Evaluation and Application of Built Environmental Components for Healthy City

- Where Do People Spend Their Leisure Time on Dusty Days? -

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1. Introduction

PM-driven deterioration of air quality has become a transboundary environmental problem in the countries of the East Asia Pacific region. During the process of intensive urbanization and industrialization, the sources of PM emission have increased drastically (Karagulian et al., 2015). Korea also has been suffering from the harmful effects of PM. OECD reported that the air quality of Korea was the 5th worst among OECD member countries in 2018 (OECD, 2018), and for more than four months in that same year, the level of PM 2.5 was higher than the World Health Organization (WHO)'s standards. Moreover, the OECD reported that the projected percentage change from 2010 to 2060 in Korea's annual Gross Domestic Product (GDP) will drop about 0.63%—fourth among OECD members—due to the reduced productivity, additional cost in the health care, and lower farm output caused by air pollution, if Korea does not cope with air pollution properly (Na, 2019).

With the worsening of air quality, from 2013 various media began to report and forecast the level of major air pollutants, including PM, to better inform the people (Ministry of Environment, 2016). Consequently, checking the level of PM has become a new routine for Koreans who are to going outside (Jeon, 2019). Anecdotal evidence points to behavioral changes of people due to bad air quality; more people try to avoid outdoor activities, if possible, and follow precautions such as wearing masks and using air-purifiers (Lee, 2019).

A large vein of PM studies has focused on the health effects of PM. However, the effects of PM on human behaviors have not been sufficiently studied. Those involving outdoor activities, in particular, have not been studied on a large spatial scale but only illuminated by case studies of individual recreational places (Chen et al., 2017). One of the main reasons may be the lack of relevant data (Ailshire et al., 2017). Pedestrian volume data is often manually acquired by surveyors' fieldwork. A yearly estimate is calculated on the basis of data recorded over a few days. Due to labor-intensive survey methods and uncertain data quality, accurate pedestrian volume data covering large areas with finer time resolutions have been rare.

To fill the gap in the literature, this study investigates the effects of PM 2.5 on recreational activities in an urban context, with a specific focus on the site selection. The following research questions will be answered: (1) Does the increase in PM 2.5 affect the number of visitors to the three categories of recreational places (open spaces, commercial spaces, and indoor sports facilities) at different times of day and week? (2) If so, does the change in the number of visitors differ by the sub-category of those recreational places?

2. Analytical Design

2.1 Study Site and Periods

The study site was Seoul, South Korea, and the study period was March 1 to June 30, 2017. We used pedestrian volume data provided by SKT Geovision, which estimated pedestrian volume using the cell phone signals from SK Telecom's base stations. Compared to traditional pedestrian volume data collected by surveyors or cameras onsite, these data are less prone to measurement errors and cover a much larger area for a longer period of time (Yoo et al., 2014). Our study site consists of 1,073 public spaces with recreational purposes in Seoul. We divided the sites into the three categories: open spaces, commercial spaces, and indoor sports facilities. All of the open spaces are open air, and they consist of 7 palaces, 11 hills, 722 small parks (≤ 10,000 m^2), 123 large parks (> 10,000 m^2), and 21 waterfront parks, totaling 884. Commercial spaces are either indoor or outdoor, including 9 specialty stores, 34 traditional markets, 13 business buildings, 15 multi-complex shopping malls, 16 department stores, and 86 large supermarkets, totaling 173. We also included 10 indoor sports facilities among the study sites (Table 1, Fig. 1).

The study period was from March 1 to June 30, 2017. As shown in Table 2, we divided all data into three different time groups: time group 1, daytime on weekdays (10 AM to 5 PM); time group 2, nighttime on weekdays (7 PM to 10 PM); time group 3, weekends (10 AM to 10 PM). We chose time groups to include times when most leisure activities are done but that did not overlap with commuting hours. The days when large-scale street protests were held (2 days in time groups 1 and 2; 5 days in time group 3) and the days with no records of air pollutant levels (10 days in time groups 1 and 2) were excluded from the study period.

Table 1. Study sites

Category	Sub-category	Location	Numbers		Percent	
Open spaces			884		82.95	
	Palaces	Outdoor		7		0.65
	Hills	Outdoor		11		1.03
	Small parks (≤10,000 m2)	Outdoor		722		67.29
	Large parks (〉10,000 m2)	Outdoor		123		12.02
	Waterfront parks	Outdoor		21		1.96
Commercial spaces			173		16.12	
	Traditional markets	Outdoor		34		3.17
	Specialty stores	Indoor		9		0.84
	Business buildings	Indoor		13		1.21
	Multi-complex shopping malls	Indoor		15		1.40
	Department stores	Indoor		16		1.49
	Large supermarkets	Indoor		86		8.01
Indoor sports facilities			10		0.93	
	Indoor sports facilities	Indoor		10		0.93
Total			1,073	1,073	100	100

Table 2. Time groups

Time group	Days	Time
Time group 1	Weekday	10 AM to 5 PM
Time group 2	Weekday	7 PM to 10 PM
Time group 3	Weekend	10 AM to 10 PM

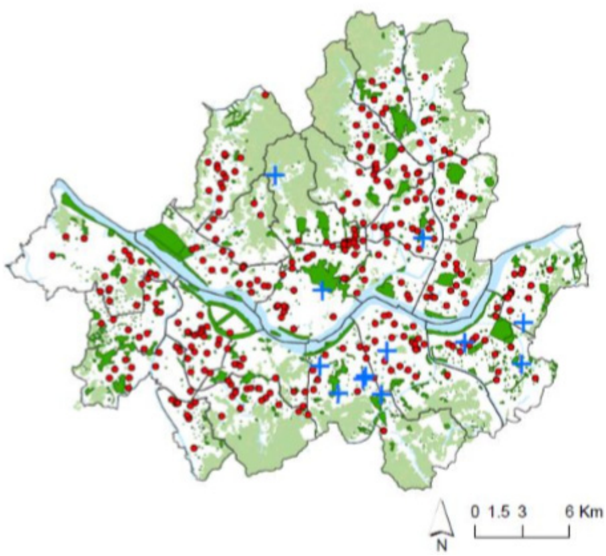

Figure 1. Study site: Seoul, South Korea

Legend:

- Study Site – Indoor Sports Facilities
- Study Site – Commercial Sites
- Study Site – Open Spaces
- Ward boundary
- Han River and Streams
- Mountains

2.2 Methodology: Panel 패널분석

In order to estimate the effects of PM on the number of visitors to the sites, we employed a random effects panel. Our model is described as follows:

$$M = \alpha + \beta P + \gamma_i S_i + \delta(P \times S_i) + \theta Z + \varkappa W + \lambda_i L_i + u + e \qquad \text{(Function 1)}$$

where *Mit* denotes pedestrian volume measured as the number of visitors in location i and time t; *Pit* denotes the level of PM 2.5 in location i and time t. *Si* denotes the type of study site as dummy variable; *Pit* × *Si* denotes the interaction terms of the mean level of PM 2.5 and the type of study site. *Zit* denotes the level of other pollutants for controlling purposes in location i and time t; *Wit* denotes the weather conditions and unemployment rates for location i and time t; *Li* consists of location-specific characteristics that affect pedestrian volume, such as distance to subway stations, the number of bus stops, and land use types (Function 1).

Reference

1. Ailshire, J., A. Karraker and P. Clarke(2017) Neighborhood social stressors, fine particulate matter air pollution, and cognitive function among older US adults. Social Science and Medicine 172: 56-63.
2. Chen, C. M., Y. L. Lin and C. L. Hsu(2017) Does air pollution drive away tourists? A case study of the sun moon lake national scenic area, Taiwan. Transportation Research Part D: Transport and Environment 53: 398-402.
3. Karagulian, F., C. A. Belis, C. F. C. Dora, A. M. Prüss-Ustün, S. Bonjour, H. Adair-Rohani and M. Amann(2015) Contributions to cities' ambient particulate matter (PM): A systematic review of local source contributions at global level. Atmospheric Environment 120: 475-483.
4. OECD(2018) Regions and Cities at a Glance 2018 - KOREA. Paris: OECD Publishing.
5. Lee, S.(2019, March 7). The economy is screaming because of fine dust. Hankook Ilbo. Retrieved from http://www.hankookilbo.com/News/Read/201903061486045784?did =NAanddtype=anddtypecode=andprnewsid
6. Ministry of Government Administration and Home Affairs(2016). Designation and Management Rules of Silver Zone - Silver Zones Management Cards. Seoul: Government Printing Office.
7. Na, S.(2019 February 9). Fine dust disaster is suffocating the economy. Kookkim Ilbo. Retrieved from http://news.kmib.co.kr/article/view.asp?arcid=0924060278andcode=11151100andcp=nv
8. Yoo, S., J. Kim and K. Ryu(2014) Using Big Data Strategy for the Development of the Communication Industry. In International Conference on Web-Age Information Management (pp. 349-359). Cham: Springer.