Correlation Analysis between Tritium Concentration in the Atmosphere and Wind Direction around Wolsong Nuclear Power Plant

So Yun Jeong, Jae Wook Kim, Young Seo Kim, Han Young Joo, and Joo Hyun Moon*
Dankook Univ., 119, Dandae-ro, Dongnam-gu, Cheonan-si, Rep. of Korea, 31116
**Corresponding author: jhmoon86@dankook.ac.kr*

1. Introduction

A domestic nuclear power plants (NPPs) operator, Korea Hydro & Nuclear Power Co. (KHNP), manages the emission amount of radionuclide emitted from each NPP in accordance with emission standards, and releases the monthly emission status to the public [1]. These radionuclides are released into the environment in liquid or gaseous form, and are detected in the local environment (seawater, air, groundwater, soil, etc.) around the NPPs.

According to these standards, emission amount from NPPs and detection amount at the measurement point are well managed separately, but there are few cases analyzed the causal relationship between the emission amount and detection amount. If the detection amount at the measurement point is high due to specific meteorological variables, a situation requiring examination of the reason may arise, even if it is lower than the reference value. Therefore, if we understand the causality between meteorological data such as wind speed, wind direction and atmospheric stability, and the emission amount from the NPPs, and the detection amount at the measure point, a more reliable basis for the detection amount can be presented.

In this study, as a preliminary study on causal analysis, we selected one of the meteorological variables that mentioned above, wind direction, and analyzed the correlation with tritium concentration. The tritium concentration was measured at two contrary points around the Wolsong NPPs, and the wind direction was measured at meteorological station in Wolsong NPPs site. We gathered the data for a total of 10 years, and derived the Pearson's correlation coefficient to confirm the correlation using R, a big data analysis program.

2. Materials and Methods

2.1 Data collection

Wind direction data and tritium concentration data were excerpted from the annual survey of environmental radiation and the assessment of the impact of radiation on environment report published by KHNP. Wind direction is measured from the meteorological station located 200m northwest of the Wolsong reactor building, and it is represented into 16 directions [1].

For the measurement of tritium in the atmosphere, a moisture absorbent, Silica-Gel, is used. Tritium was collected twice a month, and analysis was performed using a liquid scintillation counter after pretreatment of the collected Silica-Gel. The tritium collection points are at 'Sangbong', 2km north-north-east of Wolsong NPPs, and the 'Company housing', 1.9km south [1].

2.2 Data analysis methods

We used the Pearson's correlation coefficient to determine the relationship between wind direction and tritium concentration. Pearson's correlation coefficient evaluates the strength of the relationship between two vectors based on the data's covariance matrix, and it is expressed as a value between –1 and 1. When the correlation coefficient value is between 0.7 and 1, it means that the two variables have a positive correlation, and when between –0.7 and –1, it means that the two variables have a negative correlation [2].

		Wind directions (16 columns)			
Year	Tritium (Bq/m^3)	N (%)	NNE (%)	…	NNW (%)
2010	1.02	5.2	4.8	…	5.1
2011	0.59	7.4	8.2	…	7.5
2012	0.69	6.7	9.7	…	7.2
2013	0.71	6.1	7.1	…	6.7
2014	0.48	6.4	6.6	…	11
2015	0.46	6.7	6.9	…	10.9
2016	0.42	6.5	5.6	…	11.2
2017	0.44	4.2	1.6	…	9.8
2018	0.41	6.3	6.9	…	9.7
2019	0.36	5.6	5.5	…	10.5

Fig. 1. Example of analysis data set.

Figure 1 shows an example data set used for analysis. We analyzed the correlation between tritium concentration and the incidence rate in each direction using annual average data for a total of 10 years from 2010 to 2019.

3. Results

Figure 2 shows the annual average frequency of wind direction occurrence over the 10 years from 2010 to 2019. It can be seen that the southwest wind is dominant around the Wolsong NPPs. Table I shows the average annual tritium concentration measured at the points. The 'Sangbong' point located in the north of the NPPs is

measured slightly higher than that of the 'Company housing' located in the south, and the overall trend has been decreasing for 10 years.

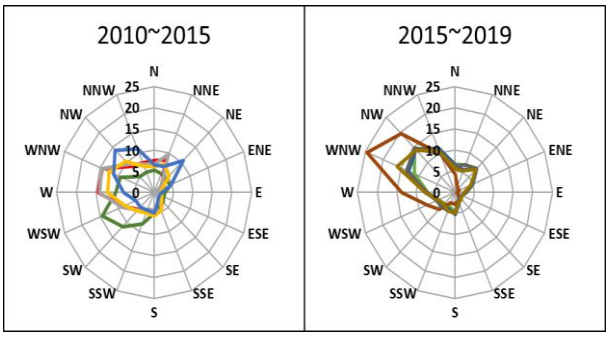

Fig. 2. Annual average of wind direction incidence frequency (unit: %).

Table I: Annual average of tritium concentration (unit: Bq/m^3)

Point / Year	Company housing	Sangbong
2010	0.45±0.27*	1.02±0.83
2011	0.31±0.19	0.59±0.52
2012	0.40±0.25	0.69±0.56
2013	0.28±0.18	0.71±0.70
2014	0.27±0.23	0.48±0.40
2015	0.22±0.13	0.46±0.41
2016	0.17±0.11	0.42±0.34
2017	0.14±0.11	0.44±0.45
2018	0.22±0.15	0.41±0.40
2019	0.17±0.21	0.36±0.38

*Standard deviation(1σ) of the mean value.

Table II shows the results of the correlation analysis between wind direction data in the Wolsong NPPs and the tritium concentration measured at the two points. As a result, we found that there is a positive correlation in the SE, SSW, SW, and WSW directions, and a negative correlation in the NW and NNW directions. That is, when the southwest wind (wind blowing from the southwest) blows, the radioactive concentration increases, and when the northwest wind (wind blowing from the northwest) blows, the radioactive concentration decreases.

Table II: Result of correlation analysis between wind direction and annual average tritium concentration

Wind direction / Point	Company housing	Sangbong
N	0.21	-0.08
NNE	0.47	0.14
NE	-0.29	-0.42
ENE	-0.16	-0.20
E	0.10	0.06
ESE	0.54	0.61
SE	0.80	0.83
SSE	0.68	0.64
S	0.22	0.17
SSW	0.73	0.79
SW	0.76	0.92
WSW	0.81	0.94
W	0.35	0.38
WNW	-0.54	-0.43
NW	-0.91	-0.85
NNW	-0.83	-0.92

4. Conclusions

It is difficult to predict the behaviors of radionuclides emitted from NPPs in gaseous form, because they are influenced greatly by meteorological variables. However, identifying radionuclides behaviors in off-site of NPPs is very important in terms of safety. Therefore, the study which grasps the relationship between meteorological variables and the stream of radionuclides must be conducted.

In this study, as preliminary study, we investigated the correlation between wind direction and tritium concentration in off-site of Wolsong NPPs. We selected the wind direction, one of many meteorological variables, and tritium, one of the radionuclides released into the air from nuclear power plants, to analyze their correlation. As a result, we identified that tritium concentration and some wind directions has correlation.

There are other meteorological factors that affect the detection amount along with the wind direction. Also, the detection amount is affected by geological variables. Therefore, these conditions must be included in the consideration. Based on this study, follow-up study involves investigation of the relation between other meteorological variables, geological factors, radionuclides emission amount and radionuclides detection amount.

Acknowledgements

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government (Ministry of Science and ICT). (No.2020M2D2A2062436)

REFERENCES

[1] Korea Hydro & Nuclear Power Co., The annual report on the environmental radiation survey and assessment around the nuclear facilities, 2020.

[2] Y. Mu, X. Liu, and L. Wang, A Pearson's correlation coefficient based decision tree and its parallel implementation, Information Sciences, Vol.435, p.40-58, 2018.