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TECHNICAL NOTE

Characteristics of PM_{10}, $PM_{2.5}$ and $PM_{2.5}/PM_{10}$ Ratio in Air Monitoring Stations in Gyeongnam

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Abstract

The characteristics of PM_{10}, $PM_{2.5}$ and Ratio($PM_{2.5}/PM_{10}$) of 11 urban air monitoring stations in Gyeongnam were analyzed for the last 3 years(`15~`17). The average of the all stations was PM_{10} 45 μg/㎥, $PM_{2.5}$ 24 μg/㎥ and Ratio 0.54, and annual reduction rates were PM_{10} -2.9%, $PM_{2.5}$ –2.7% and Ratio –1.2%, respectively. The seasonal characteristics of PM_{10} were spring 54 μg/㎥ > winter 48 μg/㎥ > summer/autumn 40 μg/㎥, $PM_{2.5}$ were spring/winter 26 μg/㎥ > summer 23 > autumn 22 μg/㎥ and Ratio were summer 0.56 > winter 0.55 > autumn 0.54 > spring 0.51, respectively. The hourly characteristics of PM_{10} were 11 μg/㎥ higher than 09:00~12:00 at 03:00~06:00, $PM_{2.5}$ were 6 μg/㎥ higher than 09:00~12:00 at 17:00~18:00 and Ratio were 0.07 higher than 04:00~06:00 at 19:00. By site, the highest concentration of PM_{10} was YJ site 53 μg/㎥ and $PM_{2.5}$ was HW site 28 μg/㎥. And Ratio at HD site showed the largest reduction from `15 0.62 to `17 0.52.

Key words : Gyeongnam air monitoring stations, PM_{10}, $PM_{2.5}$, $PM_{2.5}/PM_{10}$

1. Introduction

Atmospheric Particulate Matter(PM) is generated by primary particles that are directly emitted from various sources, secondary particles generated through the conversion of gas to particles, and are continuously distributed in a particle size range of 0.01 to 100 ㎛. Many toxicological studies have reported that fine particles have a more toxic adverse effect than coarse particles, depending on the particle size(Donaldson et al., 1998; Harrison et al. 2010).

In Korea, Atmospheric environmental standards for PM_{10} and $PM_{2.5}$, which have long-term prosperity and impact on health, have been established since 1993 and are monitored by the national air pollution monitoring network.

Coarse particles(PM_{10}-$PM_{2.5}$) are generated from natural sources such as mechanical fracturing, soil, and sea salt, and are quickly removed from the atmosphere through gravitational settling and rainfall washing. On the other hand, fine particles($PM_{2.5}$) is mainly generated from anthropogenic combustion sources including vehicles, and it is very difficult to control in terms of regional air quality control due to

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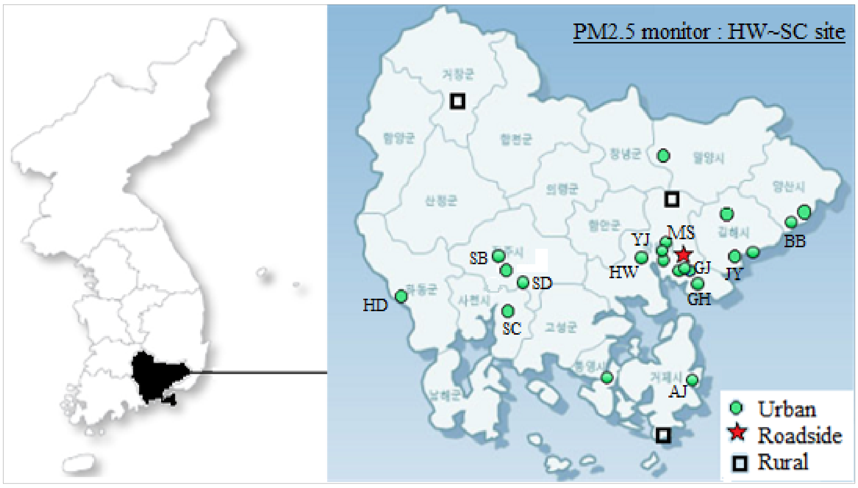

Fig. 1. The location of air pollution monitoring stations in Gyeongnam, Korea, December 2017.

active inter-regional or long-distance transportation. Therefore, it is important to analyze temporal and spatial changes of the concentration ratio as well as the concentration characteristics in order to understand the behavior characteristics of PM_{10} and $PM_{2.5}$(Munir, 2017).

Recently, fine particles have been attracting much attention not only in the atmospheric environment but also in terms of health damage. Especially, major cities such as Seoul and Busan are using the measurement data of the air pollution monitoring network to determine the effect of the local air pollution policy and the improvement of air quality. In Gyeongnam Province, the concentration of PM_{10} (45 ㎍/㎥) and $PM_{2.5}$ (25 ㎍/㎥) in 2016 is similar or not significantly lower than the national average, Seoul and Busan(MoE, 2017). Nevertheless, there is little research on the characteristics of PM_{10} and $PM_{2.5}$ in the region.

In this paper, at 11 air pollution monitoring stations where the $PM_{2.5}$ is measuring in Gyeongnam area were collected PM_{10} and $PM_{2.5}$ data for the last three years(`15~`17), and the temporal and spatial characteristics including the $PM_{2.5}/PM_{10}$ concentration ratio(Ratio) were analyzed.

2. Methodology

2.1. Air monitoring network in Gyeongnam

The air pollution monitoring network in Gyeongnam is shown in Fig. 1. As of the end of December 2017, there are a total of 25 monitoring stations in Gyeongnam, including 21 urban stations, 1 roadside station, and 3 suburban sites. Of these 11 urban stations, the $PM_{2.5}$ measuring instrument has been installed since 2015 and measurement data are available. In 11 urban stations, the $PM_{2.5}$ instrument has been installed and $PM_{2.5}$ measurement data are available from 2015(MoE, 2018).

In this study, PM_{10} and $PM_{2.5}$ data from the 11 urban stations were used. The eight sites such as the HW site(Hoewong-dong, Changwo) are located in the residential area, the GJ site(Gaeumjeong-dong, Changwo) and SD site(Sangdae-dong, Jinju) in the industrial area, and the HD site(Hadong-eup, Hadong) in the green area(KNHE, 2018).

2.2. Process PM_{10} and $PM_{2.5}$ collection data

In this study, PM_{10} and $PM_{2.5}$ data collected 26,304

Table 1. The PM monitoring stations and effective rate of 1 hour measurement data

	Site	Location	Zone	Effective rate of 1 hour measurement data		
				PM_{10}	$PM_{2.5}$	PM_{10} & $PM_{2.5}$
1	HW	Hoewong-dong, Changwon	residential	88.5%	90.5%	85.1%
2	GJ	Gaeumjeong-dong, Changwon	industrial	94.2%	95.2%	92.1%
3	YJ	Yongji-dong, Changwon	residential	94.6%	96.0%	91.9%
4	GH	Gyeonghwa-dong , Changwon	residential	95.0%	97.4%	93.5%
5	SB	Sangbong-dong, Jinju	residential	98.2%	97.7%	97.2%
6	SD	Sangdae-dong, Jinju	industrial	95.3%	95.7%	92.9%
7	HD	Hadong-eup, Hadong	green	95.6%	95.0%	91.6%
8	JY	Jangyu-dong, Gimhae	residential	95.6%	98.1%	94.7%
9	AJ	Aju-dong, Geoje	residential	95.4%	97.4%	94.0%
10	BB	Bukbu-dong, Yangsan	residential	95.1%	97.2%	93.2%
11	SC	Sacheon-eup, Sacheon	residential	95.6%	97.8%	94.5%

final confirmed hourly concentration for the last 3 years(`15~`17) in 11 urban stations on Air Korea homepage(Air Korea, 2018). As shown in Table 1, the average 93% effective measurement data excluding the error data was used in this study.

The daily, monthly and annual average concentrations were calculated using the hourly data. The average concentrations were used only when the effective measurement rate was over 75%. The average concentration of PM_{10} and $PM_{2.5}$ was rounded off to the first decimal place(MoE, 2016).

The collected data were statistically processed using the IBM SPSS Statistics program(Ver. 21).

2.3. Status of Asian dust and high concentration dust alarm

The high concentration of PM appears mainly in the case of Asian dust and fine dust alarm.

The occurrence days of Asian dust in Gyeongnam was based on the Changwon weather station(155) and occurred for a total of 13 days in the last 3 years including 4 days in 2015, 5 days in 2016 and 3 days in 2017(KMA, 2018).

The days with PM_{10} concentration of more than 150 ㎍/㎥ over 2 hours appeared for total 8 days in the last 3 years including 3 days in 2015, 2 days in 2016 and 3 days in 2017. And the days with $PM_{2.5}$ concentration of more than 90 ㎍/㎥ over 2 hours appeared for total 8 days in the last 3 years including 8 days in 2015, 0 day in 2016 and 2017.

3. Results and discussion

3.1. Daily average change over the last three years

In order to investigate the overall tendency of PM concentration in Gyeongnam during the last 3 years(`15~`17), the daily mean characteristics of PM_{10}, $PM_{2.5}$ and Ratio($PM_{2.5}/PM_{10}$) in 11 air monitoring stations are shown in Fig. 2.

The daily mean values for the last three years were PM_{10} 45 ㎍/㎥, $PM_{2.5}$ 24 ㎍/㎥ and Ratio 0.54(0.19 ~ 0.71), respectively.

The daily average of 13 days of Asian dust phenomenon occurrence was PM_{10} 130 ㎍/㎥, $PM_{2.5}$ 37 ㎍/㎥ and Ratio 0.32. The average of the PM_{10} alarm days for 8 days was PM_{10} 126 ㎍/㎥, $PM_{2.5}$ 40 ㎍/㎥ and Ratio 0.35. And the average of the $PM_{2.5}$ alarms issued for 8 days only in 2017 were PM_{10} 101 ㎍/㎥, $PM_{2.5}$ 58 ㎍/㎥ and Ratio 0.58, respectively. On the other hand, in normal days except for Asian

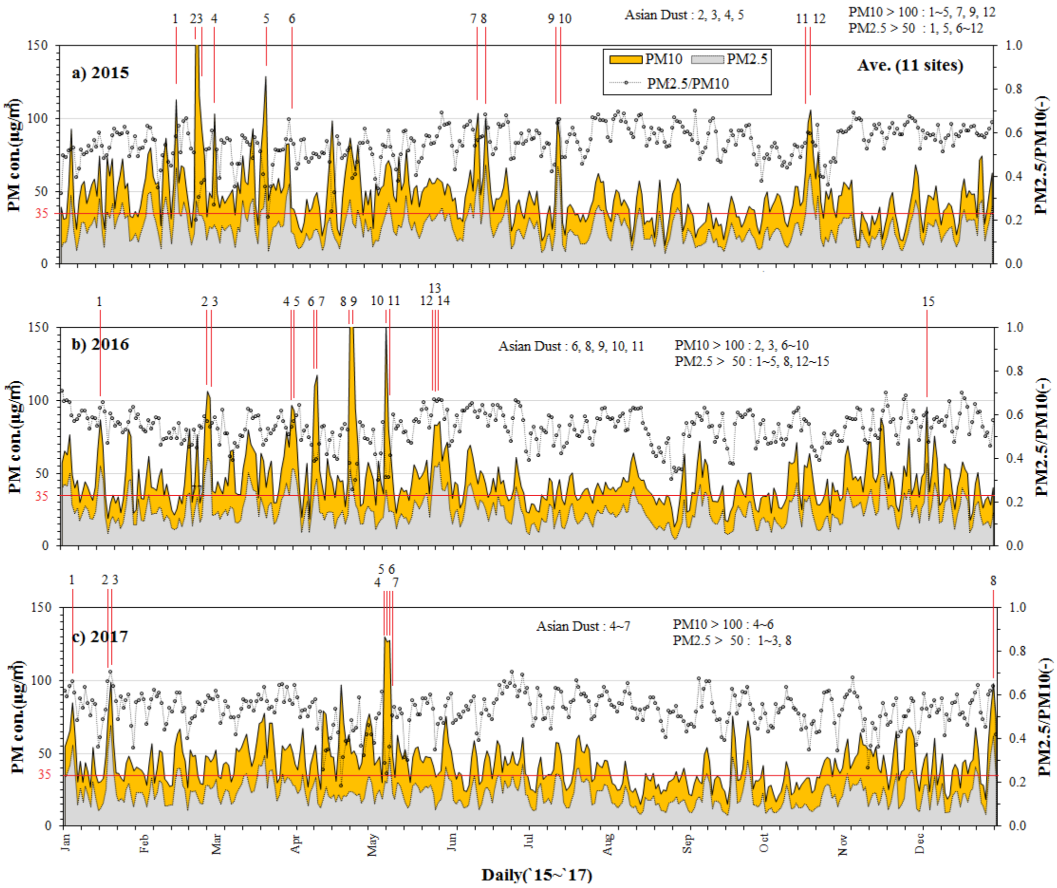

Fig. 2. Daily variation of PM_{10}, $PM_{2.5}$ and $PM_{2.5}/PM_{10}$ for 11-site average in 3 years(`15~`17).

dust phenomenon and PM alarm days were PM_{10} 44 ㎍/㎥, $PM_{2.5}$ 24 ㎍/㎥ and Ratio 0.54.

In general, characterization of PM is evaluated at an annual average concentration, but it is important to focus on the occurrence of high concentration from the viewpoint of harmfulness(Kim, 2005). The days of high concentrations of PM_{10} and $PM_{2.5}$ exceeding the 24-hour average environmental standard decreased annually. The days when PM_{10} concentration exceeded 100 ㎍/㎥ appeared `15 8 days, `16 7 days and `17 3 days. It also appeared mainly during the period from February to May and during the occurrence of Asian dust. Therefore, it was shown that the Asian dust phenomenon that appeared mainly in spring had a great influence on the occurrence of high concentration of PM_{10}. The days when $PM_{2.5}$ concentration exceeded 50 ㎍/㎥ appeared a total 23 days such as `15 9 days, `16 10 days and `17 4 days. When the new modified environmental standard $PM_{2.5}$ of 35 ㎍/㎥ was applied, it was a total 140 days such as `15 55 days, `16 51 days and `17 34 days. Especially, the days of winter and spring were two times higher than those of summer and autumn.

The concentration ratio of $PM_{2.5}$ in PM_{10}, Ratio is a key indicator of contribution of PM source. When this value is high, the contribution of secondary particles converted from gas to particles is high. When it is low, the contribution of primary particles

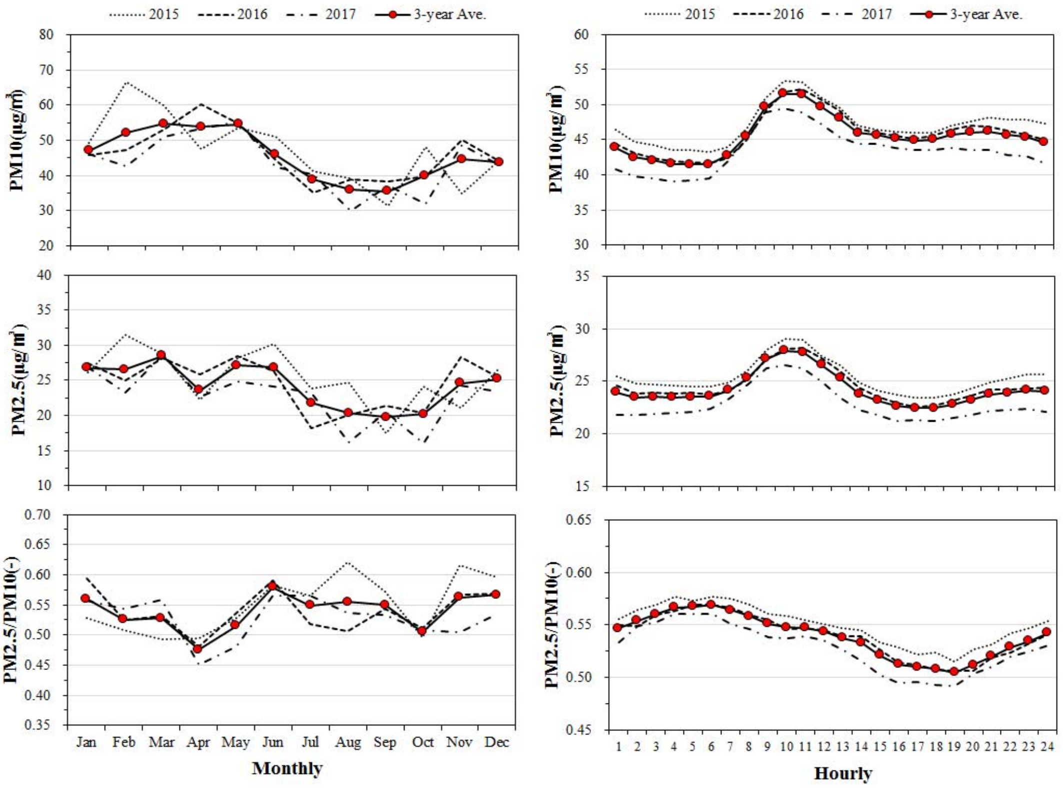

Fig. 3. Monthly and hourly variation of PM_{10}, $PM_{2.5}$ and Ratio($PM_{2.5}/PM_{10}$) for 11-site average in 3 years(`15~`17).

such as soil particles and road fugitive dust is high(Querol et al., 2004; Jeong and Hwang, 2014; Munir, 2017).

In the last three years, the Ratio has appeared in a very wide range between 0.19 and 0.71. By year, Ratio were `15 0.55(0.20~0.70), `16 0.54(0.26~0.71) and `17 0.53(0.19,~0.71). And seasonal variations were 0.56(0.31~0.70) in summer, 0.55(0.20~0.71) in winter, 0.54(0.27~0.70) in autumn and 0.51(0.19~0.69) in spring.

3.2. Monthly and hourly change characteristics

Fig. 3 shows average trends of PM_{10}, $PM_{2.5}$ and Ratio in 11 air monitoring stations by monthly and time series for the last 3 years.

The monthly average concentration of PM_{10} was the highest at March and May 55 ㎍/㎥, and the lowest at September 35 ㎍/㎥. The seasonal characteristics of PM_{10} were in order of 54 ㎍/㎥ in spring, 48 ㎍/㎥ in winter, and 40 ㎍/㎥ in summer and autumn. The monthly average concentration of $PM_{2.5}$ was the highest at 29 ㎍/㎥ in March, and the lowest at 20 ㎍/㎥ in from September to October. The seasonal characteristics of $PM_{2.5}$ were in order of 26 ㎍/㎥ in spring and winter, 23 ㎍/㎥ in summer and 22 ㎍/㎥ in autumn. The monthly average of Ratio was the highest at June 0.58, and the lowest at April 0.47. The seasonal characteristics of Ratio were in order of 0.56 in summer, 0.55 in winter, 0.54 in autumn and 0.51 in spring. In particular, the monthly maximum concentration difference was 20 ㎍/㎥ for PM_{10}, 8 ㎍/㎥ for $PM_{2.5}$ and 0.10 for Ratio,

Table 2. Changes over the last three year of PM_{10}, $PM_{2.5}$ and Ratio in the 11 sites

Site	PM_{10} (μg/㎥)					$PM_{2.5}$(μg/㎥)					Ratio*(-)				
	`15	`16	`17	Ave	△▽*	`15	`16	`17	Ave	△▽*	`15	`16	`17	Ave	△▽*
HW	48	50	46	48	-1.4%	28	29	28	28	0.0%	0.60	0.59	0.61	0.60	0.6%
GJ	49	44	46	46	-2.1%	24	22	23	23	-1.4%	0.52	0.51	0.52	0.52	0.0%
YJ	54	56	49	53	-3.2%	27	26	22	25	-6.6%	0.52	0.46	0.45	0.48	-4.7%
GH	45	47	43	45	-1.5%	25	27	26	26	1.3%	0.57	0.58	0.58	0.58	0.6%
SB	49	46	41	45	-5.8%	26	25	23	25	-4.0%	0.56	0.57	0.56	0.56	0.0%
SD	55	52	44	50	-7.2%	28	27	21	25	-9.1%	0.49	0.51	0.48	0.49	-0.7%
HD	50	45	45	47	-3.5%	30	24	23	26	-8.5%	0.62	0.53	0.52	0.56	-5.7%
JY	39	37	37	38	-1.7%	19	22	20	20	1.7%	0.51	0.6	0.53	0.55	1.3%
AJ	43	43	41	42	-1.6%	25	24	23	24	-2.7%	0.58	0.56	0.56	0.57	-1.2%
BB	55	50	49	51	-3.8%	27	26	25	26	-2.5%	0.53	0.51	0.51	0.52	-1.3%
SC	39	39	36	38	-2.6%	20	20	18	19	-3.5%	0.54	0.52	0.48	0.51	-3.9%
Ave.	47 (46)	46 (45)	43 (43)	45 (45)	-2.9% (-2.2%)	25 (〃)	25 (〃)	23 (〃)	24 (〃)	-2.7% (〃)	0.55 (〃)	0.54 (〃)	0.53 (〃)	0.54 (〃)	-1.2% (〃)

Ratio* : $PM_{2.5}/PM_{10}$, △▽* : Annual increase / decrease rate, ( ) : Non-Asian dust

respectively.

The hourly average concentration of PM_{10} was the highest 50~52 μg/㎥ at 09:00~12:00 and the lowest 41~42 μg/㎥ at 03:00~06:00. And 24-hour maximum concentration difference was 11 μg/㎥. The concentration of $PM_{2.5}$ was the highest 27~28 μg/㎥ at 09:00~12:00 and the lowest 22 μg/㎥ at 17:00~18:00. And 24-hour maximum concentration difference was 6 μg/㎥. Ratio was the highest 0.57 at 04:00~06:00 and the lowest 0.50 at 19:00. And 24-hour maximum Ratio difference was 0.07.

3.3. Characteristics of 11 monitoring sites

Table 2 shows the annual average trends of PM_{10}, $PM_{2.5}$ and Ratio for the last 3 years(`15~`17) for 11 sites.

Overall, the average concentration of PM_{10} at all sites decreased from `15 47 μg/㎥ to `17 43 μg/㎥, and 4 μg/㎥ during the last 3 years and -2.9% per year. The concentration of $PM_{2.5}$ decreased from `15 25 μg/㎥ to `17 23 μg/㎥, and 2 μg/㎥ during the last 3 years and -2.7% per year. The concentration of $PM_{2.5}$ decreased from `15 25 μg/㎥ to `17 23 μg/㎥, and 2 μg/㎥ during the last 3 years and -2.7% per year. For Ratio decreased from `15 0.55 to `17 0.53, and 0.02 in the last 3 years and -1.2% per year.

By site, the PM_{10} concentration at YJ site was 53 μg/㎥, and higher 8 μg/㎥ than the average. And the $PM_{2.5}$ concentration at HW site was 28 μg/㎥, higher 4 μg/㎥ than the average. On the other hand, the SC site had PM_{10} 38 μg/㎥, and lower 7 μg/㎥ than the average and $PM_{2.5}$ 19 μg/㎥, and lower 5 μg/㎥ than the average. On the other hand, the SC site was the lowest concentration of PM_{10} 38 μg/㎥ and $PM_{2.5}$ 19 μg/㎥. In the case of the SD site located in the industrial area, the PM_{10} concentration decreased from `15 55 μg/㎥ to `17 44 μg/㎥ and $PM_{2.5}$ concentration decreased from `15 28 μg/㎥ to `17 21 μg/㎥. The SD site was the high decreasing tendency among 11 sites.

The Ratio by site was in the order of HW site 0.60 > GH site 0.58 > AJ site 0.57 > SB site 0.56 > JY and HD site 0.55> BB site 0.52> GJ and SC site 0.51 > SD site 0.49 > YJ site 0.47.

In particular, HD site showed the largest reduction by site, with 0.62 in `15, 0.53 in `16 and 0.52 in `17.

Due to the Asian dust phenomenon, the annual concentration of PM_{10} increased by about 1 ㎍/㎥. However, there was no change in $PM_{2.5}$ and Ratio.

4. CONCLUSIONS

For PM reduction plans in Gyeongnam, PM_{10} and $PM_{2.5}$ data in 11 air monitoring stations for the past 3 years(`15~`17) were collected and analyzed. The results of the analysis are as follows.

The annually average of all the stations for 3 years was PM_{10} 45, $PM_{2.5}$ 24 and Ratio 0.54 and there were decreasing with PM_{10} -2.9%, $PM_{2.5}$ -2.7% and Ratio -1.2% every year.

In the seasonal characteristics, PM_{10} concentration were in order of 54 ㎍/㎥ in spring, 48 ㎍/㎥ in winter, and 40 ㎍/㎥ in summer and autumn. $PM_{2.5}$ were in order of 26 ㎍/㎥ in spring and winter, 23 ㎍/㎥ in summer, and 22 ㎍/㎥ in autumn. Ratio were in order of 0.56 in summer, 0.55 in winter, 0.54 in autumn, and 0.51 in spring.

In the 24-hour characteristics, PM_{10} concentration was the highest 50~52 ㎍/㎥ at 09:00~12:00 and 24-hour maximum concentration difference was 11 ㎍/㎥. $PM_{2.5}$ was the highest 27~28 ㎍/㎥ at 09:00 ~12:00 and 24-hour concentration difference was 6 ㎍/㎥. Ratio was the highest 0.57 at 04:00~06:00 and 24-hour difference was 0.07.

By site, PM_{10} concentration at YJ site was 53 ㎍/㎥, and higher 8 ㎍/㎥ than the average. And the $PM_{2.5}$ concentration at HW site was 28 ㎍/㎥, higher 4 ㎍/㎥ than the average. The Ratio at HD site showed the largest reduction from `15 0.62 to `17 0.52.

REFERENCES

Air Korea, 2018, http://www.airkorea.or.kr.

Donaldson, K., Li, X. Y,, MacNee, W., 1998, Ultrafine(nanometre) particle mediated lung injury, Journal of Aerosol Science, 29(5/6), 553-560.

Gyeongnam Institute of Health & Environment(KNHE), 2018, Operational results of air pollution monitoring network in Gyeongnam.

Harrison, R.M., Giorio, C., Beddows, D.C., Dall'Osto, M., 2010, Size distribution of airborne particles controls outcomes of epidemiological studies, Sci. Total Environ., 409, 289-293.

Jeon, B. I., Hwang, Y. S., 2014, Characteristics of weekday/weekend PM10 and PM2.5 concentrations at Busan, J. Env. Sci. Intern., 23(7), 1241-1251.

Kim, Y. S., 2005, Issues and tasks for air quality management in the greater seoul metropolitan area, Environmental policy, 4(1), 1-19.

Korea Meteorological Administration(KMA), 2018, http://www.kma.go.kr.

Ministry of Environment(MoE), 2016, Operation of establishment guideline of air pollution monitoring network.

Ministry of Environment(MoE), 2017, Annual report of air quality in Korea, 2016.

Ministry of Environment(MoE), 2018, Annual report of air quality in Korea, 2017.

Munir, S., 2017, Analysing temporal trends in the ratios of PM2.5/PM10 in the UK, Aerosol and Air Quality Research, 17, 34 – 48.

Querola, X., Alastueya, A., Ruiza, C. R., Artinanob, B., Hanssonc, H. C., Harrisond, R. M., Buringhe, E., Brink, H. M., Lutzg, M., Bruckmannh, P., Straehli, P., Schneide, J., 2004, Speciation and origin of PM10 and PM2.5 in selected European cities, Atmospheric Environment, 38, 6547 – 6555.