여수산업단지 주변 대기질 평가

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Air Quality Assessment around Yeosu Industrial Complex

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ABSTRACT

In this work, the air quality assessment around Yeosu Industrial Complex was carried out. We investigated the main fuel consumption from the main companies in Yeosu Industrial Complex from Nov. 2008~Oct. 2009. We based on the data of fuel consumption and calculated the total of SO_2 emission. The analytical items of air quality included nitrogen dioxide(NO_2), ozone(O_3) and sulfur dioxide(SO_2) which are the main air pollutants around this area. Samples were collected from a total of 14 sampling sites including the industrial area(Y-1~Y-11) and the controlled area(C-1~C-3). The LNG consumption was significantly higher than the consumption of other fuels, and 75% of the SO_2 was emitted from two companies which is the largest emission sources in Yeosu Industrial Complex. The concentrations of NO_2, O_3, and SO_2 were 0.009~0.022 ppm, 0.005~0.028 ppm, 0.003~0.013 ppm around the industrial area, respectively. In addition, the concentrations of NO_2, O_3, and SO_2 in spring and summer were higher than in fall and winter. All the concentrations were not exceeded the limits of the Environmental Standard(1 hr concentration). It showed the higher air pollutant concentrations in Yeosu than those of in other Air Pollution Monitoring System. This was due to the characteristics of industry in Yeosu. The predominant wind direction around Yeosu Industrial Complex are northeast(NE), northwest(NW) and southwest(SW). According to this result and the factor of the geography in this area, the SO_2 concentration diffusion was by the order of southwest(SW), southeast(SE) and northeast(NE). We expect our study can be utilized to improve the air quality around Yeosu Industrial Complex.

Keywords : Air Quality, Nitrogen dioxide(NO_2), Ozone(O_3), Sulfur dioxide(SO_2), Industrial Complex

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1. Introduction

During the last few decades, Korea has given priority to economic development. However, several negative issues have also arisen. One of these is environment-related problems. Especially in last few years, ambient air pollutant levels at industrial areas have become a serious air quality problem in Korea[1),2),4)]. Nowadays, not only Korea but also other industrialized countries have taken various methods to reduce and control the emission of air pollutants[6)]. Yeosu is located at the southern part of Korea with the population of about thirty thousand. The Yeosu Industrial Complex, built in 1967, is the country's largest heavy chemical industrial complex. It accommodates over 120 oil refining, fertilizer, and petrochemical companies, accounting for about 26% of domestic oil refining and about 50% of domestic ethylene production[10)]. So large numbers of air pollutants are emitted in each year by fuel combustion. Prior to this study, we performed a great deal of research on the air quality assessment around this area for several years[7),8)]. In this study, we collected the fuel consumption from the main companies and calculated the total of SO_2 emission by the fuel consumption. We also investigated the concentration distributions and seasonal variation of the air pollutants. Finally, we analysed the weather material in order to estimate the diffusion of SO_2 concentration around Yeosu Industrial Complex.

2. Materials and Methods

In this study, we used the method of questionnaire to investigate the fuel consumption from the main companies covering the period from Nov. 2008 ~ Oct. 2009. We collated the questionnaire and calculated the total of SO_2 emission by the fuel consumption. In the case of air sampling, we carried out the samples collection including nitrogen dioxide(NO_2), ozone(O_3) and sulfur dioxide(SO_2). This 3 compounds as the air pollutants established by the Korea government[3)]. Total of 14 sites are assigned including industrial area(Y-1~Y-11) and the controlled area(C-1~C-3). We filled the respective absorption liquid with the impingers and used the handy sampler to collected the samples. When sampling finished, the sample bottles were then stored immediately in an ice-b ox, transported to the laboratory, reserved in a refrigerator, and analysed within 24 h. All of the collection and analytical methods for NO_2, O_3 and SO_2 were established by the Korean Ministry of Environment (KMOE)[5)]. The basic information on the analytical items and the geographical map of the study area are shown in Table 1 and Fig. 1, respectively. In addition, we carried out the SO_2 concentrations diffusion by using Industrial Source Complex(ISC3) model which was recommended by U.S. EPA[9)].

Table 1. Basic information of the analytical items in the present study

Sampling site	Analytical item	Environmental Standard[3]	Analytical method
Industrial area (Y-1~Y-11) Controlled area (C-1~C-3)	Sulfur dioxide (SO_2)	Annual : less than 0.02 ppm 24 hr : less than 0.05 ppm 1 hr : less than 0.15 ppm	Pulse U.V. Fluorescence Method
	Nitrogen dioxide (NO_2)	Annual : less than 0.03 ppm 24 hr : less than 0.06 ppm 1 hr : less than 0.10 ppm	Chemiluminescent Method
	Ozone (O_3)	8 hr : less than 0.06 ppm 1 hr : less than 0.10 ppm	U.V. Photometric Method

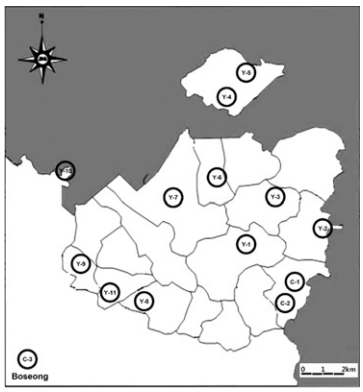

Fig. 1. Geographical map of the study area.

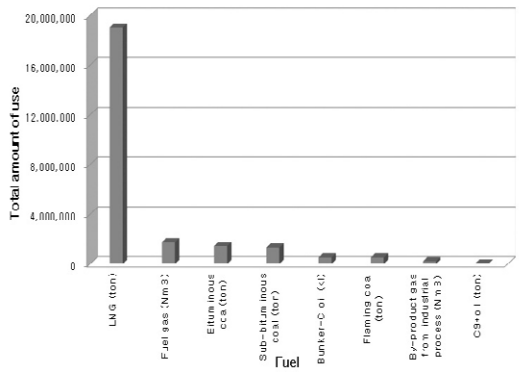

Fig. 2. Main fuel consumption from the companies in Yeosu Industrial Complex.

3. Results and Discussion

3.1. Fuel consumption and the related SO_2 emission

The main fuel consumption from the main companies in Yeosu Industrial Complex during the study period are shown in Fig. 2. The consumption of LNG(1.9×10^7 ton) was significantly higher than the consumption of any other fuels, followed by fuel gas, bituminous coal, sub-bituminous coal, bunker-C oil, flaming coal, by-product gas from industrial process, and C9+ oil with the consumption values of 1.8×10^6 Nm^3, 1.4×10^6 ton, 1.3×10^6 ton, 5.2×10^5 kl, 5.1×10^5 ton, 2.2×10^5 Nm^3, 4.0×10^4 ton, respectively. A total of SO_2 as 1.8×10^4 ton was emitted from the main companies in Yeosu Industrial Complex. Among this companies, the largest and the second largest sources of SO_2 emission are with the proportion of 43% and 32%, a total of 75 % of the SO_2 are emitted from this two companies in Yeosu Industrial Complex.

3.2. Distributions of NO_2, O_3 and SO_2 concentrations

Statistical summary of NO_2, O_3 and SO_2 concentrations at each sampling site and period are shown in Fig. 3 to Fig. 5, respectively. Error bar means the maximum and minimum concentration of each air pollutant. The concentration distribution of NO_2, O_3, and SO_2 showed 0.15 ppm (0.009~0.022 ppm), 0.015 ppm (0.005~0.028 ppm) and 0.007 ppm (0.003~0.013 ppm) around the industrial area, respectively. The concentrations around the industrial area were much higher than the concentration around the controlled area. For the industrial area, the concentrations in site Y-6 and Y-7 were significantly higher than the concentration around any other sites. Because these two sites are near from the 2 largest air pollution sources in Yeosu Industrial Complex than other sampling sites, so we can determine that the emission of air pollutants had a great impact on this region. For the controlled area, the NO_2, O_3 and SO_2 concentrations were very low and not as high as we expected. In the case of seasonal variation, the concentration of each air pollutant from spring and summer (Apr.~Aug.) are higher than the concentration from fall and winter (Oct.~Feb.). Especially for O_3, this phenomenon is more obviously. As we know that O_3 is a secondary air pollutant, with the large number of NO_2 and VOC emissions, large number of O_3 was generated from spring and summer under the enough sunlight. Even so, all of the air pollutant concentrations in each sampling site are not exceeded the limit of 1 hr concentration of the Environmental Standard.

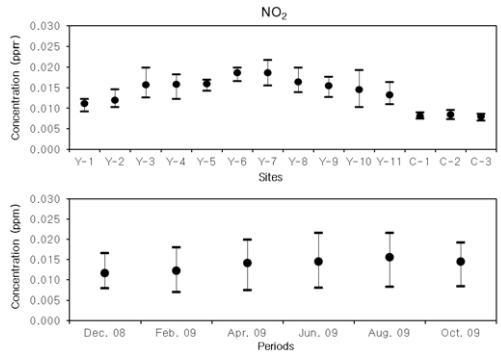

Fig. 3. Distributions of NO_2 concentration at each sampling site and period.

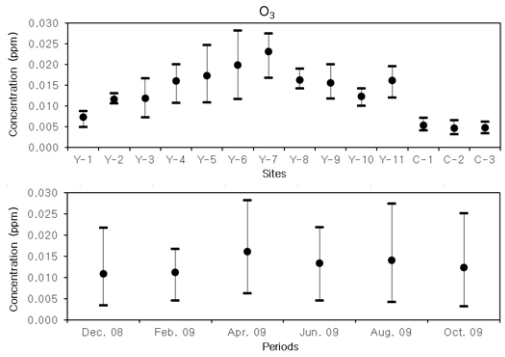

Fig. 4. Distribution of O_3 concentration at each sampling site and period.

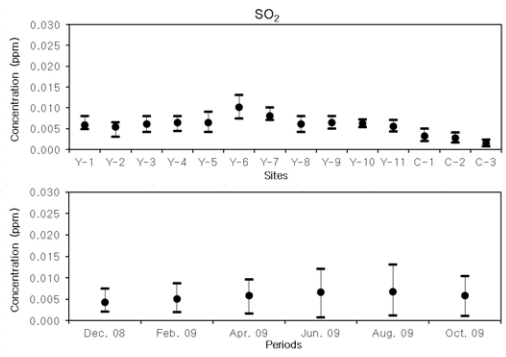

Fig. 5. Distribution of SO_2 concentration at each sampling site and period.

3.3. Comparison of air pollutant concentrations

Fig. 6 shows the comparison of NO_2, O_3 and SO_2 concentrations from Air Pollution Monitoring System. There are 7 main industrial areas such as Siheung, Yeosu, Gwangyang, Pohang, Gumi, Changwon and Ulsan. We compared the NO_2, O_3 and SO_2 concentrations in the ambient air around these 7 industrial areas in 2009. All data was obtained from the Air Pollution Monitoring System around these industrial areas. In the case of NO_2, the order of the concentration can be described as Siheung > Yeosu > Ulsan > Changwon, Gumi > Pohang > Gwangyang. As we know, the main source of NO_2 emission is automobile. Siheung is located at Gyeonggi-do, where the automobile ownership is highest in Korea. So compared with the industrial area, the automobile has become the largest emission source of NO_2 in Siheung. For O_3, and SO_2, the concentrations in Yeosu are higher than in other industrial areas, it was showed the characteristics of industry in Yeosu.

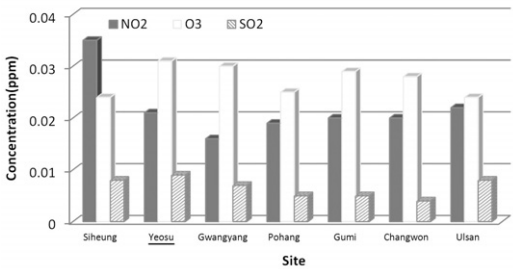

Fig. 6. Comparison of NO_2, O_3, SO_2 concentration from Air Pollution Monitoring System in 2009.

3.4. Spatial distribution of the ambient SO_2 concentration

Fig. 7 shows the wind rose of Yeosu Industrial Complex. The predominant wind direction in this area was northeast(NE), the frequency of northwest(NW) and southwest (SW) were also appeared relatively high. In addition, the wind in other directions were very weak. The annual average concentration of SO_2 was shown in Fig. 8. It can be seen that the higher SO_2 concentration appears near the two companies which is the largest emission sources in Yeosu Industrial Complex. The most polluted areas are the northeast of Yeosu Industrial Complex. According to the results of wind direction and the topography of YoungChui Mountain, the SO_2 diffusion was towards the direction of southwest(SW), southeast(SE) and northeast(NE).

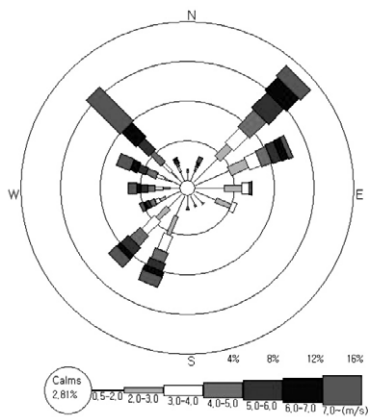

Fig. 7. Wind rose of Yeosu Industrial Complex.

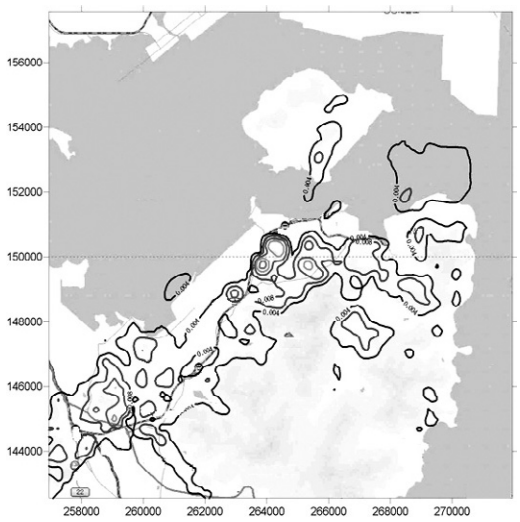

Fig. 8. Spatial distribution of the ambient SO_2 concentration.

4. Conclusions

In the present study, we assessed the air quality around Yeosu Industrial Complex. Based on the current study, the following conclusions can be drawn.

1) The consumption of LNG was significantly higher than the consumption of any other fuels. Most of SO_2 emission were from two companies which is the largest emission sources in Yeosu Industrial Complex.

2) The concentrations of NO_2, O_3, and SO_2 were 0.15 ppm, 0.015 ppm and 0.007 ppm around the industrial area, respectively. All of the concentrations around the industrial area are much higher than around the controlled area and were not exceeded the limits of the Environmental Standard(1 hr concentration). It showed the higher concentration in spring and summer than in fall and winter.

3) Compared the air pollutant concentrations in Yeosu, it showed the higher concentration values than those of in other Air Pollution Monitoring System. It was indicated the characteristics of industry in Yeosu.

4) The predominant wind direction in Yeosu Industrial Complex is by the order of northeast(NE), northwest(NW) and southwest(SW) while the SO_2 concentration diffusion was towards the direction of southwest(SW), southeast(SE) and northeast(NE).

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References

1. Chung, Y. S., Kim, S. H., Moon, J. H., Kim, H. R., Lim, J. M., and Lee, J. H.(2008). Air pollution monitoring of an urban dust in Daejeon city, Korea by using instrumental neutron activation analysis. Journal of

Radioanalytical and Nuclear Chemistry. 278(2). pp.441~447.
2. Kim, Y. P., Na, K., and Moon, K. C.(1998). Air pollutant levels at Ulsan, an industrial area, Korea. Journal of Aerosol Science. 29. pp.237~238.
3. Korean Ministry of Environment (KMOE)(2007). Standard Method for the Examination of Air.
4. National Institute of Environmental Research(NIER)(2008). 2006 Greenhouse Gas and Air Pollutants Emissions in Korea.
5. National Institute of Environmental Research(NIER)(2010). Annual Report of Air Quality in Korea 2009.
6. Qzden, Q., Dogeroglu, T., and Kara, S.(2008). Assessment of ambient air quality in Eskiṡeḧir, Turkey. Environment International. 34. pp.678~687.
7. Seo, S. G.(2004). Final Report: Investigation of Odor Emission and Management at Yeosu Petrochemical Industrial Complex(Ⅰ-Ⅲ), JETeC.
8. Seo, S. G.(2008). Final Report: Air Quality Monitoring at Yeosu Industrial Complex, JETeC.
9. U.S.EPA(1995). User's guide for the industrial source complex(ISC3) dispersion models. EPA-454/B-95-003a.
10. Yeosu city(2010). http://eng.yeosu.go.kr/home/eng/Tourists/light/page.wscms.