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Original article

Research on The Damage Scale Analysis of a Tactical Nuclear Attack by Wind Direction and Speed

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ABSTRACT North Korea's tactical nuclear attack poses the most dangerous threat to South Korean society. However, the Ministry of National Defense and the government do not predict or prepare adequately for which tactical nuclear attack will occur or what damage scale it will cause if it happens. Additionally, there is a lack of analysis on how wind direction and speed affect the extent of damage caused by a tactical nuclear attack in any given area. This research focused on the damage scale caused by a tactical nuclear attack on a nuclear power plant among national important facilities. Additionally, the average direction and speed of wind for 10 years in the nuclear power plant area were analyzed to determine the extent of their impact. Among the various data sets of the Korea Meteorological Administration, this research utilized wind direction and wind speed data collected from 2015 to 2025. The scope of the research is limited to three nuclear power plants, namely Wolseong, Hanul, and Saeul, among the national important facilities, which are classified as "A" grade in South Korea. The research is also limited to plutonium 10 kt sizes for tactical nuclear attacks in North Korea. The simulation program is NUKEMAP by Alex Wellerstein.

Key words: Tactical nuclear attack, Wind, Nuclear power plant, NUKEMAP

1. Introduction

1.1. The purpose and focus of the research

North Korea's tactical nuclear attack poses the most dangerous threat to South Korean society [1,2]. However, the government and the Ministry of National Defense do not sufficiently predict or prepare enough for the type of tactical nuclear attack that will occur or what damage scale it will cause if it happens. Additionally, there is a lack of analysis on how wind direction and speed affect the extent of damage caused by a tactical nuclear attack in any given area. This research focused on the damage scale caused by a tactical nuclear attack on a nuclear power plant among national important facilities. In addition, the average wind direction and speed for 10 years in the nuclear power plant area were analyzed to determine as to how much more effect they have. Among the various data provided by the Korea Meteorological Administration, in this research, wind direction and speed data were collected from 2015 to 2025. The scope of the research is limited to three nuclear power plants, such as Wolseong, Hanul, and Saeul, which are among national important facilities, "A" grade in South Korea, and is limited to plutonium 10 kt size of the tactical nuclear attack by North Korea. The simulation program is NUKEMAP by Alex Wellerstein.

1.2. The scope of this research

The scope of this research is to thoroughly analyze wind direction and speed in the area of three nuclear power plants, which are national important facilities, "A" grade, for the 10-years period from 2015 to 2025. The various damage scales according to tactical nuclear attacks, such as plutonium 10 kt, were analyzed through simulation.

The research is organized as follows;

Chapter 1 presents an introduction that consists of the purpose, the scope, and the key questions related to the purpose of this research.

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Chapter 2 reviews the related literature.

Chapter 3 presents the wind direction and speed in the area of three nuclear power plants, which are national important facilities, "A" grade, for the 10-year period from 2015 to 2025.

Chapter 4 presents the various damage scales of the attack according to tactical nuclear attacks, such as plutonium, and analyzes them using the wind direction and speed data through simulation.

Chapter 5 presents the conclusion.

2. Reviews of Related Literature

Philseo Kim, Hanna Yasmine, Man-Sung Yim, and Sunil S. Chirayath (2024) analyzed that it is necessary to identify the crucial factors influencing a nation's decision to terminate its peaceful nuclear power programs. Hans M. Kristensen & Matt Korda (2022) analyzed that there is considerable uncertainty about which of North Korea's missiles have been fielded with an active operational nuclear capability. Hans M. Kristensen, Matt Korda, Eliana Johns & Machenzie Knight (2024) analyzed that North Korea may have produced enough fissile material to hypothetically build up to 90 nuclear warheads. Hans M. Kristensen, Matt Korda, Eliana Johns & Machenzie Knight (2024) analyzed that China now possesses roughly 500 nuclear warheads, with more in production to arm future delivery systems. Chung-in Moon and Young-Deok Shin (2023) analyzed the evolving nature of public debates on South Korea's nuclear path, unraveling internal and external forces propelling the quest for independent nuclear armament and analyzing its costs and consequences. Edward Kwon (2022) analyzed the North Korean nuclear crisis from various contending international relations perspectives, analyzing North Korea's WMD. Inseok Yoo (2024) analyzed that North Korea has incentives to arm itself with nuclear weapons for the regime's survival and for various political, diplomatic, and economic goals. Peter Hayes and Scott Bruce (2011) analyzed the policy toward the DPRK as a nuclear-armed state and the status of the nuclear threat in Korea. Aprilia Putri Adiningsih and Ngboawaji Daniel Nte (2022) analyzed that North Korea is modernizing the country by focusing its strength on the planning economy, heavy industry, and military development. Md. Wazihur Rahman, Mohammad Zoynal Abedin, and Md. Saadbin Chowdhury (2023) analyzed that maximizing the efficiency of nuclear power plants is crucial for optimizing energy output and reducing operational costs while ensuring safety and environmental sustainability.

3. The wind direction and speed in the area of three nuclear power plants which are the national important facilities, "A" grade, for the 10-year period from 2015 to 2025

There are a total of five nuclear power plants, which are Hanbit, Gori, Saeul, Wolseong, and Hanul in South Korea, as shown in Table 1. The location is distributed in five places, which are Jeollanamdo, Busan, Ulsan, and Gyeongsangbukdo. The current status of the nuclear power plants is Hanbit 6, Gori 5, Saeul 2, Wolseong 5, and Hanul 7. The facilities' capacity of the nuclear power plants is Hanbit 6,000 MWe, Gori 4,600 MWe, Saeul 2,800 MWe, Wolseong 4,100 MWe, and Hanul 6,400 MWe.

Nuclear power plants in South Korea are classified as national important facilities, such as "A" grade. They are also regarded as a critical facility in terms of national security strategies. The term "national important facilities" means facilities that have a crucial effect on national security if they are destroyed or occupied by enemies, such as airports, ports, public institutions and major industrial facilities. Therefore, it is very important to analyze the wind direction and speed in the area where the nuclear power plant is located and to analyze in which direction the nuclear radiation will expand further in the event of a tactical nuclear attack in the future [3].

Table 1. The nuclear power plant which are the national important facilities, "A" grade

Division	Hanbit	Gori	Saeul	Wolseong	Hanul
Location	Hongnong-eup, Yeonggwang-gun, Jeollanamdo	Jangan-eup, Gijang-gun, Busan	Seosaeng-myeon, Ulju-gun, Ulsan	Yangnam-myeon, Gyeongju-si, Gyeongsangbukdo	Buk-myeon, Uljin-gun, Gyeongsangbukdo
Current Status of Power Plant	6	5	2	5	7
Facility capacity (MWe)	6,000	4,600	2,800	4,100	6,400

Table 2. Wind speed and direction of Wolseong nuclear power plant from 2015 to 2025

WIND SPEED	DIRECTION																
	N	NNE	NE	ENE	E	ESE	SE	SSE	**S**	**SSW**	SW	WSW	W	**WNW**	**NW**	NNW	Total
-0.4	0	0	0	0	0	0	0	0	**0**	**0**	0	0	0	**0**	**0**	0	5.1
0.5-3.3	4.9	3.7	2.8	1.8	1.3	1.7	2.7	5.3	**14.4**	**8.7**	4.2	2.8	2.7	**3.8**	**4.1**	3.3	68.1
3.4-7.9	1.3	2.9	2.1	0.4	0.1	0.2	0.3	0.1	**2.2**	**1.3**	0.8	0.9	1.5	**5.1**	**5.4**	1.5	26.2
8.0-13.8	0	0.1	0	0	0	0	0	0	**0**	**0**	0	0	0.1	**0.2**	**0.1**	0	0.6
13.9-	0	0	0	0	0	0	0	0	**0**	**0**	0	0	0	**0**	**0**	0	0
Total	6.2	6.7	4.9	2.2	1.4	1.9	3	5.5	**16.6**	**10**	4.9	3.8	4.3	**9.1**	**9.6**	4.7	100

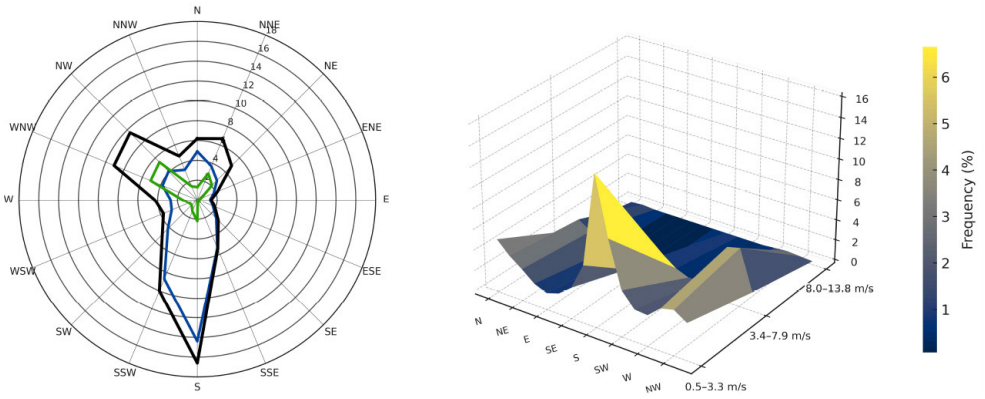

Fig. 1. The analysis of wind speed and direction of Wolseong nuclear power plant from 2015 to 2025

First of all, the direction and speed of wind in the Wolseong nuclear power plant area for 10 years were analyzed. As shown in Table 2, in terms of the average wind direction for 10 years, S was the most, and after that, the wind direction was blown in the order of SSW, WNW, and NW. In terms of the average wind speed for 10 years it is 5.1 m/s, and the wind speed is from 8.0 to 13.8 m/s in NNE, WNW, and NW as shown in Fig. 1. In conclusion, the average direction of wind is South and the average speed is 5.1 m/s, allowing us to analyze the direction of expansion of nuclear radioactive contamination when subjected to tactical nuclear attacks from the nuclear power plants [4].

Second, the direction and speed of wind in the Hanul nuclear power plant area for 10 years were analyzed. As shown in Table 3, in terms of the average wind direction for 10 years, W was the most, and after that, the wind direction was blown in the order of WSW, WNW, and SW. In terms of the average wind speed for 10 years it is 1.5 m/s, and the highest wind speed is from 8.0 to 13.8 m/s in NW and NNW, as shown in Fig. 3. In conclusion, the average direction of wind is West and the average speed is 1.5 m/s, allowing us to analyze the direction of expansion of nuclear radioactive contamination when subjected to tactical nuclear attacks from the nuclear power plants [5].

Table 3. Wind speed and direction of Hanul nuclear power plant from 2015 to 2025

WIND SPEED	DIRECTION																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	**SW**	**WSW**	**W**	**WNW**	NW	NNW	Total
-0.4	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	**0**	0	0	1.5
0.5-3.3	1.6	1.6	1.9	1.7	3.8	2.9	3.5	3.7	3.2	4.3	**8**	**12.5**	**15**	**8.2**	4.5	1.7	78.1
3.4-7.9	0.9	0.4	0.3	0.4	1	0.3	0.6	0.7	0.3	0.8	**1.9**	**3.2**	**1.7**	**2.5**	3.3	1.8	20.1
8.0-13.8	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	**0**	0.1	0.1	0.3
13.9-	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	**0**	0	0	0
Total	2.5	2	2.3	2.2	4.8	3.2	4.1	4.4	3.5	5.1	**9.9**	**15.7**	**16.7**	**10.7**	7.9	3.6	100

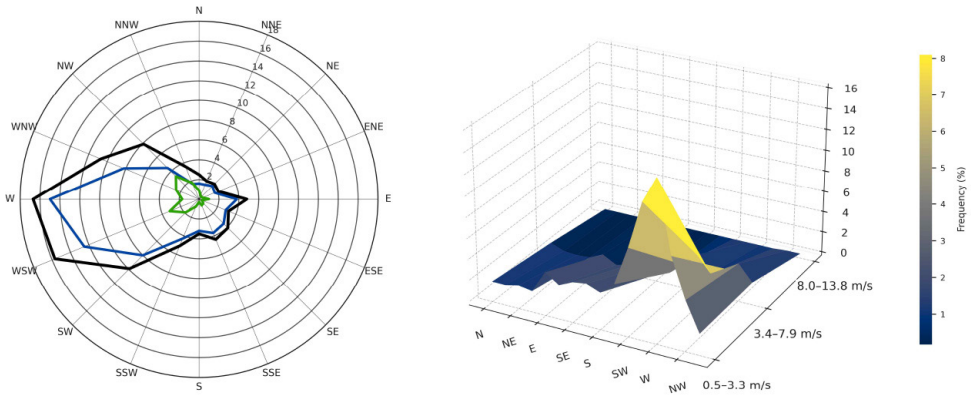

Fig. 2. The analysis of wind speed and direction of Hanul nuclear power plant from 2015 to 2025

Table 4. Wind speed and direction of Saeul nuclear power plant from 2015 to 2025

WIND SPEED	DIRECTION																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	**WNW**	**NW**	**NNW**	Total
-0.4	**0**	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	6.1
0.5-3.3	**8.1**	5.4	4.1	3.3	2.6	2.3	3.5	3.1	2.5	3.4	2.7	2.2	3.5	**6**	**11.2**	**13**	76.8
3.4-7.9	**1.1**	0.8	0.8	1.1	1.1	0.3	0.4	0.3	0.5	2.1	1	0.5	0.6	**2**	**2.3**	**2.1**	17
8.0-13.8	**0**	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	0.1
13.9-	**0**	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**	0
Total	**9.2**	6.2	4.9	4.4	3.7	2.6	3.8	3.4	3	5.5	3.7	2.7	4.1	**8.1**	**13.6**	**15.1**	100

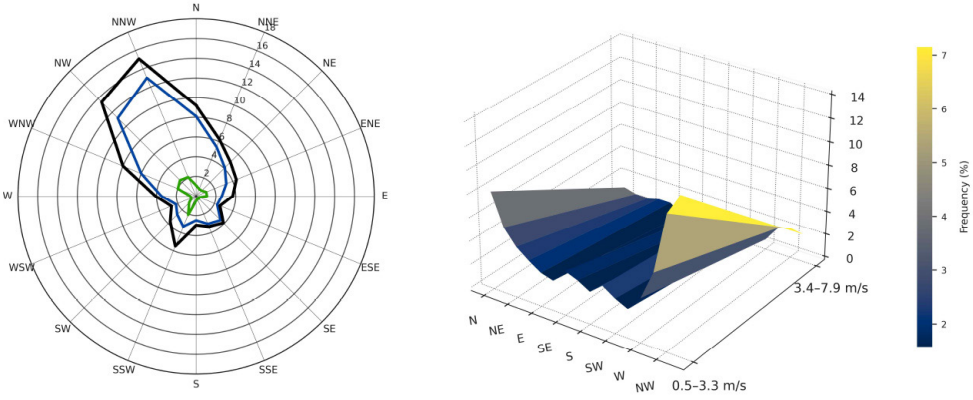

Fig. 3. The analysis of wind speed and direction of Saeul nuclear power plant from 2015 to 2025

Third, the direction and speed of wind in the Saeul nuclear power plant area for 10 years were analyzed. As shown in Table 4, in terms of the average wind direction for 10 years, NNW was the most, and after that, the wind direction was blown in the order of NW, N, and WNW. In terms of the average wind speed for 10 years it is 6.1 m/s, and the wind speed is from 3.4 to 7.9 m/s in NW, NNW, and SSW as shown in Fig. 3. In conclusion, the average direction of wind is NNW and the average speed is 6.1 m/s, allowing us to analyze the direction of expansion of nuclear radioactive contamination when subjected to tactical nuclear attacks from the nuclear power plants [6].

4. The various damage scales of the attack according to tactical nuclear attacks such as plutonium 10 kt, with the wind direction and speed analyzed through simulation

The average direction and speed of wind in the Wolseong

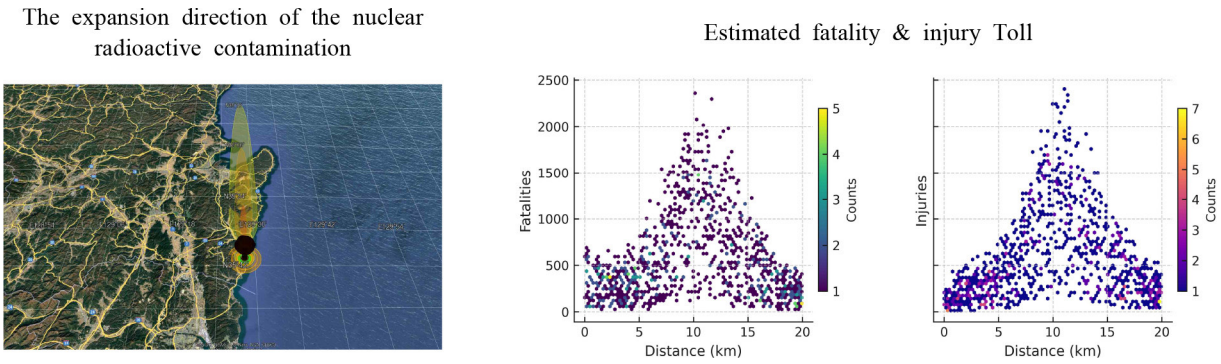

Fig. 4. Nuclear weapon attack on the Wolseong nuclear power plant by plutonium 10 kt

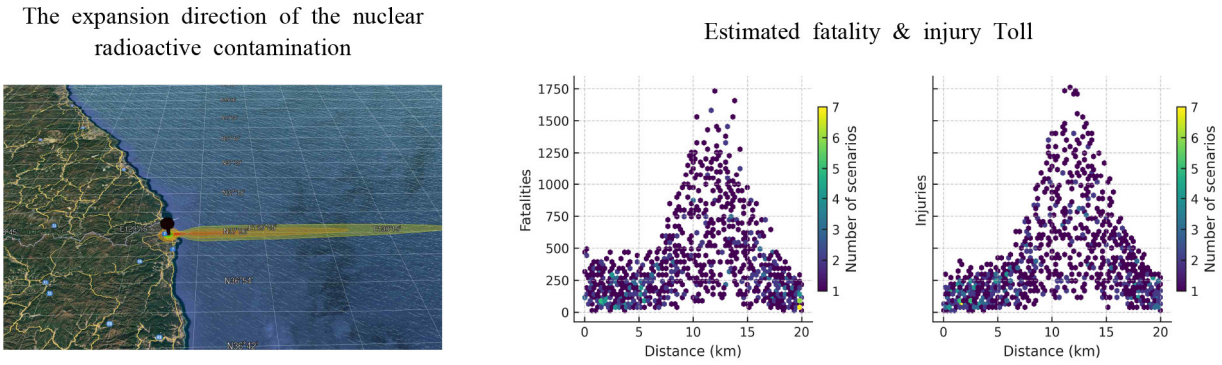

Fig. 5. Nuclear weapon attack on the Hanul nuclear power plant by plutonium 10 kt

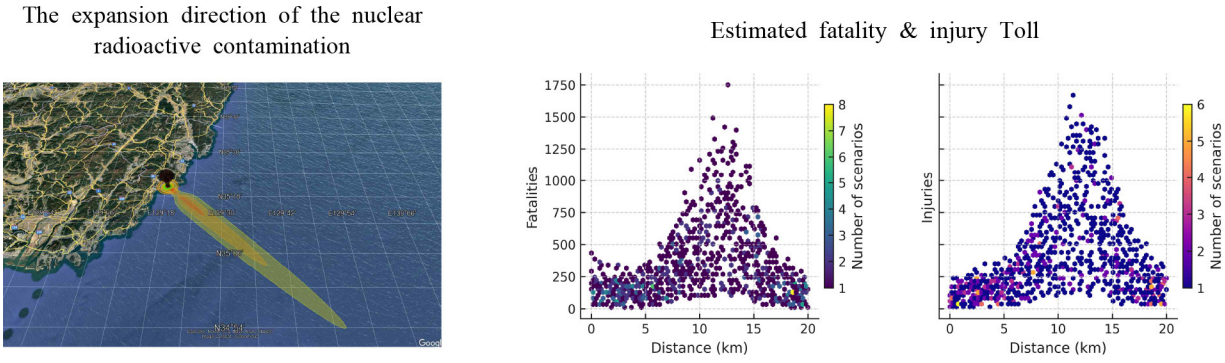

Fig. 6. Nuclear weapon attack on the Saeul nuclear power plant by plutonium 10 kt

nuclear power plant area for 10 years were S and 5.1 m/s. The expansion direction of the nuclear radioactive contamination is the same as shown in Fig. 4. The estimated fatality toll is distributed from 156 to 2,365 after 1,000 repetitions of the test by the nuclear attack, plutonium 10 kt, and distance 10km. The estimated injury toll is distributed from 236 to 2,462, plutonium 10 kt, and a distance of 11km as well [7]. As a result, it continues to increase both the fatality and injury toll until 11km, after that, to decrease them.

The average direction and speed of wind in the Hanul nuclear power plant area for 10 years were W and 1.5 m/s. The expansion direction of the nuclear radioactive contamination is the same as shown in Fig. 5. The estimated fatality toll is distributed from 56 to 1,750 after 1,000 repetitions of the test by the nuclear attack, plutonium 10 kt, and distance 10 km. The estimated injury toll is distributed from 84 to 1,822, plutonium 10 kt, and distance 13 km as well [8]. As a result, it continues to increase both the fatality and injury toll until 13km, after that, to decrease them.

The average direction and speed of wind in the Saeul nuclear power plant area for 10 years were NNW and 6.1 m/s. The expansion direction of the nuclear radioactive contamination

is the same as shown in Fig. 5. The estimated fatality toll is distributed from 112 to 1,750 after 1,000 repetitions of the test by the nuclear attack, plutonium 10 kt, and distance 13 km. The estimated injury toll is distributed from 124 to 1,718, plutonium 10 kt, and a distance of 12 km as well [9]. As a result, it continues to increase both the fatality and injury toll until 12~13 km, after that, to decrease them.

5. Conclusion

North Korea's tactical nuclear attack poses the most dangerous threat to South Korean society. However, the government and the Ministry of National Defense do not predict or prepare enough for which tactical nuclear attack will occur or what damage scale it will cause if it happens. Additionally, there is a lack of analysis on how wind direction and speed affect the extent of damage caused by a tactical nuclear attack in any given area. This research focused on the scale of damage caused by a tactical nuclear attack on a nuclear power plant among national important facilities [10]. In addition, the average direction and speed of wind for the 10-year periods from 2015 to 2025 in the three Wolseong, Hanul, and Saeul nuclear power plant areas were analyzed, as to how much more effect they have. The research is limited to three nuclear power plants, such as Wolseong, Hanul, and Saeul, among national important facilities, “A” grade, and is limited to a plutonium 10 kt size of the tactical nuclear attack by North Korea. The simulation program is NUKEMAP by Alex Wellerstein.

The analysis of results is a simple one of fatalities and injuries in the nuclear power plant, but the expansion direction of the nuclear radioactive contamination by the average wind direction and speed is shown with more significance. Therefore, much more research should be started with this analysis. Implications should be made in various parts, such as a more accurate damage scale, emergency medical system, construction of preparedness facilities, and so on.

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