SUMMARY

A Study on Integration of Spatial and Environmental Planning to Mitigate Particulate Matter: Focusing on Ventilation Corridors

Park Jongsoon, Park Taesun, Kim Eunnan, Lee Sangeun, An Seungman, Lee Jungchan, Sung Sunyong, Yoon Eunjoo, Nam Seongwoo, Joo Hyunsoo, Kim Jaejin, Lee Gunwon

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1. Introduction

Particulate matters(PM) in Korea have been emerged as main concerns raising people's anxiety. The annual average concentration of particulate matter(PM10) in Korea and Seoul has been gradually decreasing since 2002. Nevertheless, it is still about two times higher than the World Health Organization's recommended standard(20㎍/㎥). In order to address the problem, the Korean government mainly promoted a policy to regulate its emission source. This includes the management of emission sources such as replacing old diesel vehicles, expanding the supply of eco-friendly vehicles, and distributing road cleaning vehicles. To improve air quality, the budget has increased by about 20% over the last four years. However, the correlation between emissions and PM since 2012 has been decreasing. This means that it

is not enough to simply manage the emission of the source for targeting the problem of PM.

Therefore, it would be more helpful in case spatial management policies such as ventilation corridors are combined with the current emission control policy. The case of Stuttgart, Germany, and a number of studies of Korea have shown empirically that plants reduce PM, and that the layout and height of buildings affects the concentration of PM.

It is somewhat difficult to locate a case where the ventilation corridors in city are practically employed in Korea. Although there may be a number of causes, current divided spatial and environmental planning systems are one of them. In order to apply them to spatial planning, urban atmosphere is analyzed and applied on the basis of this information. In other words, if environmental plans give an idea on the potential area of them, spatial plans reflect them. In the similar way, the ventilation corridors are able to be applied by internalizing in city and development plans.

This study aims both to identify the usefulness of the ventilation corridors in order to reduce the PM in the city and to explore the policy alternative to include them in the spatial plans. In more detail, their effects including PM's reduction and dispersion are to be identified, and the integration between spatial(or urban) and environmental plans is explored as an alternative to apply them.

2. Scope and method of research

1) Scope of Study

The spatial scope of this study can be categorized into national, urban, and

district units, whereas its temporal scope can be seen as the planning period or the duration of simulation. First, the overall characteristics of Korea's PM concentration were discussed at the national level, and Sejong City was selected as a study area at the regional and urban levels.

The prevailing winds of Sejong City are the north wind and northwest wind. As a result, PM is more likely to come from the west coast, and smog combined with fog frequently occurs during the four seasons. As the city is under construction with a target of 800,000 populations, we should identify the change in wind speed and direction before and after development. At the district level, Sejong City is in need of simulation of wind direction and PM's impacts of the development in order to mitigate PM's concentration.

In 2019, the Fifth National Territorial Comprehensive Plan was addressed for the target year of 2040, whereas the Sejong Development Plan aimed at 2030. As the cold air flow chart covers the wind blowing from the mountain to the city at night, the time range can be viewed about 8 hours after sunset. Therefore, the temporal scope of the study varies, 20 years in terms of the planning period, and 8 hours in the simulation.

2) Methodology

Research methods can be divided into three categories; literature review, PM flow simulation using CFD (Computational Fluid Dynamics) model and interdisciplinary research with external experts.

First, the plans and government policies of PM are reviewed. They include the Comprehensive National Land Plan, Metropolitan Urban Plan, Urban and Military Master Plan, National Comprehensive Environmental Plan, and Local Environmental Conservation Plan. In addition, a number of countermeasures for

PM reduction of overseas countries are reviewed aiming both to drive implications and to apply them for Korea. The foreign countries cover Germany, USA, Hong Kong and Japan.

Secondly, the CFD model is used to simulate the impacts of new town development on both urban air environment and PM concentration, and to investigate the cold air flow at night.

This study adopts a research method that integrates and cooperates with external experts. Its topics can be broadly divided into 'spatial and environmental legislation and planning' and 'PM and atmosphere modeling'. In-depth study of the two themes requires interdisciplinary research with different expertise and cooperation among specialized institutions.

3. Literature reviews and Case studies

In order to fill the gaps of previous studies and to set the direction of this study, the previous studies and overseas cases have been reviewed in relation to the integration between urban climate, PM, ventilation corridors, urban and environmental plans.

To reduce PM in the city, the stagnant atmosphere should be circulated. For overseas countries the ventilation corridors could be one of a means in achieving this purpose. They are used to reduce PM and heat island effect of the city. Ventilation corridor plans are often inherent in urban planning, for example, Hong Kong. They are also linked to environmental planning, such as Germany. Despite many different approaches, urban and environmental planning regards urban microclimate as an important planning element to ensure clean air quality.

In Korea, it has been studied that the ventilation corridors are effective in

reducing and dispersing PM. At night, cold and fresh air from mountainous areas flows into city to improve air quality. Plants in the ventilation corridors is able to absorb PM. Furthermore, there have been attempts to apply the ventilation corridors by improving the legal system related to urban planning. However, there is somewhat limited that the introduction of the ventilation corridors has not dealt with the linkage of national and environmental plans.

4. PM and Its Reduction Policies of Korea

Regarding PM10 in Korea, it exceeded the annual average standard in the early 2000s, but have gradually improved into stagnation stage. There is a trend for the correlation between emissions and PM concentration to decrease around 2012, which means that the policy of simply managing emissions from sources is insufficient to address the problem.

Since 2015, PM2.5 have been measured and at present it is on the rise. Its average monthly concentration in 2018 was higher in winter than in summer. Furthermore, the metropolitan area was higher than the other areas, while the western side of the country was higher than the east side.

In order to mitigate the PM, the Korean government is pursuing various policies including management of emission sources and cooperation with neighboring countries. However, it is relatively limited to mitigate PM as it may not regard an association between PM concentration and urban form. As a result, mitigation budgets are not sufficient enough to applying ventilation corridors.

The PM in Sejong City, which is a study area, is higher in winter than in summer. It is generated in order of scattering dust, non-road use, bio-combustion, and road movement. In order to mitigate PM, it is necessary

to control scattering dust generated at construction sites and to employ the ventilation corridors in the process of developing a new town.

5. Ventilation Corridor Simulation for PM Mitigation

In this chapter, we simulated the changes in the atmospheric environment, the flow of cold air after sunset, and the correlation between urban form and PM's concentration in Sejong City. Areas with relatively flat terrain and rivers have high wind speeds, while those in other regions have low wind speeds. The construction of a new town changed the surface wind vectors into a complex or distorted form while the wind speed generally tended to decrease.

The construction of large-scale apartment causes changes in the direction and speed of the prevailing wind, which are related to the dispersion of urban air pollutants. This means that it is necessary to conduct meteorological impact assessment before construction.

After sunset, fresh winds from the surrounding mountains move along rivers, valleys, and roads. When new cities such as the 4th, 5th and 6th neighborhoods are constructed, wind flow should be managed in accordance with ventilation corridors planning. In the block unit, wind field changes according to the height and layout of the building, which have a high correlation with PM concentration. Under the given conditions, it is more effective to arrange the plate-shaped buildings in the horizontal direction with wind corridors in mitigating PM. In this study, simulations were carried out under conditions similar to those of reality, however there are some limitations in that it uses different sizes of grids for individual simulations. Nevertheless, the results can provide various implications when determining the planning factors in developing new towns.

6. Integrating Urban and Environment Plans in Employing Ventilation Corridors

Laws, systems, and plans dealing with ventilation corridors can be divided into urban and environmental fields. In the urban legislation system, PM and ventilation corridors is rarely applied in the plans due to the lack of detailed regulations. The environmental legislation addresses that the environmental plan should reflect climate status map and wind road. However, the local environmental plans may not present the maps of climate, air pollution, and ventilation corridors. Even though the environmental maps are provided, the climate factors are not reflected in land use because of the divided urban and environmental planning systems.

It is necessary to integrate the two plans by (1) internalizing ventilation corridors in urban plans, (2) setting out urban plans reflecting the contents of the environmental plan, and finally (3) integrating urban plan with the environmental plan completely. This study suggests that it is appropriate to play a complementary role by linking the planning procedures and contents for the two plans. Accordingly, it was recommended that it is realistic of urban plans to reflect the ventilation corridors which is suggested by the environmental plan at the regional and urban level. In addition, it was appropriate that the ventilation corridors are internalized at the district and block level.

To achieve this purpose, the planning stages were divided into investigation, preparation, evaluation, and implementation stages. This study suggested the improvement of the legal system at each stage.

7. Limitations and Further Studies

The study deals with the usefulness of ventilation corridors for the mitigation of PM, and the integration between urban and environmental plans to apply them effectively. In this study, a number of previous studies, simulations, and limitations of the legal system are discussed in depth; however, the following limitations still remain. They are summarized and then further studies are suggested.

First, it is insufficient to identify the cause of PM concentration, though domestic PM's emissions have decreased since 2002. In future studies, it is necessary to conduct a research on the recent increase in the number of days and duration of high concentration. In addition, a study is needed to investigate the accumulation of PM in the metropolitan area and their difference from that of the non-capital area. Furthermore, it is necessary to prepare not only a two-dimensional emission source map, but also a three-dimensional map in order to detect the distribution and movement characteristics of the PM.

Second, it proposed an integration between spatial and environmental plans through the ventilation corridors; however, additional research is conducted on the results of this study in order to apply them to site. This study describes the improvement of some spatial and environmental legislations; however, it could not collect opinions on the planners and private construction companies. In order to amend the law in the future, it is necessary to take into account the opinions of stakeholders and to analyze its quantitative effects by calculating costs and benefits.

Third, mitigation policy can be divided into a suppression of emission and a reduction of PM and the providing of information to the public. It focuses on its reduction associated with ventilation corridors. On the other hand, it does

not fully deal with the abilities of plants which are able to absorb it. At the city level, the creation on a location of parks and green spaces should be researched in view of its reduction.

In case PM is reduced by supplying green infrastructure to the city, a study can be considered to set minimum requirements for green infrastructure that citizens need. In addition, this study did not cover both how to address a detailed map of PM and service it effectively. Furthermore, it does not deal with how to operate fine dust reduction facilities using smart technology. Therefore, it is needed to study how to build a more secure city for PM by combining 'ventilation corridors construction', 'green infrastructure supply' and 'an application of smart technology'.

Once a city is constructed, it lasts for 50 or 100 years. The benefits of ventilation corridors, thus, accumulate over time. In addition, they can not only reduce PM, but also improve the overall quality of atmosphere in a city. A green network on them is expected to play an important role in improving the overall urban environment as well as air quality. In this respect, they may make a contribution to creating an eco-friendly green city in the long run.