Chemosphere 65 (2006) 201–212

CHEMOSPHERE

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Comparison of spatiotemporal distribution patterns of NO_2 between four different types of air quality monitoring stations

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Received 24 November 2005; received in revised form 27 February 2006; accepted 28 February 2006
Available online 18 April 2006

Abstract

The concentration data of nitrogen dioxide (NO_2), obtained from four different types of air quality monitoring (AQM) stations in Korea (i.e., urban traffic (A), urban background (B), suburban background (C), and rural background (D)), were explored to evaluate the fundamental facets of its distribution and behavior. As there are many distinctions between these four types of AQM stations, the observed NO_2 values were clearly distinguished from each other. It is found that the average NO_2 concentrations from all A stations exhibit notably high values within the range of 24.8 (Gwangju) to 54.6 ppb (Seoul), while those of all B stations change from 19.6 (Ulsan) to 34.7 ppb (Seoul). Similarly, large differences were also observed from NO_2 values measured between C and D type stations. The NO_2 values of the former were from 16.5 (Jeonbuk) to 30.2 ppb (Gyunggi), while the latter from 4.3 (Gyeongbuk) to 8.7 ppb (Gyunggi). Although their annual patterns are rather complicated to explain, the results by and large reflected the changes in the conditions of the surrounding environment. When the results are compared across seasons, most stations (A, B, and D types) tend to exhibit their maximum values in the winter followed by spring, fall, and summer. The results of this study confirm that the distribution patterns of NO_2 are fairly sensitive enough to reflect the basic characteristics of its source processes in association with such factors as the intensity of anthropogenic activity or population density.

Keywords: Nitrogen dioxide; Pollution; Ambient; Roadside; Background; Korea

1. Introduction

The air pollutants transported via prevailing winds can be dispersed by diffusion and become a part of the atmosphere (Lyons et al., 1990). Classified as a major criterion pollutant, nitrogen dioxide (NO_2) is released into the atmosphere from natural and man-made sources (e.g., burning of fossil fuels, construction, and mining) (e.g., Bell and Ashenden, 1997). Once released, it can undergo several different processes such as transport driven by wind, transformation due to atmospheric reactions, and scavenging processes (wet and dry deposition). The chain of chemical processes governing the fate of this pollutant is hence crucial to the evaluation of the impact of photochemical pollution.

A great number of studies have assessed the air pollution effects of nitrogen oxides on human health. For instance, a cohort study reported significant increases in cardiopulmonary mortality for those living near major road areas in the Netherlands (Hoek et al., 2002). Due to extensive industrialization and urbanization, most major cities in developing countries suffer from serious outdoor air pollution. It was reported that about 50% of anthropogenic emissions come from fossil-fuel-fired heat and electricity power generating plants (World Bank Group, 1998). In addition, urban areas have been exposed to transportation-related air pollution processes with the observations of exceedingly high NO_2 concentrations (Jain and Saxena, 2002). Moreover, such factors as fuel types and vehicular speed can also play key roles in determining the

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0045-6535/$ - see front matter
doi:10.1016/j.chemosphere.2006.02.061

release patterns of pollutants. In addition, emissions from diesel vehicles are considerably more important than those of petrol vehicles. In fact, low vehicular speeds can also lead to higher NO_2/NO_x emission ratios (Carslaw and Beevers, 2005a). The site-to-site variations in NO_2 levels can also be explained by wide differences in the local oxidant sources (Jenkin, 2004). The decline in NO_2 at greater distances from the road is however found to be less steep in suburban areas or near rural motorways due to the enhanced oxidant level at low background NO_2 concentrations (Stedman et al., 2001).

It is perceived that the relative importance of nitrogen-containing acids has increased substantially over its sulfur counterpart in the recent years (Kim et al., 2003). In our recent study, the NO_2 data for two types of ambient AQM stations (major cities and province areas) have been compared to investigate their respective NO_2 pollution levels (Nguyen and Kim, 2006). In the present study, we attempted to expand this NO_2 study through a comparison of the data sets acquired from each of all 4 AQM station types under varying environmental conditions. The results of this study will help us extend the basis for comparing the types and effects of NO_2 source processes. In addition, the analysis of the temporal distribution patterns of these NO_2 data sets in varying time scales (i.e., monthly, seasonal, and annual) can help explain the effects of temporal factors on its behavior and distribution.

2. Materials and methods

In this study, the NO_2 distribution patterns were investigated using data sets obtained from four AQM station types in Korea over a five-year duration (from 1998 to 2003). As shown in Table 1, four types of AQM stations investigated in this study are distinguished as urban traffic (A), urban background (B), suburban background (C), and rural background (D) types. The geographical locations of the major cities and provinces for such monitoring tasks are also shown in Fig. 1. Although stations of A and B types are located in major city areas, they are distinguished from each other in the basic allocation strategy. Selected for different purposes, the A and B type stations are dispersed all across the major city areas in Korea. Hence, their values can be directly used to meaningfully distinguish the effects of different sources within large city areas. The B type stations were selected to represent urban background air, whereas A stations very near the roadside locations in major cities. In contrast, C and D type stations are set to represent the suburban and rural background concentrations of NO_2, respectively. They are all located in provincial areas for parallel comparison of NO_2 data in relatively or fairly clean areas, respectively. The concentrations of NO_2 determined from all four types of AQM stations can hence be used to explore the spatial and temporal distribution patterns of NO_2 under varying environmental

Table 1
Comparison of the annual growth patterns of four different AQM station types in Korea during the study period of 1998–2003

Seven major cities in Korea			Stations											
Full name	Short name	Population density[a]	Urban traffic (A type)						Urban background (B type)					
			'98	'99	'00	'01	'02	'03	'98	'99	'00	'01	'02	'03
(A) The number of AQM stations in major cities through years: A and B type stations														
Seoul	SL	9895	7	7	7	7	7	7	27	27	27	27	27	31
Busan	BS	3663	1	2	2	2	2	2	9	9	9	9	13	16
Daegu	DG	2481	2	2	2	2	2	2	6	7	6	6	7	11
Incheon	IC	2475	1	2	2	2	2	2	8	10	10	10	10	11
Gwangju	GJ	1353	1	1	1	1	1	1	4	4	4	4	4	4
Daejeon	DJ	1368	1	1	1	1	1	2	3	3	3	3	3	5
Ulsan	US	1014	0	1	1	1	1	1	7	7	11	12	12	14
Sum			13	16	16	16	16	17	64	67	70	71	76	92

Nine provinces in Korea			Stations											
Full name	Short name	Population density[a]	Suburban background (C type)						Rural background (D type)					
			'98	'99	'00	'01	'02	'03	'98	'99	'00	'01	'02	'03
(B) The number of AQM stations in provinces through years: C and D type stations														
Gyunggi	GG	8984	20	26	31	32	43	47	1	1	1	2	3	3
Gangwon	GW	1487	4	4	4	5	4	8	0	0	1	2	2	2
Chungbuk	CB	1467	4	4	4	4	4	5	0	0	0	1	1	1
Chungnam	CN	1845	3	3	3	3	3	3	1	1	1	1	1	2
Jeonbuk	JB	1891	6	6	6	6	6	6	0	0	1	1	1	1
Jeonnam	JN	1996	8	8	8	8	8	9						
Gyeongbuk	GB	2725	9	9	9	10	10	10	1	1	2	2	2	2
Gyeongnam	GN	2979	8	8	8	8	8	8	0	1	1	1	1	2
Jeju	JJ	513	1	1	1	1	2	2	2	1	1	1	1	1
Sum			63	69	74	77	88	98	5	5	8	11	12	14

[a] The population of all cities and provinces investigated in year 2002: all data given per 1000 persons.