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A Study on the Concentration Analysis of Roadside Air Pollutants

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Abstract

Purpose: In this study, volatile organic compounds(VOCs) and aldehydes generated from roadside vehicles and other pollutants were measured and analyzed. **Research design, data and methodology:** As a result of measuring and analyzing three areas near the roadside, Vinyl chloride 0.00 ~ 0.02 ppb, Benzene 2.87 ~ 5.01 ppb. Toluene 4.51 ~ 8.62 ppb, Styrene 0.00 ~ 0.34 ppb, Formaldehyde 8.45 ~ 17.12 ug/m^3, Acetaldehyde 7.01 ~ 17.64 ug/m^3 were detected. When comparing the analysis results and the 6-month average concentration of the hazardous air monitoring network, the analysis results were about 26 times higher for Benzene, about 5 times for Toluene, and about 3.75 times for Styrene. In the case of vinyl chloride, it was confirmed that it was about 20 times lower than that of the hazardous atmosphere monitoring network. **Results:** Therefore, it is necessary to reexamine the installation location of the measurement network because people are exposed to pollutants on the actual roadside. It is judged that it is right to build a measurement network that is practically helpful to people by increasing the measurement items in the measurement network.

Keywords : Roadside, VOCs, Aldehydes, Rush-hour traffic, Hazardous atmospheric measuring network

JEL Classification Codes : I10, Q52, Q53, Q55, Q59

1. Introduction

Air pollution monitoring network in Korea is a measurement network installed to evaluate air quality improvement and air quality concentration change according to air environment standards. In Korea, the first 4 measuring networks were installed in Seoul in 1973. As of the end of December 2019, the measurement network is developing rapidly, with 676 measurement networks of 11 types operating nationwide (Kim et al., 2020).

However, the management system to check and confirm the suitability of the location of the air pollution monitoring station and the selection process is somewhat lacking. In particular, location management of the air pollution monitoring network is important for the verification of air pollution monitoring network data to improve the quality of providing environmental services to the public (fine dust, ozone forecast) (Kim et al., 2015).

According to the Air Pollution Monitoring Network Installation and Operation Guidelines (National Institute of Environmental Sciences, 2021), the standard sampling pit height is within the range of 1.5m to 10m above the ground, which is the height at which people live and breathe.

However, most of the air pollutants such as volatile organic compounds (VOC), O_3, and NO_2 are mainly generated within 1m from the ground or from vehicles.

However, the conditions for the proper operation of the air pollution monitoring station require many spatial restrictions due to the surrounding environment, weather changes, and stable power supply. For this reason, it was confirmed that there were many cases of installing and operating air pollution monitoring stations by selecting rooftop sites (3m to 10m) for schools and government offices during the site selection process.

In addition, only PM-10, PM-2.5, SOx, NO_2, O_3, and CO items are being measured at roadside measurement stations in Korea. Therefore, measurement of toxic gases (volatile organic compounds, aldehydes, etc.) generated from vehicles is insufficient. Among air pollutants, volatile organic compounds are not only harmful to the human body, but also the main cause of photochemical smog. This increases the concentration of ozone in the atmosphere (Park et al., 2002), and aldehydes are carcinogenic and irritating chemical species that are important pollutants of workplace and indoor air pollution (Jung et al., 2003). Therefore, this study intends to measure and analyze volatile organic compounds and aldehydes that occur on the roadside during domestic work hours.

2. Research Methodology

2.1. Survey Period and Location

In this study, from July to December 2020, the areas with high vehicle and population flow and frequent traffic jams were selected among the Dongan Gu, Anyang-City. The survey area is shown in Figure 1. This area is an area where traffic congestion occurs for about 30 minutes to an hour during commuting time due to road construction and narrow lanes. Sample collection was measured once a month between 5pm and 7pm, the time when vehicles and floating populations are the most. The concentration of VOCs and aldehydes was measured at a height of 1.5m above the ground within 1m of a bus stop where there are many vehicles and floating populations at the sampling location. The measurement points are in Table 1, and the weather conditions are in Table 2.

Table 1: Measurement Points

	Location
P-1	529, Heungan-daero, Dongan-Gu, Anyang-City, Gyeonggi-Do, Republic of Korea
P-2	523-2, Heungan-daero, Dongan-Gu, Anyang-City, Gyeonggi-Do, Republic of Korea
P-3	1580, Gwanyang-dong, Dongan-Gu, Anyang-City, Gyeonggi-Do, Republic of Korea

Table 2: Weather Conditions

Date of Measurement	Temp.(℃)	W.D.	W.S. (m/sec)	Atmospheric pressure (mmHg)
2020.7.17	28.4	WNW	2.5	756
2020.8.21	30.4	W	2.9	760
2020.9.18	23.4	W	5.3	760
2020.10.16	15.1	NW	1.3	767
2020.11.13	15.0	WNW	2.2	771
2020.12.11	7.6	W	1.8	764

Figure 1: The Measurement Points of Roadside

2.2. Analysis Method and Conditions

For the measurements of VOCs, 4L was sampled at a flow rate of 0.1L/min using SIBTA MP-Σ30KNII equipment. The analysis conditions are shown in Table 3. Among VOCs, Vinyl chloride, Benzene, Toluene, and Styrene were included in the investigation. Formaldehyde and Acetaldehyde were targeted as analysis items of Aldehyde. For measurement and analysis, 5mL of a sample collected for 5minutes at 1.0L/min using the Top Trading ENG's Ozone scrubber and DNPH cartridge was extracted with an acetonitrile solution, and then measured by high-performance liquid chromatography. The conditions of the analysis equipment are shown in Table 4.

Table 3: The Conditions of VOCs Analysis

Analytical Equipment Conditions		
Equipment model	PerKinelmer TD/GC/MS (TurboMatrix 650 ATD/clarus600/SQ8)	
Flow gas	He	
Column	DB-5ms(60 m * 0.25 um * 1 um)	
Oven	35 ℃(4 min)→10 ℃/min→250℃(5 min)	
Ms mode	Scan and SIM	
M/z range	35 ~ 300 amu	
TD analysis conditions		
	Control Variables	Conditions
1. Absorption tube purge stage	Flow	50 mL/min
	Time	10 min
2. Absorption tube detachable stage	Temp.	300 ℃
	Flow	50 mL/min
	Time	10 min
	Cold temp.	-30 ℃
3. Enrichment trap detachable stage	Temp.	280 ℃
	Flow	1.0 mL/min
	Time	10 min
4. Valve temp.	Temp.	230 ℃
5. Line temp.	Temp.	230 ℃
6. Split ratio	-	100 : 2
7. Gas flow	Flow	1.0 mL/min

Table 4: The Conditions of Aldehyde Analysis

Equipment model	Perkinelmer HPLC-UV
Column	C18 (5um × 150mm × 4.6mm)
Oven temp.	35 ℃
Solvent	Acetonitrile : Water (6:4)
Injection volume	20uL
Wavelength	360nm
Flow	1.0mL/min
Analysis time	30min

3. Results and Discussions

3.1. Concentration Distribution Characteristics of VOCs

Looking at the measurement results of VOCs for 6 months, Vinyl chloride was 0.00 ~ 0.02ppb, Benzene 2.87 ~ 5.01ppb. Toluene 4.51 to 8.62ppb and Styrene 0.00 to 0.34ppb were detected. Table 5 shows the monthly analysis results. The 6-month average concentration in the sampling area was 0.004ppb for Vinyl chloride and 3.75ppb for Benzene. It was measured to be 6.52ppb of Toluene and 0.15ppb of Styrene. In the order of pollutant emission concentration, Toluene > Benzene > Styrene > Vinyl chloride was confirmed to detect high toluene. This result confirmed that concentrations were detected in the same order in other studies (Kim et al., 2018).

3.2. Concentration Distribution Characteristics of Aldehydes

In the aldehyde measurement results for 6 months, 8.45 ~ 17.12ug/m3 of Formaldehyde and 7.01 ~ 17.64ug/m3 of Acetaldehyde were detected. The monthly measured concentrations are shown in Table 6.

The average concentration of aldehydes in the sampling area for 6 months was 12.93 ug/m^3 for Formaldehyde and 11.75ug/m^3 for Acetaldehyde. In the case of aldehydes, it was confirmed that the two items similarly increased or decreased.

3.3. Seasonal Concentration Characteristics

The monthly maximum, minimum, and average

Table 5: The Analytical Concentration of VOCs

	Points \ Month	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Vinyl Chloride	P-1	0.02	0.01	0.00	0.00	0.00	0.00
	P-2	0.00	0.01	0.00	0.00	0.01	0.02
	P-3	0.00	0.00	0.00	0.00	0.00	0.01
	Ave.	0.01	0.01	0.00	0.00	0.00	0.01
Benzene	P-1	3.43	5.01	3.79	2.87	3.05	3.11
	P-2	4.49	4.41	3.16	3.95	3.12	3.41
	P-3	4.18	4.74	4.28	3.44	3.09	3.97
	Ave.	4.03	4.72	3.74	3.42	3.09	3.50
Toluene	P-1	8.62	6.94	7.15	6.32	4.51	5.26
	P-2	7.95	7.37	7.28	6.14	5.18	5.02
	P-3	7.88	7.49	7.33	6.45	5.49	5.00
	Ave.	8.15	7.27	7.25	6.30	5.06	5.09
Styrene	P-1	0.34	0.22	0.14	0.26	0.00	0.08
	P-2	0.15	0.18	0.15	0.23	0.12	0.11
	P-3	0.11	0.21	0.15	0.22	0.00	0.06
	Ave.	0.20	0.20	0.15	0.24	0.04	0.08

Note: Unit(ppb)

Table 6: The Analytical Concentration of Aldehyde

	Points \ Month	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Formaldehyde	P-1	15.21	16.85	12.51	10.35	9.84	14.78
	P-2	14.36	17.12	11.05	10.84	9.25	15.93
	P-3	15.73	15.44	8.45	10.76	8.49	15.80
	Ave.	15.10	16.47	10.67	10.65	9.19	15.50
Acetaldehyde	P-1	12.85	16.50	10.08	9.63	8.75	13.15
	P-2	12.35	17.64	9.99	9.22	7.01	12.62
	P-3	16.28	13.44	8.16	8.87	10.90	14.11
	Ave.	13.83	15.86	9.41	9.24	8.89	13.29

Note: Unit(ug/m^3)

concentrations of VOCs and aldehydes are shown in Fig 2 ~ Fig 7. As for the seasonal characteristics, in the case of VOCs, Benzene and Toluene showed a tendency to increase in summer and decrease after autumn based on the 6-month average concentration. Styrene confirmed that summer and autumn were high or similar, and decreased in winter. In the case of benzene and toluene, similar to this study, there are research data showing the highest concentration in summer (Nguyen et al., 2009; Na & Kim, 2001), whereas research data showing the highest concentration in winter and low summer (Hoque et al., 2008; Brocco et al., 1997) were also confirmed.

It was confirmed that the measurement of aldehydes was high in summer and winter and decreased in autumn. This is judged to be higher than in autumn due to an increase in the amount of fuel burned due to an increase in ambient temperature in summer and use of indoor air conditioners and heaters in vehicles in winter.

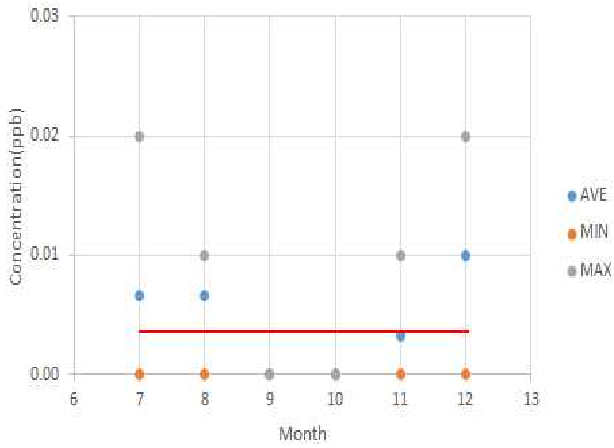

Figure 2: Ave. Min. Max. Analytical Concentration of Vinyl Chloride

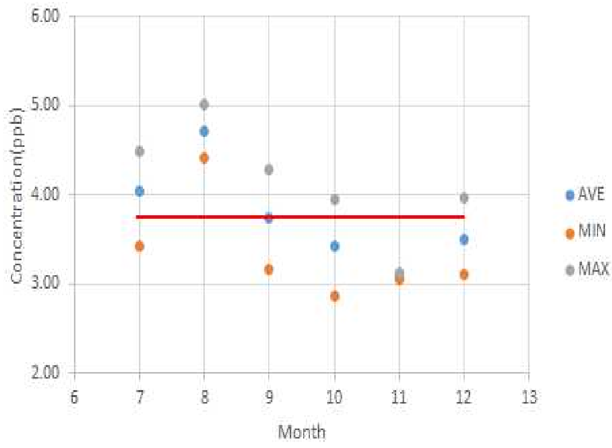

Figure 3: Ave. Min. Max. Analytical Concentration of Benzene

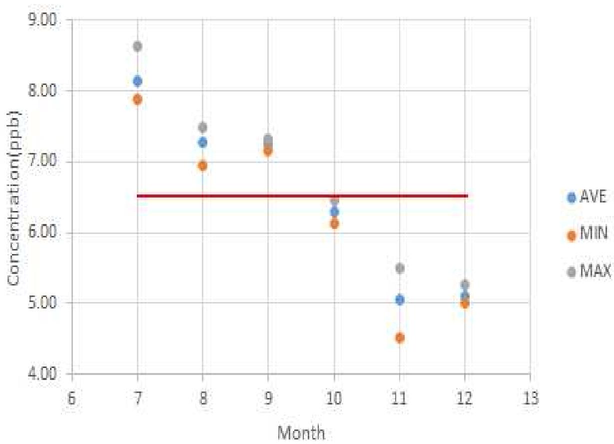

Figure 4: Ave. Min. Max. Analytical Concentration of Toluene

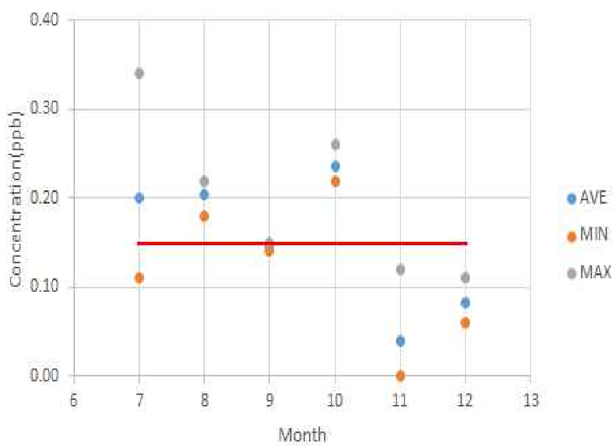

Figure 5: Ave. Min. Max. Analytical Concentration of Styrene

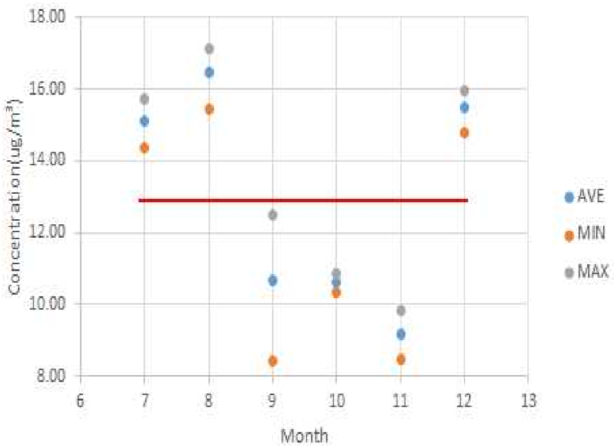

Figure 6: Ave. Min. Max. Analytical Concentration of Formaldehyde

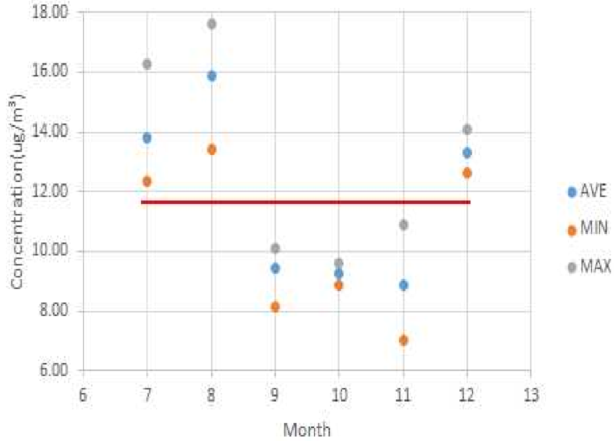

Figure 7: Ave. Min. Max. Analytical Concentration of Acetaldehyde

3.4. Comparison with Hazardous Air Monitoring Network

The results of the analyzed VOCs were compared with the average monthly VOCs of the Noxious Atmospheric Monitoring Network in Sinpung-Dong, Paldal-Gu, Suwon-City, Gyeonggi-Do, located closest to the study area. The monthly average data of the measurement network are in Table 7 (Ministry of Environment., 2020). In comparison of the analysis results and the 6-month average concentration of the hazardous atmosphere monitoring network, the analysis results were about 26times higher for Benzene, about 5times for Toluene, and about 3.75times for Styrene. In the case of vinyl chloride, it was confirmed that it was about 20times lower than that of the hazardous atmosphere monitoring network.

However, the measurement network is the result of measurement from a higher position than in this study. Because the measurement time and the measurement location are different, it is judged that it is correct that the results of this study measured directly at the location where a lot of pollutants are generated are measured high. Therefore, it is judged that the location of the measurement network needs to be recalculated because the exposure of pollutants is high at intersections and bus stop areas with high population flow.

Table 7: Hazardous Atmospheric Material Measurements of Net Monthly VOCs Concentration

	Vinyl Chloride	Benzene	Toluene	Styrene
Jul.	0.02	0.09	1.30	N.D.
Aug.	0.07	0.02	0.85	0.26
Sep.	0.12	0.09	0.92	N.D.
Oct.	N.D.	0.17	1.29	N.D.
Nov.	N.D.	0.22	2.00	N.D.
Dec.	0.24	0.25	1.30	N.D.
Ave.	0.08	0.14	1.28	0.04

Note: Unit (ug/m3), Source (Ministry of Environment)

4. Conclusions

This study analyzed the volatile organic compounds and aldehydes that are generated on the roadside where there are many vehicles and floating population, and vehicles are stagnant. In the analysis results, in the case of VOCs, Benzene, Toluene, and Styrene were measured to be about 3.75 to 26times higher than that of the measurement network. In the case of vinyl chloride, it was confirmed that it was about 20times lower. It was confirmed that the concentration of VOCs in summer was higher than that of other seasons, and toluene was detected at a higher concentration than other items.

In addition, it was confirmed that VOCs also increased with an increase in traffic volume in other research data (Park et al., 2006; Lee et al., 2011).

In the case of aldehydes, the 6-month average concentration was measured to be 12.93ug/m^3 of Formaldehyde and 11.75ug/m^3 of Acetaldehyde. In particular, it was confirmed that this occurred high in summer and winter. In the case of aldehydes, since there is no separate measurement network, it is difficult to determine the high and low aldehydes in the area. However, in the case of formaldehyde according to domestic indoor air quality management standards, it was confirmed that it was measured about 6times lower at 80ug/m^3. However, according to a study by Kim (2013), it was confirmed that a large amount of formaldehyde was generated in diesel vehicles, and it is judged that the concentration of aldehydes will increase when the number of large trucks and vehicles using diesel increases.

Based on the above results, in the case of aldehydes, the degree of exposure to pollution is lower than that of indoors, but it is considered that it is not serious. Among VOCs, benzene was measured to be lower than the average annual average of 5ug/m^3 of benzene, which is the domestic environmental air management standard. There is no regulation on other VOCs items. In addition, many atmospheric monitoring networks have been installed since the first measurement network was installed in 1973. However, there is no place that directly operates a measurement network at a distance where the population flows due to restrictions by installation conditions and atmospheric sample collection methods.

Therefore, as the interest in improving the quality of life and reducing pollutants around the world increases, regulations and strengthening of pollutants are in progress. Targeting an area where there is a large floating population and a lot of various harmful substances, the development of portable measuring equipment that can measure at the height of the population and various hazardous substances and installation of a measuring network using GIS (Geographic Information System) was selected (Kim & Kwon, 2016) and others. Therefore, it is judged that big data should be established to prepare a way to minimize the pollutants exposed to the human body.

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