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Wind Direction and Wind Speed Analysis around Hanbit Nuclear Power Plant

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Abstract The Korean Peninsula is affected by westerlies and seasonal monsoons. In addition, a typhoon may generate storms with maximum wind speeds of 17 m s^{-1} or more. The direction and speed of the wind have the greatest influence on the distribution of radioactivity (radioactive material) leaks from a nuclear facility to the outside. In the event of such a radiation emergency, local wind direction and wind speed data are very important when preparing resident protection measures, such as the evacuation of residents. Among the various weather data provided by the Korea Meteorological Administration, in this study, temperature, wind direction, and wind speed data measured and recorded from 2012 to August 2022 at the Yeonggwang Weather Station, the location of the Hanbit Nuclear Power Plant, were provided and analyzed. The characteristics of the wind direction and wind speed were investigated based on the annual wind speed and wind direction data in this area over a period of 10 years. The average temperature of the Yeonggwang area is 13.41 degrees, and the average temperature is gradually increasing. The maximum wind speed by year was counted as a gradual downward trend. In the case of wind direction, it was found that a northeast wind of 0~30 degrees and a north wind and northwest wind between 330~360 degrees were predominant, despite the influence of the westerly and monsoon winds. Based on the Hanbit Nuclear Power Plant, the location of the first aid station is mainly located in the east and south, and the first aid station is concentrated in places where the influence of the wind direction is relatively small in terms of the probabilistic impact of the emergency accident. Based on the nuclear power plant, the location of the monitoring center for radiation emergency prevention is located in the southeast, so it is expected that the detector installed outside the plant fence can efficiently detect leakage accidents early.

Key words: Wind direction, Wind speed, Windrose, Disaster, Prevention strategy

1. INTRODUCTION

The Korean Peninsula is affected by the westerlies and seasonal monsoons. In addition, typhoons can cause wind and flood damage, accompanied by storm bands with maximum wind speeds of 17 m s^{-1} or more. The wind direction and speed resulting from topographical and seasonal factors can affect the diffusion of radioactive materials.

The direction and speed of the wind have the greatest influence when radioactivity (radioactive material) leaks from a nuclear facility to the outside. To deal with such a radiation emergency, a radiation emergency planning area is set up in advance to prepare measures to protect residents, such as evacuation [1].

The radiation emergency planning zone is divided into an Urgent Protective Action Planning zone and a Precautionary Action Zone. The emergency protection action planning zone averages 3 to 5 km, and the Urgent Protective Action Planning zone averages 20 to 30 km. This distance is centered on the nuclear power plant [2].

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The current technical basis of emergency plans established for radiation disaster prevention is the content described in NUREG0396, which is more than 30 years old. Consequently there is an opinion that is necessary to re-evaluate the risks related to radiation accidents at nuclear power plants [3,4].

Among the various weather data provided by the Korea Meteorological Administration in this study, the temperature, wind direction, and wind speed data measured and recorded from 2012 to August 2022 at the Yeonggwang Weather Station, the location of the Hanbit Nuclear Power Plant, were provided and analyzed [5].

In the present study, the annual wind speed and wind direction data for this region were calculated for the past 10 years, and quarterly changes were also analyzed to observe changes in the year-by-year characteristics. The characteristics of wind direction and wind speed according to temperature were also analyzed. In this way, we tried to investigate the relationship between the gathering point around the power plant and the location of the relief station.

2. METHODS AND MATERIALS

2.1. Meteorological station

Atmospheric circulation ranges from small-scale circulations such as turbulence and tornadoes to circulations such as typhoons, high pressure, low pressure, and large atmospheric circulations. These are usually classified into micro-scale, medium scale, synoptic scale, and global scale. The Korea Meteorological Administration provides synoptic observation data for 103 regions nationwide [6].

Synoptic Observing refers to ground observation conducted at the same time at all observatories at a fixed time in order to grasp the weather on a synoptic scale. For the Hanbit nuclear power plant, there are 5 weather stations, in Jeollanam-do and Jeollabuk-do (Yeonggwang 252, Gochang 172, Gochang 251, Jeongeup 245, Buan 243). Fig. 1 shows the meteorological stations around the Hanbit nuclear power plant.

Based on the wind direction and speed data observed at Yeonggwang 252 Observatory from 2012 to August 2022, we investigated whether there was a special wind direction.

2.2. Observation data

Analysis was conducted based on 119,226 hourly data

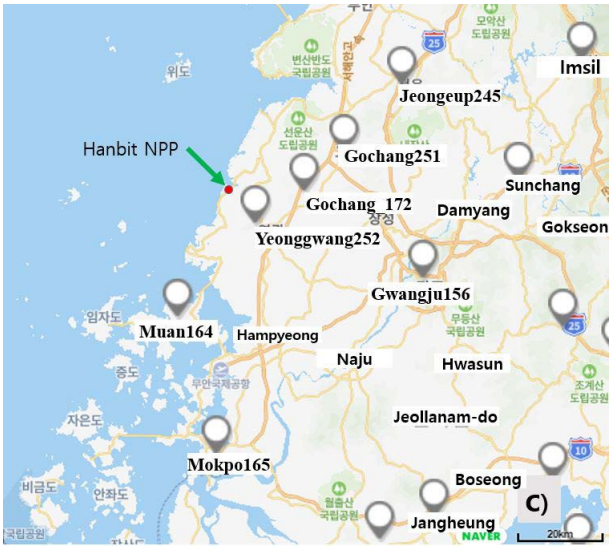

Fig. 1. The location of the Korea Meteorological Administration Meteorological Observatory near Hanbit Nuclear Power Plant.

Table 1. Location of weather stations and nuclear environment monitoring equipment around Hanbit Nuclear Power Plant

Classification	Names	Latitude	Longitude
Nuclear Power Plant	Hanbit Nuclear Power Headquarters, Korea Hydro & Nuclear Power Co., Ltd	35°24′31.9″N	126°24′59.4″E
Regional Meteorological Station of the Korea Meteorological Administration	Yeonggwang 252	35°17′01.2″N	126°28′40.2″E
	Gochang 172	35°20′53.6″N	126°35′56.3″E
	Gochang 251	35°25′35.8″N	126°41′49.1″E
	Jeongeup 245	35°33′48.1″N	126°50′20.5″E
	Buan 243	35°43′46.8″N	126°42′59.7″E
Nuclear Monitoring Organization	Hanbit Nuclear Power Plant Civil Environmental Monitoring Organization	35°17′05.1″N	126°30′49.8″E

from 00:00 on January 1, 2012 to 23:00 on August 28, 2022. The acquired data were temperature (°C), wind direction (16 directions), and wind speed (m s^{-1}).

2.3. Relief center and assembly area

Detailed information on relief stations and gathering points around nuclear power plants can be obtained on the open operation information site operated by Korea Hydro & Nuclear Power. For the Hanbit Nuclear Power Plant, there are 512 assembly points and 126 relief stations, as shown in Fig. 2 [7].

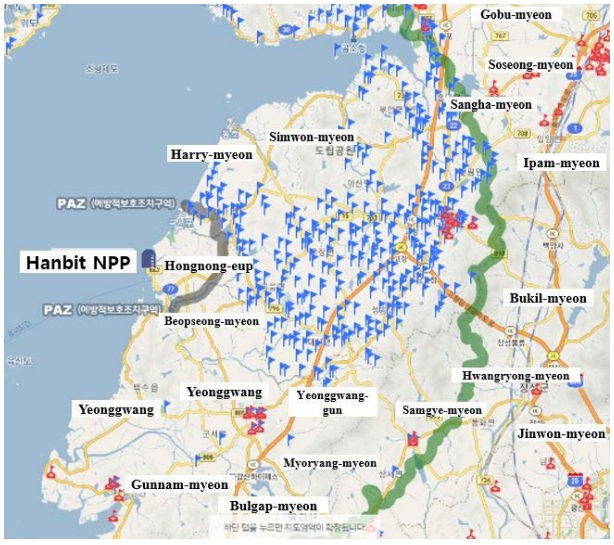

Fig. 2. Location of Hanbit Nuclear Power Plant Main Gathering Areas and Relief Stations - Blue Flags are the Gathering Areas and Red Flags are the first aid stations.

3. RESULTS AND DISCUSSION

3.1. Temperature

Fig. 2 shows the average temperature and the maximum and minimum temperatures in the Yeonggwang area from 2012 to 2022. The average temperature in this area is 13.41 degrees Celsius, and by year, the maximum observed temperature was 36.5 degrees in 2018 and the minimum temperature was minus 17.3 in 2021. The average temperature is rising as a function of $y = 0.1053x + 12.781$.

3.2. Wind direction and wind velocity

Looking at the maximum wind direction by season in Korea, westerly winds in spring, south winds in summer, north winds in autumn, and northwest winds in winter are dominant. It can be seen from the distribution map that the average wind speed decreases from the past to the present, and the wind speed is stronger mainly in coastal areas than inland [8].

The wind rose in Fig. 3 is a radial graph showing the frequency of wind direction for 10 years from 2012 to 2022 at the Yeonggwang Weather Station. The percentage of the frequency is expressed as the length of the azimuth line on the azimuth plate corresponding to each wind direction. However, the frequency of occurrence of Calm (wind speed of 0.4 m s^{-1} or less) is indicated by the bar at the center of the graph indicating the direction in which the wind blows, and the frequency by wind speed class of each wind direction is also indicated.

The Korean Peninsula is affected by the west wind. This

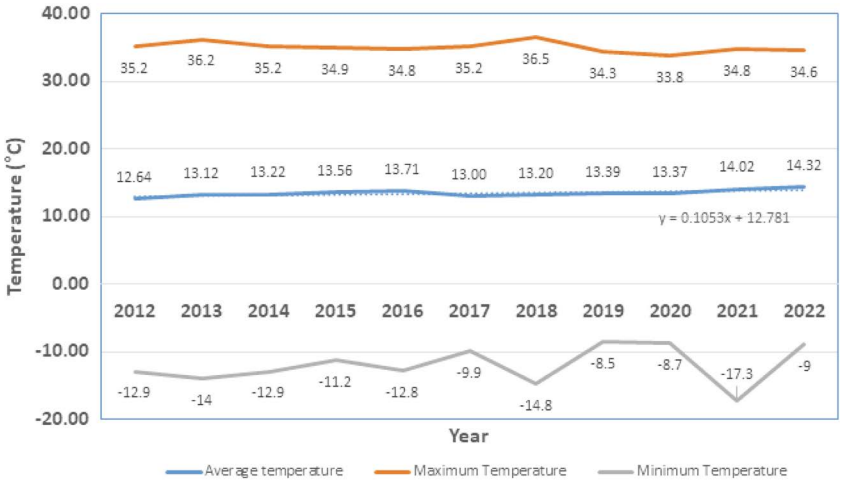

Fig. 3. Average temperature and maximum and minimum temperatures in the Yeonggwang area from 2012 to 2022.

Table 2. Distribution of wind direction by year from 2012 to 2022

Years	Direction (deg.)											
	1~30	31~60	61~90	91~120	121~150	151~180	181~210	211~240	241~270	271~300	301~330	331~360
2012	**13.67**	8.75	10.48	8.24	8.23	7.79	2.81	3.85	9.68	2.40	2.68	**21.43**
2013	10.60	6.61	9.43	5.90	6.96	9.53	5.14	6.42	11.56	1.68	2.67	**23.48**
2014	11.39	8.25	10.28	7.54	8.29	8.93	2.68	3.54	12.90	2.49	2.97	**20.73**
2015	8.66	7.06	11.73	5.22	6.20	7.62	3.39	4.70	12.52	3.50	8.20	**21.20**
2016	11.16	9.32	**13.13**	4.80	6.23	10.67	4.34	4.42	8.75	4.71	7.63	**14.84**
2017	**16.65**	11.31	12.98	4.45	1.47	1.13	0.52	0.56	11.12	5.34	5.04	**29.42**
2018	**13.17**	8.40	11.16	4.90	6.16	6.72	2.49	2.22	10.34	3.23	7.67	**23.54**
2019	**13.22**	5.14	8.16	6.73	6.06	8.94	4.31	4.32	**14.81**	1.68	2.88	**23.74**
2020	**13.86**	4.30	6.90	4.57	4.87	13.06	5.67	5.37	11.11	1.82	4.08	**24.39**
2021	12.45	5.03	8.48	5.39	6.42	**15.30**	4.92	4.41	10.35	2.84	4.14	**20.28**
2022	11.88	2.94	6.29	3.87	4.57	13.10	7.80	8.07	**13.95**	1.99	2.63	**22.93**

The number in red is the top 20.

is a wind blowing from west to east within the troposphere. The is called westerly from the region where this wind originates, and it is also called a mid-latitude westerly because it occurs in the mid-latitudes of the northern and southern hemisphere, that is, in the 30~65 degree latitude range. In winter it spreads toward lower latitudes, and in summer it contracts at higher latitudes [9].

However, as shown in Table 2, when the wind direction is aggregated by year, it can be seen that without the influence of the westerly wind the main wind direction is to the north. In this table, the numbers in bold red indicate the frequency of wind speed corresponding to the top 20. It can be seen that most of the north and northwest winds are between 330 and 360 degrees.

Westerly winds are also caused by the difference in specific heat between continents and oceans. Continents have less specific heat than oceans, so continents warm up and cool faster than oceans [10].

Oceans cool like continents, but do not cool as quickly as continents because they have a higher specific heat than continents.

Therefore, the ocean area is relatively warmer than the continent, so a low pressure zone is formed, and the wind blows from the continent to the ocean [11].

Fig. 4 shows the trend in changes in the maximum wind speed and average wind speed by year as a graph. The trend in wind speed also gradually decreases in a downward trend.

Fig. 5 graphically shows the wind speed in the vicinity of the Hanbit Nuclear Power Plant from 2013 to 2022. The

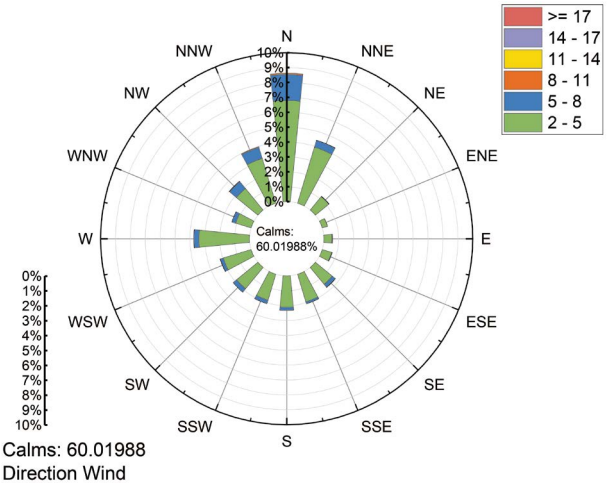

Fig. 4. Wind direction distribution in Yeonggwang area from 2012 to August 2022.

average wind speed is 2 m s^{-1}.

4. CONCLUSION

The average temperature of the Yeonggwang area is 13.41 degrees, and the average temperature is gradually increasing. The maximum wind speed by year was observed to have a gradual downward trend. In the case of wind direction, it was found that a northeast wind of 0~30 degrees and a north wind and a northwest wind between 330~360 degrees were predominant, despite the influence of the westerly and

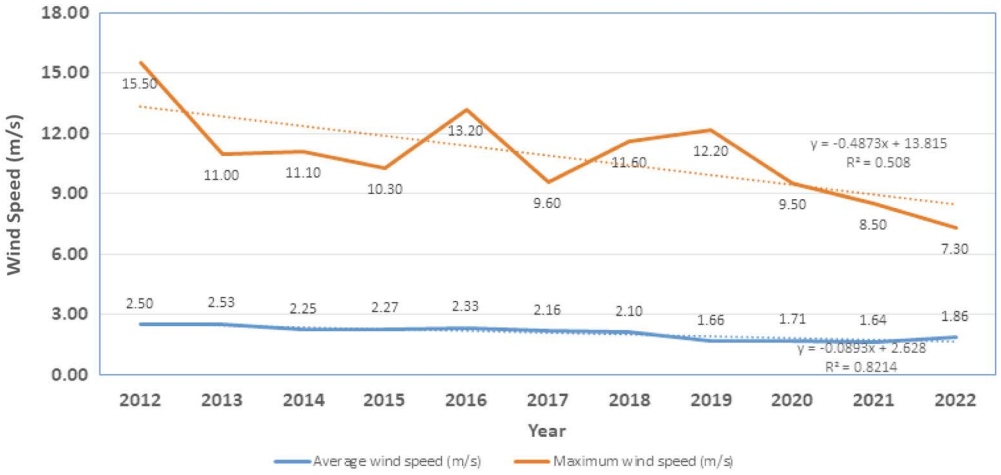

Fig. 5. Status of wind speed variation by year by year.

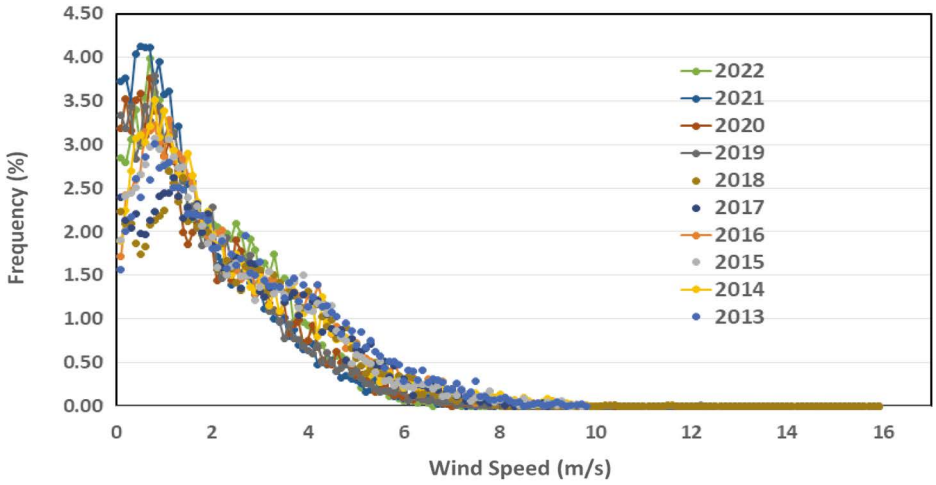

Fig. 6. Current status of wind speed in Yeonggwang region from 2012 to 2022.

monsoon winds.

For the Hanbit Nuclear Power Plant, the locations of the relief stations are mainly to the west and south of the facility, so in terms of the probabilistic effects of an emergency accident, the relief stations are concentrated in a place with relatively little influence from the wind direction.

The location of the radiation disaster monitoring center based on the nuclear power plant is in the southeast. Further analysis of wind direction data measured at future power plants will be made to report regional connectivity.

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