/2022	22.6	58.3
08/26/2022	24.1	69.4
08/27/2022	22.9	54.3
08/28/2022	23.0	57.1

Note:

- 1) Automatic measurement vehicle's internal measurement data
- 2) Humidity should not be high in the measurement site, and an appropriate operating temperature of 18~30°C should be maintained. [Air Pollution Monitoring Network(APMN) Installation and Operation Guidelines, Ministry of Environment and National Academy of Environmental Sciences, 2021]

Table 10: Analysis of Measurement Results (8/17~8/20)

Dates Items	08/17			08/18			08/19			08/20		
	A-1	A-2	A-3	A-1	A-2	A-3	A-1	A-2	A-3	A-1	A-2	A-3
SO ₂ (ppm)	0.001	0.002	0.002	0.001	0.002	0.002	0.001	0.002	0.002	0.001	0.002	0.002
CO (ppm)	0.2	0.4	0.4	0.2	0.3	0.3	0.1	0.2	0.3	0.1	0.3	0.4
NO ₂ (ppm)	0.022	0.019	0.019	0.017	0.015	0.011	0.014	0.017	0.015	0.013	0.009	0.009
PM-10 (µg/m ³)	19	27	24	20	28	24	17	31	29	19	28	27
PM-2.5 (µg/m ³)	10	17	11	12	20	11	9	18	7	12	19	9
O ₃ (ppm)	0.016	0.026	0.023	0.021	0.036	0.038	0.013	0.023	0.021	0.026	0.039	0.036

Table 11: Analysis of Measurement Results (8/21~8/24)

Dates Items	08/21			08/22			08/23			08/24		
	A-1	A-2	A-3	A-1	A-2	A-3	A-1	A-2	A-3	A-1	A-2	A-3
SO ₂ (ppm)	0.001	0.002	0.002	0.002	0.002	0.003	0.002	0.002	0.002	0.001	0.002	0.002
CO (ppm)	0.1	0.3	0.4	0.1	0.3	0.3	0.1	0.2	0.3	0.2	0.2	0.3
NO ₂ (ppm)	0.009	0.011	0.008	0.017	0.016	0.012	0.020	0.014	0.013	0.013	0.015	0.014
PM-10 ($\mu\text{g}/\text{m}^3$)	18	28	24	19	29	24	15	22	18	13	23	16
PM-2.5 ($\mu\text{g}/\text{m}^3$)	12	16	9	13	16	10	9	13	7	9	12	5
O ₃ (ppm)	0.023	0.039	0.036	0.028	0.031	0.031	0.026	0.031	0.031	0.022	0.021	0.021

Table 12: Analysis of Measurement Results (8/25~8/28)

Dates Items	08/25			08/26			08/27			08/28		
	A-1	A-2	A-3	A-1	A-2	A-3	A-1	A-2	A-3	A-1	A-2	A-3
SO ₂ (ppm)	0.001	0.002	0.002	0.002	0.002	0.003	0.001	0.002	0.002	0.001	0.002	0.002
CO (ppm)	0.1	0.3	0.3	0.1	0.3	0.4	0.2	0.2	0.3	0.2	0.2	0.3
NO ₂ (ppm)	0.024	0.024	0.018	0.021	0.017	0.015	0.011	0.008	0.005	0.012	0.013	0.012
PM-10 ($\mu\text{g}/\text{m}^3$)	16	25	14	24	39	31	15	25	18	13	20	16
PM-2.5 ($\mu\text{g}/\text{m}^3$)	11	13	4	16	25	15	10	14	8	9	10	7
O ₃ (ppm)	0.006	0.008	0.014	0.038	0.040	0.042	0.030	0.034	0.033	0.026	0.025	0.029

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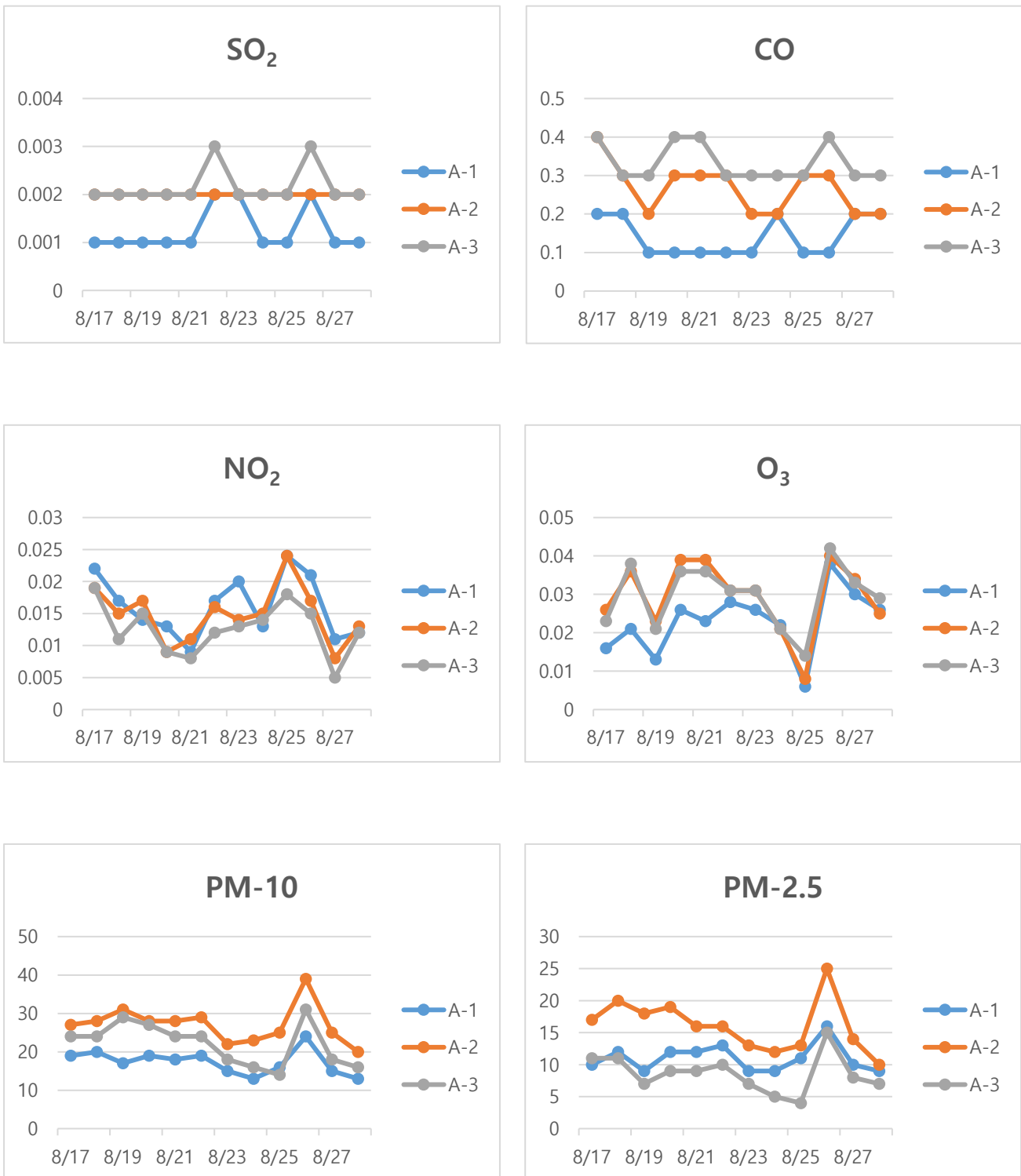


Figure 8: Analysis

Table 13: Calibration before Measurement(Gas)

	Items	Calibration	1 repetition	2 repetitions	3 repetitions	Allowable Deviation	Standard Deviation
Calibration before Measurement	CO (ppm)	ZERO	0.01	0.01	0.02	0.5	0.01
		SPAN	39.9	39.8	39.8		0.06
	O ₃ (ppm)	ZERO	0.001	0.001	0.004	0.005	0.001
		SPAN	0.399	0.397	0.396		0.001
	SO ₂ (ppm)	ZERO	0.001	0.001	0.002	0.005	0.001
		SPAN	0.393	0.392	0.394		0.001
	NO _x (ppm)	ZERO	0.001	0.003	0.005	0.005	0.002
		SPAN	0.401	0.402	0.399		0.002

Table 14: Calibration after Measurement(Gas)

	Items	Calibration	1 repetition	2 repetitions	3 repetitions	Allowable Deviation	Standard Deviation
Calibration after Measurement	CO (ppm)	ZERO	0.03	0.05	0.10	0.5	0.04
		SPAN	39.6	39.5	39.2		0.15
	O ₃ (ppm)	ZERO	0.002	0.004	0.005	0.005	0.002
		SPAN	0.397	0.395	0.395		0.002
	SO ₂ (ppm)	ZERO	0.002	0.004	0.007	0.005	0.003
		SPAN	0.390	0.388	0.387		0.002
	NO _x (ppm)	ZERO	0.004	0.007	0.010	0.005	0.003
		SPAN	0.397	0.394	0.393		0.002

Table 15: Accuracy of Measurement Results

Accuracy of Measurement Results				
Repeatability	CO (ppm)	O ₃ (ppm)	SO ₂ (ppm)	NO _x (ppm)
ZERO	>0.5	>0.005	>0.005	>0.005
SPAN				

Note: Among the detailed guidelines for the regular proficiency test in the atmospheric field, the environmental atmospheric continuous automatic measuring instrument operation capability proficiency test evaluation table criteria (gas phase)

Table 16: Calibration before Measurement(Particle)

	Items	Design Flow (LPM)	Measurement Flow (LPM)	Allowable Deviation	Measurement Deviation (%)
Calibration before Measurement	PM-10	16.7	16.6	2.0	0.6
	PM-2.5	16.7	16.6	2.0	0.6

Table 17: Calibration after Measurement(Particle)

	Items	Design Flow (LPM)	Measurement Flow (LPM)	Allowable Deviation	Measurement Deviation (%)
Calibration after Measurement	PM-10	16.7	16.5	2.0	1.2
	PM-2.5	16.7	16.6	2.0	0.6

Table 18: Accuracy of Measurement Results

Accuracy of Measurement Results	
SO2 (ppm)	>2.0%

Note: Among the detailed guidelines for the regular proficiency test in the atmospheric field, the standard of the proficiency test evaluation table for the continuous automatic measuring instrument operation capability (particulate phase)

4. Conclusions

The results of comparing the measurement results of the national Air Pollution Monitoring Network (APMN) with the measurement results of the PAQMS performed in this study are somewhat different. However, this result is considered to be a result of reflecting the characteristics between the measurement points, and it can be confirmed that the trend of the result value is also quite similar. The PAQMS can be effectively applied to various fields, such as areas where it is difficult to install a measurement network, and urgent investigations are required. However, while carrying out this study, some points to be improved by the PAQMS with these advantages were discovered.

The first improvement is the lack of structural rigidity. The PAQMS has a structure in which the measurement device is fixed to the vehicle and moved. Therefore, for this reason, there were cases in which the fixing device of the measuring equipment became loose due to vibration or shock. It is judged that the solution to this problem can be solved by adding complementary materials that can buffer vibration and impact to the vehicle's fixing device, or by changing the structure of the fixing device.

The second improvement is the issue of stable power supply. During measurement, there was a case in which the power of the measurement site was supplied unstable when moving to a new location due to the movement of the vehicle. At this time, data deviation was induced due to noise in the measurement result. In order to solve this problem, a Power Stabilization Device (PSD) is required, and if a UPS (Uninterruptible Power Supply) is additionally installed and operated in case of a sudden power failure, it is judged that the noise generated can be minimized and deviations can be prevented.

Through this study, although there are improvements as above, it was also possible to discover the advantages of a PAQMS. A general measuring station must use a temperature control device installed to maintain the temperature inside the measuring system (18~30°C) in accordance with the APMN Installation and Operation Guidelines (Ministry of Environment, National Institute of Environmental Sciences 2021). However, the advantage is

that more stable measurement is possible by controlling the humidity without additional reinforcement of constant temperature and humidity equipment.

In this study, the improvement and supplementary points of the system were sought through the actual use of the PAQMS, and two major points of improvement were presented. A countermeasure to solve this problem was also suggested, and if it is applied, it is judged that the accuracy and usability of the measurement of the PAQMS can be improved. However, it is judged that a budget for the PAQMS is required, such as additional installation of facilities. The PAQMS has the advantage of being portable and highly useful, but the unit price increases due to the installation of the measurement device in a vehicle. Since the improvements suggested in this study are also methods that consume additional budget, additional research on unit cost and budget reduction is needed in order to increase economic feasibility and increase usability.

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