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Setting the Current Air Quality Concentration Using the National Atmosphere Measurement Network

Dong-Myung CHO[1], Ju-Yeon LEE[2], Lee-Seung KWON[3], Su-Hye KIM[4], Woo-Taeg KWON[5]

1. First Author Researcher, SM Environment & Consulting.CO.,LTD, Korea, Email: encvdm@naver.com
2. Second Author Researcher, SM Environment & Consulting.CO.,LTD, Korea, Email: juyeon2723@daum.net
3. Third Author Professor, Department of Health Care Management, Catholic Kwandong University, Korea, Email: leokwon@cku.ac.kr
4. Fourth Author Researcher, Department of Environmental Health & Safety, Eulji University, Korea, Email: kagome00@naver.com
5. Corresponding Author Professor, Department of Environmental Health & Safety, Eulji University, Korea, Email: awtkw@eulji.ac.kr

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Abstract

Purpose: In the course of the domestic environmental impact assessment, the current status survey was improperly conducted, and the issue of false and inaccurate environmental impact assessment reports has been raised several times recently through media reports. **Research design, data and methodology:** There is a continuous demand for improvement measures for the current status measurement method, such as having difficulties in securing a normal measurement date in consideration of equipment operation and rainfall days in the field. **Results:** In addition, in order to grasp the general air quality status of the evaluation target area, it is necessary to check the various current status concentrations by season and time series per year. However, there is a problem that is currently being carried out based on limited results such as measurement for 1 day or 3 days. **Conclusions:** Therefore, in this study, based on the national atmospheric measurement network, an inverse distance weighted (IDW) interpolation method was applied to calculate the current state concentration. This study suggested a method to use it in preparing the air quality item in the environmental impact assessment report.

Keywords : Environmental Impact Assessment, National Atmospheric Measurement Station, Inverse Distance Weighted, Current Status Concentration

JEL Classification Codes : I30, I31, I38

1. Introduction

1.1. Environmental Quality Measurement, Non-compliance with Related Standards

The domestic environmental impact assessment system proceeds through the process of surveying the current situation, predicting the impact, and establishing a reduction plan. Most of the environmental quality measurement work among the current status surveys is

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performed by an environmental impact assessment company (type 1) by signing a re-agent contract with a measurement agency. However, in the recent environmental quality measurement and investigation process, continuous problems have been identified, such as not complying with the matters stipulated in the air pollution process test standards. In addition, the preparation of the environmental impact assessment report is false and insolvent.

1.2. Difficulty in Operating Equipment and Securing Normal Measurement Days When Measuring Air Quality

In particular, in the case of environmental quality measurement in the air field, there are difficulties in normal operation of equipment in winter, the problem of providing a power source (electricity), and the regulation that "air quality samples should not be collected within one day before or after rainfall".

Guidelines (Ministry of Environment, 2016) for writing a report on the results of the post-environmental impact investigation. Therefore, it is difficult to secure the absolute measurement date considering the average number of rainfall days in Korea (about 120 to 130 days) when measuring.

1.3. Limitation of Understanding the General Air Quality Status in the Area with One or Three Days of Measurement

In addition, in the environmental impact assessment, it is important to understand the current status of various air quality such as the year, season, and time series of nearby receptors, depending on the progress of construction types that generate a lot of air pollutants and the operating hours of emission facilities.

Current air quality measurement is limited for one or three consecutive days, making it difficult to understand the overall air quality status of the target area. Accordingly, there is a problem in establishing appropriate reduction measures.

Therefore, this study tries to improve the problems of air quality measurement so far. In order to write an environmental impact assessment that is more reliable in measurement, we would like to present a methodology to calculate the current state of air quality by using the national atmospheric measurement network and to use it when writing an environmental impact assessment.

2. Research Methodology

This study proceeds as follows. The purpose of this study is to review how the current air quality concentration calculated by the inverse distance-weighted interpolation technique is applied to the current status survey results of the air quality item in the Environmental Impact Assessment.

2.1. Selection of Target Site for Development Project

The selection of the target site for the development project for this study is based on the distribution of the surrounding urban air quality monitoring network, installation and operation guidelines for air pollution monitoring networks, Ministry of Environment/National Institute of Environmental Sciences, 2021.1 was confirmed. Areas where at least three measurement networks are distributed within 10km were randomly selected.

2.2. National Atmospheric Network (Urban Air) Statistical Analysis

At airkorea, which is operated by the government, the final confirmed measurement data (data by time of year) was obtained for the measurement network around the project site, and the quarterly average was aggregated.

2.3. Calculate IDW Concentration using QGIS Program

The current air quality (PM-10, NO2) concentration of multiple measurement networks within 10km of the selected project site was adopted. In the QGIS program, an IDW interpolation method was used to create a grid diagram of air quality concentration distribution (applying quarterly average values). When performing IDW interpolation in QGIS, the default value of 2.0 was applied to Distance coefficient P to set the distance coefficient for interpolation. The current air quality concentrations of receptors (overlapping TM coordinates) around the development project site were calculated quarterly and presented in a table.

2.4. Proposal of Application of Current Status Concentration When Preparing Air Quality Environmental Impact Assessment Report

Table 1: IDW Interpolation Technique

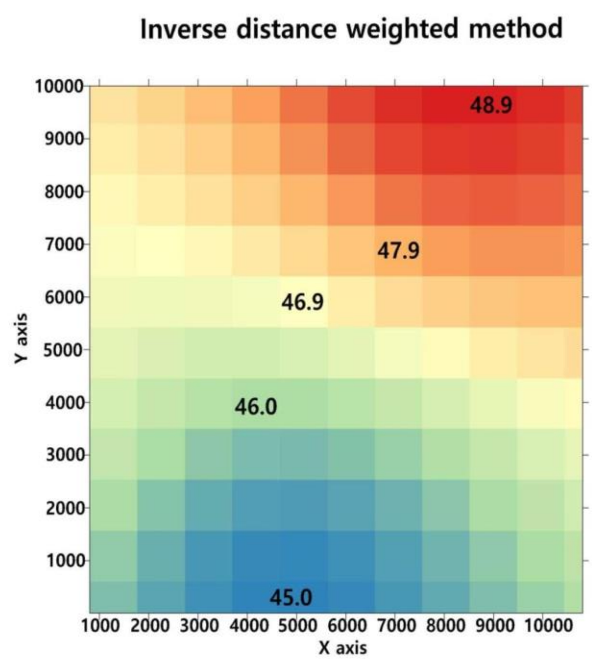
- Interpolation method used in the field of geostatistics
- Calculate the value of the interpolation point by weighting it in inverse proportion to the distance of the interpolation point using the coordinates already known
- A method of interpolation by giving a larger weight value to a nearby actual value (point)

$$Z_p = \frac{\sum_{i=1}^{n} Zi\,Wi}{\sum_{i=1}^{n}}$$

Zp : Prediction value of prediction point (interpolation value)

Zi : Reference value of position (xi,yi)

Wi : Weight (=1/di2), inversely proportional to the square of the distance



The current air quality concentration calculated by IDW interpolation method at the receptors around the development project site and the air quality prediction modeling result (weighted concentration) using AERMOD during construction were added. The air quality forecast for the future time period was implemented and necessary reduction measures were reviewed.

IDW Interpolation Calculation Status Concentration + Air Quality Modeling Predicted Concentration (Weighted Concentration)

3. Research Results

3.1. Random Selection of Development Project Site

The target site of the development project for this study was selected arbitrarily as "the area around San 27-3, Jeondae-ri, Pogok-eup, Cheoin-gu, Yongin-si, Gyeonggi-do," where a number of measurement networks are located within 10km after confirming the distribution of nearby urban atmospheric measurement networks.

3.2. Status of the National Air Quality Monitoring Network (airkorea.or.kr) around the Development Project Site

The urban air measurement network within 10km of the center of the development project site was identified. As a result, three locations, Giheung, Gimryangjang-dong, and Mohyun-eup operated by Gyeonggi-do Health and Environment Research Institute, were identified and presented as follows.

Table 2: Current Status of National Air Quality Monitoring Network Near Development Project Site

Measuring Station	Measuring Station Address	Operating Institution	Separation Distance	Direction
Giheung	95, Gwangok-ro, Giheung-gu, Yongin-si, Gyeonggi-do (Giheung-gu Office)	Gyeonggi-do Health and Environment Research Institute	8.4km	West side
Gimryangjang-dong	50, Geumnyeong-ro, Cheoin-gu, Yongin-si, Gyeonggi-do (Choin-gu Office)	Gyeonggi-do Health and Environment Research Institute	4.8km	South side
Mohyun-eup	31-6, Monok-ro, Mohyeon-eup, Cheoin-gu, Yongin-si, Gyeonggi-do (Mohyeon-eup Community Service Center)	Gyeonggi-do Health and Environment Research Institute	6.1km	North side

The final confirmed measurement data (data by time of year) of the three measurement networks were downloaded from airkorea. For QGIS program analysis, the quarterly average aggregation is presented as follows. As a result of analyzing the quarterly average value, although there is a slight difference by pollutant, the concentration was usually high in the first quarter. It can be seen that thereafter, it gradually decreases, showing the lowest level in the third quarter, and then increasing again in the fourth quarter.

Table 3: National Monitoring Network Air Quality Measurement Status (Average by Quarter in 2020)

Site	Date		SO_2	CO	O_3	NO_2	PM-10	PM-2.5
Giheung	2020	first quarter	0.002	0.5	0.018	0.031	47	29
		second quarter	0.002	0.4	0.040	0.019	39	20
		third quarter	0.003	0.4	0.026	0.015	21	11
		fourth quarter	0.003	0.5	0.016	0.034	41	24
	Average		0.003	0.5	0.025	0.025	37	21

Gimryangjang-dong	2020	first quarter	0.004	0.5	0.018	0.034	45	32
		second quarter	0.002	0.3	0.037	0.017	41	20
		third quarter	0.002	0.4	0.024	0.014	22	12
		fourth quarter	0.003	0.5	0.014	0.029	41	27
	Average		0.003	0.4	0.023	0.024	37	23
Mohyun-eup	2020	first quarter	0.002	0.5	0.021	0.020	49	29
		second quarter	0.002	0.4	0.044	0.012	42	20
		third quarter	0.002	0.4	0.029	0.008	21	10
		fourth quarter	0.003	0.5	0.018	0.022	49	27
	Average		0.002	0.5	0.028	0.016	40	22

Note: http://airkorea.or.kr

3.3. Selection of Representative Receptors near the Development Project Site

A total of 5receptors were selected and presented within 5km of the center of the development project site for the estimation of the current state concentration, through this study and the future air quality prediction considering the weighted concentration during the construction period. The selected receptor was targeted for the residential area where damage is expected from air pollutants generated during the construction period in the development project site.

Table 4: Status of Receptors around the Project Site

Type	TM coordinates		Separation distance (m)	Note
	x	y		
receptor1	220,489	520,055	1,507	
receptor2	222,535	518,399	3,913	
receptor3	214,825	520,368	3,733	
receptor4	219,426	524,622	4,468	
receptor5	218,978	515,817	4,044	

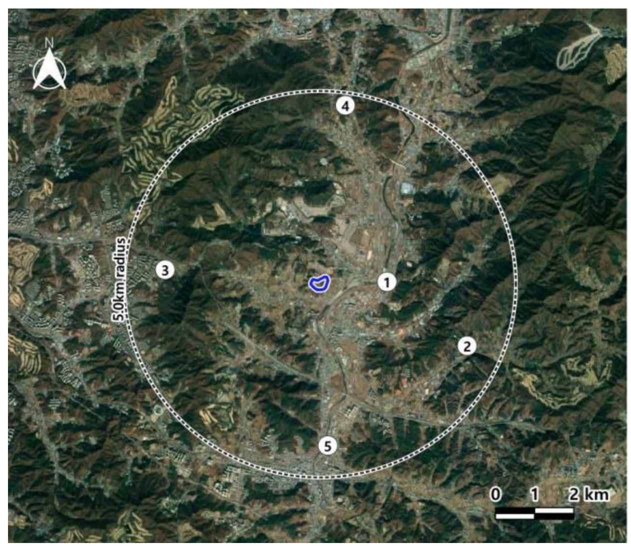


Figure 1: Project Site and Receptor Status Map

3.4. IDW Concentration Calculation Result using QGIS

IDW interpolation was performed in the QGIS program by applying three national measurement networks located within 10km of the center of the development project site. The results are presented as grid images so that the concentration distribution can be easily checked with the naked eye. At this time, the size of the gird was presented as 1,000m × 1,000m in consideration of the spatial scale of the analysis area. TM coordinate values were measured for receptors around the project site. As a result of calculating the current status of air quality by quarter (seasonal) at each receptor, it was possible to obtain a result value in which the quarterly average value of three measuring networks was weighted and reflected according to the inverse distance.

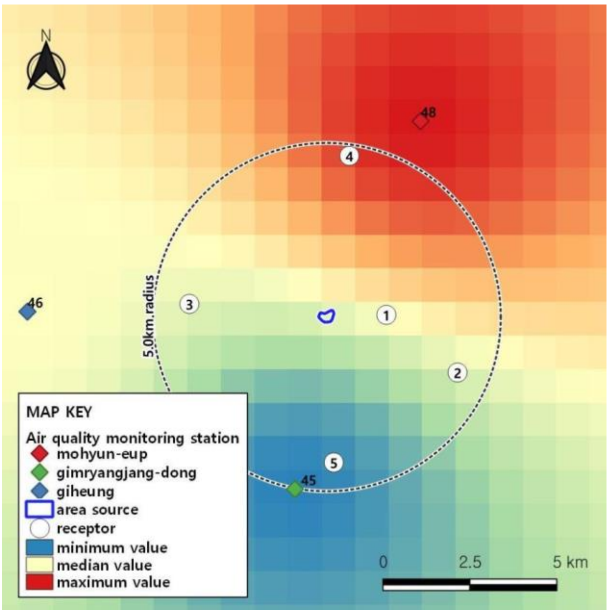
Relatively high concentrations were analyzed in the first and fourth quarters as well as the quarterly average value of each measurement network. It decreased in the second quarter, and the minimum concentration was analyzed in the third quarter. This is considered to be closely related to the quarterly fuel consumption. The reason for the minimum concentration in the third quarter is considered to be the point at which fuel consumption is the lowest according to seasonal characteristics. In this study, quarterly average values were applied throughout the year.

However, it is expected that the behavioral characteristics of air pollutants according to various time scales can be grasped if the monthly and daily hourly analysis is carried out.

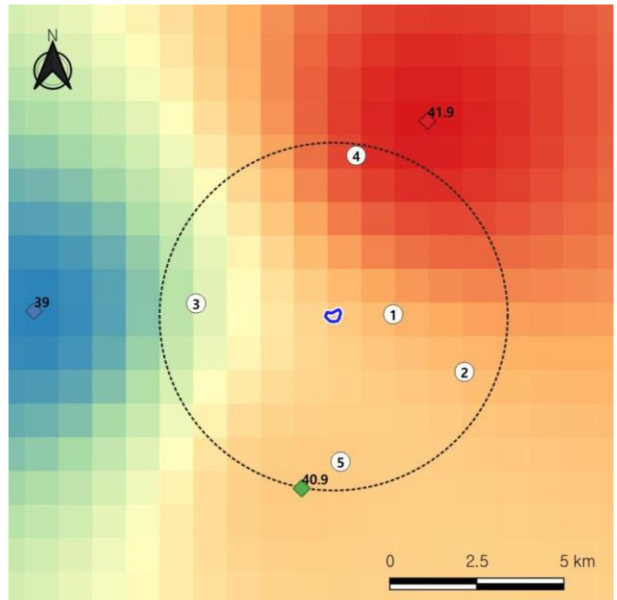
Table 5: Calculation Result of Current Concentration of Receptor (IDW interpolation)

Classification		TM coordinates		Current Concentration (IDW interpolation)		Note
		x	y	PM-10 (㎍/㎥)	NO_2 (ppm)	
receptor1	first quarter	220,489	520,055	46.8	0.028	
	second quarter			41.1	0.015	
	third quarter			21.5	0.012	
	fourth quarter			44.1	0.027	
receptor2	first quarter	222,535	518,399	46.5	0.029	
	second quarter			41.1	0.016	
	third quarter			21.6	0.012	
	fourth quarter			43.6	0.027	
receptor3	first quarter	214,825	520,368	46.6	0.030	
	second quarter			40.3	0.017	
	third quarter			21.4	0.013	
	fourth quarter			42.3	0.030	
receptor4	first quarter	219,426	524,622	48.7	0.021	
	second quarter			41.8	0.013	
	third quarter			21.1	0.009	
	fourth quarter			48.1	0.023	
receptor5	first quarter	218,978	515,817	45.2	0.034	
	second quarter			41.0	0.017	
	third quarter			22.0	0.014	
	fourth quarter			41.2	0.029	

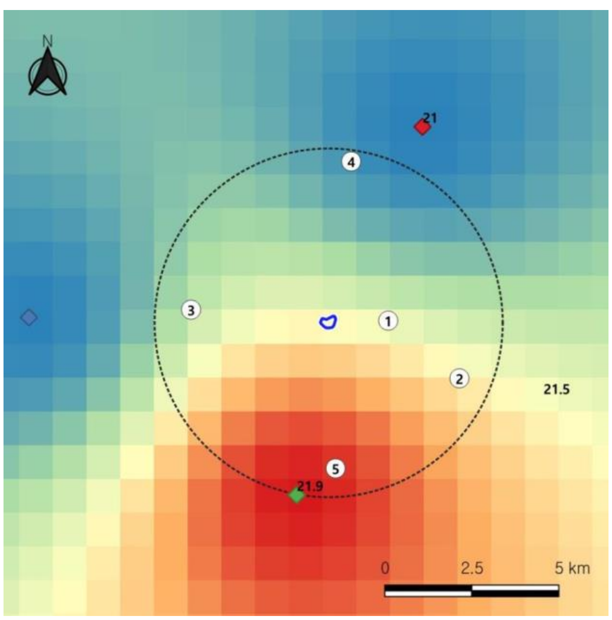
The grid image of the analysis result indicates the 3 measurement networks and 5 receptor locations. Color images were used so that the distribution status of max, med, and min concentration areas could be grasped. In addition, four images were presented sequentially from the first quarter to the fourth quarter to facilitate understanding of the concentration characteristics by period.



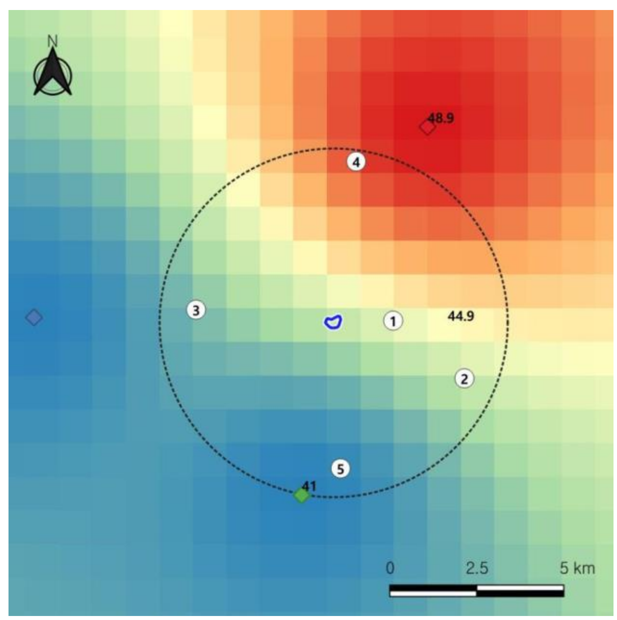
2020 first quarter



2020 second quarter



2020 third quarter



2020 fourth quarter

Figure 2: Quarterly IDW Concentration Grid Image (PM-10)

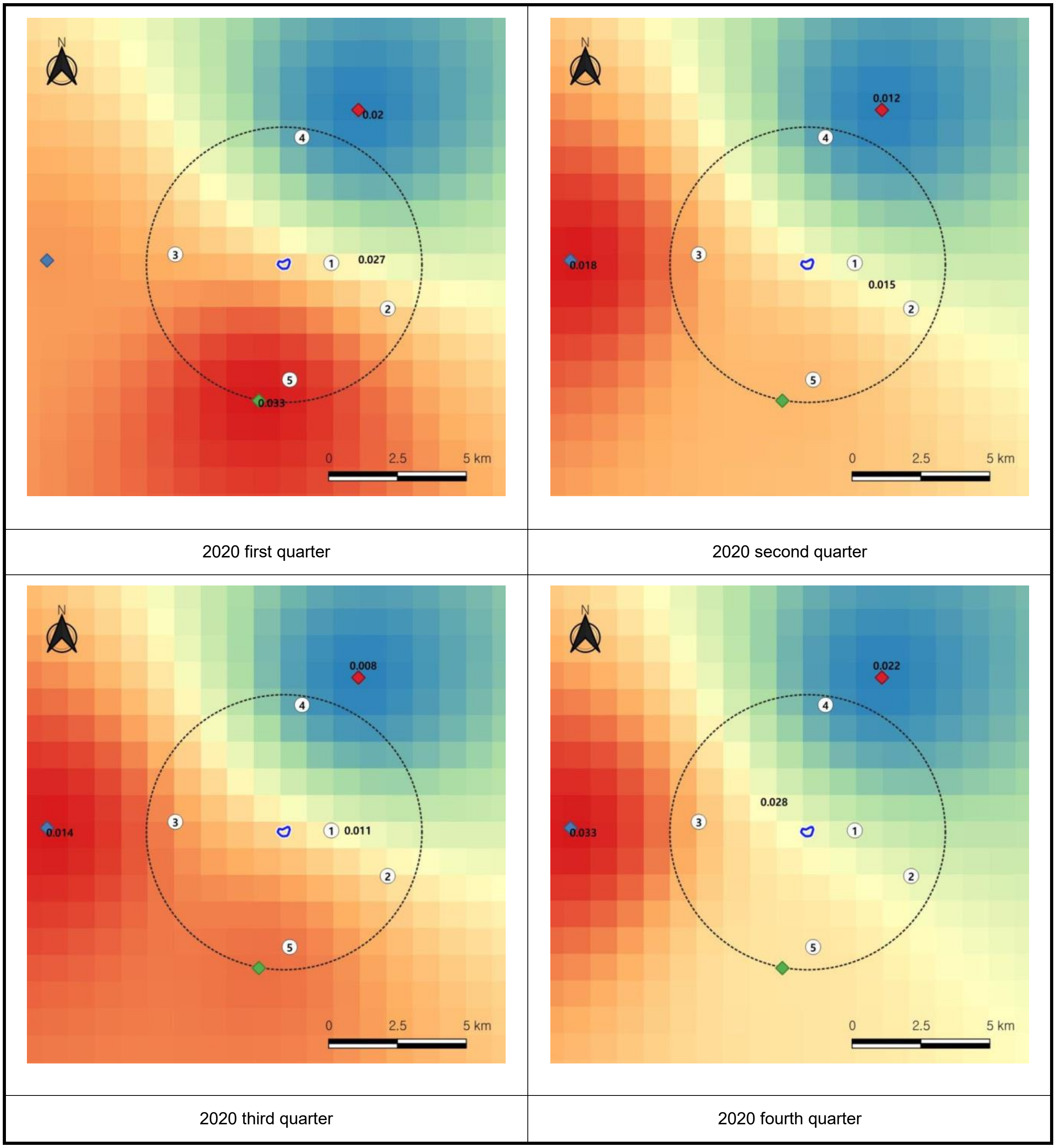


Figure 3: Quarterly IDW Concentration Grid Image (NO_2)

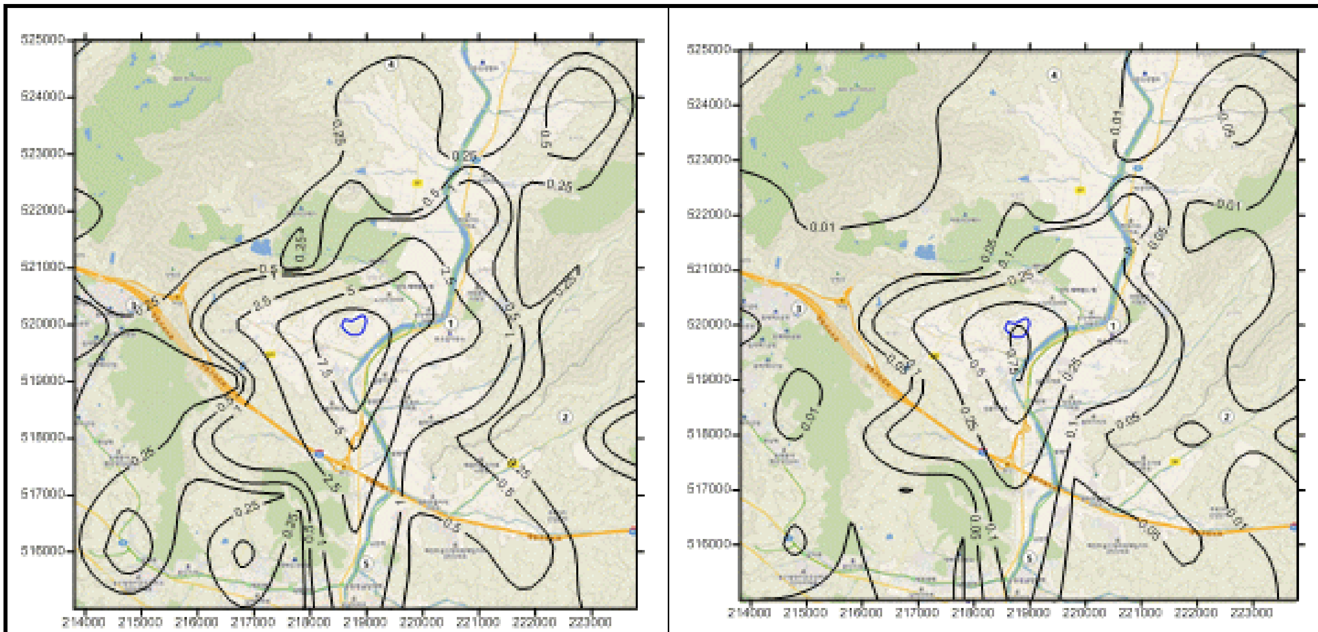
3.5. Results of Application of Current Status Concentration during Environmental Impact Assessment

At the development project site, the amount of air pollutants generated was calculated based on earthworks during construction. Effect prediction (PM-10, NO2) using the AERMOD air quality prediction program was conducted to obtain weighted concentrations. The final predicted result value for each receptor was derived by summing it with the current concentration calculated through IDW interpolation.

The final prediction result showed the maximum concentration in the first quarter and the minimum concentration in the third quarter, reflecting the current concentration by IDW interpolation. Based on these analysis results, it was possible to derive the results that it is desirable to selectively carry out earthworks in the 3rd quarter (July to September) in the case of earthworks that generate a lot of air pollutants during construction.

Table 6: Air Quality Impact Prediction Results

Classification		TM coordinates		Current Concentration (IDW interpolation)		Weighted concentration		Prediction result		Note
		x	y	PM-10	NO_2	PM-10	NO_2	PM-10	NO_2	
receptor1	first quarter	220,489	520,055	46.8	0.028	3.2	0.0003	50.0	0.0283	
	second quarter			41.1	0.015			44.3	0.0153	
	third quarter			21.5	0.012			24.7	0.0123	
	fourth quarter			44.1	0.027			47.3	0.0273	
receptor2	first quarter	222,535	518,399	46.5	0.029	1.2	0.0001	47.7	0.0291	
	second quarter			41.1	0.016			42.3	0.0161	
	third quarter			21.6	0.012			22.8	0.0121	
	fourth quarter			43.6	0.027			44.8	0.0271	
receptor3	first quarter	214,825	520,368	46.6	0.030	1.4	0.0001	48.0	0.0301	
	second quarter			40.3	0.017			41.7	0.0171	
	third quarter			21.4	0.013			22.8	0.0131	
	fourth quarter			42.3	0.030			43.7	0.0301	
receptor4	first quarter	219,426	524,622	48.7	0.021	0.1	0.0000	48.8	0.0210	
	second quarter			41.8	0.013			41.9	0.0130	
	third quarter			21.1	0.009			21.2	0.0090	
	fourth quarter			48.1	0.023			48.2	0.0230	
receptor5	first quarter	218,978	515,817	45.2	0.034	1.5	0.0001	46.7	0.0341	
	second quarter			41.0	0.017			42.5	0.0171	
	third quarter			22.0	0.014			23.5	0.0141	
	fourth quarter			41.2	0.029			42.7	0.0291	



PM-10($\mu g/m^3$)	NO_2(ppb)

Figure 4: Air Quality AERMOD Prediction Result (weighted concentration)

4. Research Utilization Plan and Limitations

4.1. Research Utilization Plan

This study presented a methodology for estimating air quality concentration surveys necessary for environmental impact assessment by using IDW interpolation based on the national network instead of conducting on-site surveys. It is expected that it will be possible to reduce the time and cost required for sample collection and measurement analysis required for air quality survey. In addition, since it is possible to secure data with public credibility by using the measurement network established by the state, it is judged that it will be possible to solve the problems of false and inaccurate basic surveys that have been continuously raised during environmental impact assessment to some extent.

In addition, it is possible to establish customized (active) reduction measures in consideration of the seasonal and hourly air quality prediction results (max, med, min) at the receptors around the development project site during the environmental impact assessment. It is expected that the environmental impact assessment will be substantial.

4.2. Limitations of the Study and Further Research in the Future

As a result of understanding the distribution status of national measurement networks through this study, measurement networks are concentrated in large cities. It was confirmed that the number of measurement networks installed in the suburbs was absolutely insufficient. Therefore, in light of the fact that development projects are carried out in relatively non-urban areas, it was found that the expansion of the national atmospheric measurement network in the relevant area is continuously necessary.

In this study, only the urban air measurement network was used among the national measurement networks. However, if an IDW concentration analysis is performed including the results of various other measurement networks such as suburban atmospheric monitoring networks and roadside atmospheric monitoring networks, results that reflect the characteristics of subdivided areas such as residential areas and roadside areas can be derived. It is considered that further research is needed in the future.

5. Conclusions

Through this study, the problem of false and inaccurate preparation of the environmental impact assessment report due to the cause of improper implementation of the current status survey was solved, and the effect on the receptor was predicted based on reliable data.

It is expected that the effectiveness of the environmental impact assessment system will be improved, such as preparing specific reduction measures that take into account the current status of air quality in the target area and the period when the impact is greatly increased.

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