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THE NORTH KOREAN NUCLEAR DISMANTLEMENT AND THE MANAGEMENT OF ITS NUCLEAR WASTES

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CURRENT STATE, INNOVATIONS & FINDINGS

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KEYWORDS

Denuclearization, nuclear decommissioning, Punggye-ri Test Site, radioactive waste management, Yongbyon Nuclear Scientific Research Center.

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SUMMARY

The scope of this work is related to the nuclear facilities in the DPRK. The objectives of this study are to address key issues and critical paths for dismantling nuclear facilities in the DPRK from the radioactive waste management perspective.

Government entities countries need to consider the technical implications of any forthcoming political agreement and should be interested in the result of this study.

As of now, the DPRK nuclear programme consists of a large WMD infrastructure which represent some kind of dangers on a internal scale (the DPRK) and external (countries bordering with the DPRK).

INTRODUCTION

One critical aspect of any denuclearization of the DPRK involves dismantlement of its nuclear facilities and management of their associated radioactive wastes. Such issues were already discussed in 2005 by two scholars: Professor Whang Jooho (Kyung-Hee University Seoul, Republic of Korea) and Dr. George T. Baldwin affiliated to the Sandia National Laboratories (Albuquerque, USA). This report will update and complete information gathered and analyzed by the two previously mentioned scholars.

In spite of the multiple declarations of the North Korean Foreign Minister Ri Yong-ho notifying the Chinese authorities that Pyongyang's

commitment to denuclearization remains unchanged1, the confidence on the North Korean government is still very low. For instance, starting from 2017 the North Korean authorities expanded several major missile bases such as the Sino Village Missile Operating Base (Sino Village, Onjon County, North Pyongyan Province), or the Sakkanmol missile base (Hwangju county, North Hwanghae Province)2.
The purposes of this article are triple. First provide a historical approach concerning the development of Nuclear weapons. Secondly, discuss North Korean nuclear waste, and finally discussing why the North Korean government will not stop over its nuclear program.

1. GLOBAL HISTORICAL FACTS

According to the CTBTO, Nuclear weapons tests were done - some successful, others not - in all environments since 1945: in the atmosphere, underground and underwater. Tests have been carried on different fields such as out onboard barges, on top of towers, suspended from balloons, on the Earth's surface, more than 600 meters underwater and over 200 metres underground. Nuclear test bombs have also been dropped by aircraft and fired by rockets up to 320 km into the atmosphere. We may categorize nuclear tests in four categories: atmospheric test; underground test; underwater test, and upper atmospheric test3.

From a chronological perspective, the first nuclear test was carried out by the United States in July 1945, followed by the Soviet Union in 1949, the United Kingdom in 1952, France in 1960, and China in 1964. The National Resources Defense Council estimated the total yield of all nuclear tests conducted between 1945 and 1980 at 510 megatons (Mt). Atmospheric tests alone accounted for 428 mt, equivalent to 83% of all nuclear tests or to over 29,000 Hiroshima size bombs4.

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1 *N. Korean minister reaffirms denuclearization commitment in Beijing talks*, Yonhap News Agency, 7 December 2018.

2 *US think tank CSIS report cites another "undeclared" missile base ahead of 2nd NK-US summit*, Hankyoreh, http://english.hani.co.kr/arti/english_edition/e_northkorea/879552.html?fbclid=IwAR2j_GboV-tC00ihk1FXLwlMQZ1bxGnzGEfCsLWgDcU5AeJYOsJ_n_cQGWg (accessed: 11 February 2019).

3 *General Overview of the Effects of Nuclear Testing*, https://www.ctbto.org/nuclear-testing/the-effects-of-nuclear-testing/general-overview-of-theeffects-of-nuclear-testing. CTBTO (undated), (accessed: 11 December 2018).

4 *General Overview of the Effects of Nuclear Testing*, https://www.ctbto.org/nuclear-testing/the-effects-of-nuclear-testing/general-overview-of-theeffects-of-nuclear-testing. CTBTO (undated), (accessed: 11 December 2018).

The amount of radioactivity generated by a nuclear explosion can vary considerably depending upon a number of factors. These include the size of the weapon and the location of the burst. An explosion at ground level may be expected to generate more dust4 and other radioactive particulate matters than an air burst. The dispersion of radioactive material is also dependent upon weather conditions5. Radioactive dust could escape through holes or cracks in the mountain, where the nuclear activity was generated. Any cracks may appear with the last tests of 2017, as until 2017, the mountain's surface had shown no visible damage after four underground nuclear tests before 2016.

2. KEY HISTORICAL FACTS CONCERNING THE DPRK'S NUCLEAR PROGRAMME

Two development phases are to be distinguished in the DPRK´s nuclear programme history6. The first started at the end of the fifties and was set up with Soviet assistance.

- In march 1953, DPRK authorities signed a Peaceful Utilization Agreement with the Soviet Union.
- In 1956, some DPRK scholars were sent to the Soviet Union where they trained at the Joint Institute for Nuclear Research of the city of Dubna (Moscow region).
- In 1962, the Yongbyon Nuclear Scientific Research Center started to be erected. In June 1963, the 2 MW(e) small-scale research reactor IRT-2000 was introduced by the Soviet Union.

The second phase started in 1974 with the expansion of the previous reactor to 5 MW(e) natural uranium, graphite moderated reactor in Yongbyon. In the same period an ore processing plant and a fuel rod fabrication plant were built.

- On 12 December 1985 the DPRK became a party to the NPT. On 10 April 1992 the NPT Safeguards Agreement entered into force (INFCIRC/403). Before that, in 1977, the country had concluded an INFCIRC/66 type Safeguards Agreement (INFCIRC/252) for two nuclear research facilities (the IRT research reactor and a critical assembly).

5 *General Overview of the Effects of Nuclear Testing*, https://www.ctbto.org/nuclear-testing/the-effects-of-nuclear-testing/general-overview-of-theeffects-of-nuclear-testing. CTBTO (undated), (accessed: 11 December 2018).

6 A table summarizing DPRK's nuclear testing trials is provided at the end of the chronology.

The management of nuclear waste can be done through different channels. The first one is the trade of nuclear waste. The second one is called decommissioning.

- In 1986, the 5 MW(e) reactor became operational.
- In 1987 started the construction of the first of two larger gas-graphite reactors and the construction of a Radiochemical Laboratory with a sizeable reprocessing capacity started. The initial reactor was expanded to 8 MW(e).
- After the DPRK had submitted its initial report to the IAEA under its Safeguards Agreement in May 1992, inspections began. Shortly thereafter inconsistencies emerged between the DPRK's initial declaration and the Agency´s findings, centring on a mismatch between declared plutonium product and nuclear waste solutions and the results of the Agency´s analysis. The latter suggested that there existed in the DPRK undeclared plutonium.
- DPRK Nuclear wastes sites were denied access to IAEA officials in February 1993.
- In 1994 the IAEA was permitted by the DPRK to conduct safeguards activities with a limited scope only.
- On 13 June 1994, the DPRK, which had been an IAEA Member State since 1974, withdrew from its membership in the Agency. Although the withdrawal did not affect the DPRK obligations under its Safeguards Agreement, which in the Agency´s view remains binding and in force, the DPRK took the position that it was in a special position with regard to the Safeguards Agreement and that it was no longer obliged to allow the inspectors to carry out their work under the Safeguards Agreement.
- In June 1994, President Jimmy Carter met with North Korean President Kim Il Sung in June, initiating the negotiations that produced the U.S.-North Korea Agreed Framework on nuclear safeguards in August 1994. Unfortunately, Kim Il Sung passed away in July 1994 and the agreement was cancelled in 2002.
- On the 11 January 2003, North Korea announced its withdrawal from the NPT.
- In April 2009, the DPRK authorities stated that it would build an LWR.

- In June 2007, a visit of an IAEA delegation to the DPRK took place for talks on verification and monitoring the shutdown of the Yongbyon Nuclear Scientific Research Center.
- In 2010, some Americans were allowed to visit North Korea's new LWR.
- On 2 April 2013, the General Department of Atomic Energy of the DPRK (조선 민주주의 인민 공화국 원자력 총국) announced that the DPRK would take measures for "readjusting and restarting all the nuclear facilities in Yongbyon.
- As of June 2013, major external work on the LWR appeared to have been completed.
- Since the DPRK has continued to stress the importance of its nuclear weapons programme.

Table 1. North Korea's nuclear testing series summary[7]

Date time	Location	Elevation; depth	Delivery	Yield
9 Oct. 2006	Punggye-ri Test Site	1,340 m; 310 m	underground	0.7 - 2 kt
25 May 2009	Punggye-ri Test Site	1,340 m; 490 m	underground	2 - 5.4 kt
12 Feb. 2013	Punggye-ri Test Site	1,340 m; 1000 m	underground	6 - 16 kt
6 Jan. 2016	Punggye-ri Test Site	1,340 m; 1000 m	underground	7 - 16.5 kt
9 Sept. 2016	Punggye-ri Test Site	1,340 m; 1,000 m	underground	15 - 25 kt
3 Sept.2017	Punggye-ri Test Site	1,340 m; 0 m	underground	70 - 280 kt

Table 2. Status of Nuclear Facilities in the DPRK

Geographical Name	Name in Korean	Enriched Uranium Facility	Uranium Mine	Nuclear Water Reactor	Nuclear Waste Deposit	Nuclear Test Zone	Radiation Chemistry Laboratory	Province	Remarks
Wiwon	위원	-	X	-	-	-	-	Jaggang	-
Haegeumgang	해금강	-	X	-	-	-	-	Kangwon	-
Punggye-ri Nuclear Test Site	풍계리 핵 실험장	-	-	-	-	X	-	North Hamgyong	Demolished and ready for inspection purposes

7 *List of nuclear weapons tests of North Korea,* https://en.wikipedia.org/wiki/List_of_nuclear_weapons_tests_of_North_Korea, (accessed: 31.10.2018)

Geographical Name	Name in Korean	Enriched Uranium Facility	Uranium Mine	Nuclear Water Reactor	Nuclear Waste Deposit	Nuclear Test Zone	Radiation Chemistry Laboratory	Province	Remarks
Musan	무산	-	X	-	-	-	-	North Hamgyong	One of the largest iron ore reserves in the DPRK
Cheonmasan	천마산	X	X	-	-	-	-	North Pyongan	No one reportedly lives within 10km of the facility
Daechon	태천	-	-	-	X	-	-	North Pyongan	-
Jeolsan	절산	-	X	-	-	-	-	North Pyongan	-
Keumchangli	금창리	X	-	-	-	-	-	North Pyongan	-
Pyongsan	평산	-	X	-	-	-	-	North Pyongan	-
Yongbyon Nuclear Facility	영변핵시설	X	-	X	X	X	X	North Pyongan	-
Yeongdeog-dong	영덕동	-	-	-	-	X	-	North Pyongan	-
Pakcheon	박전	X	X	-	-	-	-	South Pyongan	-
Suncheon	순전	-	X	-	-	-	-	South Pyongan	-
Hyesan	혜산	-	X	-	-	-	-	Ryang-gang	-
Yongjeoli	영저리	X	-	-	-	-	-	Ryang-gang	-
Keumchon	금천	-	X	-	-	-	-	South Hwangae	-
Pyongsong	편성	-	X	-	-	-	-	South Hwangae	ICBM assembly facility dismantled in July 2018
Hungnam	홍남	-	X	-	-		-	South Hamgyong	-
Najin	라진	-	X	-	-	-	-	Special City of Rason	DPRK's oldest mine
Pyongyang	편양	-	-	X	-	-	-	Special City of Pyongyang	-

Source: Yonhap News Agency

Table 3. List of Education centers linked to DPRK's nuclear program[8]

Name	Name in Korean	Type	Localization - city	Localization - province
Korea National Defense University	고려국방대	University	Hyesan	Ryanggang
Pyongsong University of Science	평성과학대	University& Research Center	Pyongsong	South Pyongan
Kim Chaek University of Technology	김책공업종합대학	University	Pyongyang	Special City of Pyongyang
Kim Il Sung University	김일성종합대학	University	Pyongyang	Special City of Pyongyang
Korea International Chemical Joint Venture Co	고려 국제 화학 조인트 벤쳐	Research Center	Pyongyang	Special City of Pyongyang
Yongbyon Nuclear Research Center	영변원자력연구센터	Research center	Yongbyon	North Pyongan

3. LIST OF RADIOACTIVE MATERIALS

Due to historic activities typically related to radium industry, uranium mining, and military programs, numerous sites contain or are contaminated with radioactivity. Radioactive dangers come from the following elements: Pu-2399 is the primary fissile material used in nuclear bombs, plus some material with much higher specific activities, such as Cesium, Iodine, and Plutonium. has been released into the atmosphere, soil and water. The impacts of such isotopes depend on their uptake in the environment and in the human body, the type of radiation emitted, the quantity of isotopes, and their half-life and degree of radioactivity.

8 8 [그래픽] 북한 주요 핵시설 현황, Graep'ik: Pukhan chuyo haeksisŏl hyŏnhwang, https://m.yna.co.kr/view/GYH20180503002800044, 3 May 2018, „Yonhap News Agency" . (accessed: 12 December 2018).

9 Pu-239 is the main isotope of the Plutonium.

Table 4. Nuclear Isotopes

Full name of the chemical element	Main isotope of the chemical element	Isotope symbol	Half life (rounded values)
Americium	Am-241	^{241}Am	432 years
Carbon	C-14	^{14}C	40 years
Cesium	Cs-137	^{137}Cs	30 years
Iodine	I-131	^{131}I	8 days
Polonium	Po-210	^{210}Po	138 days
Plutonium	Pu-238	^{238}Pu	88 years
Plutonium	Pu-239	^{239}Pu	24 years
Plutonium	Pu-240	^{240}Pu	6500 years
Strontium	Sr-90	^{90}Sr	29 years
Xenon	Xe-131	^{131}Xe	12 days
Xenon	Xe-133	^{133}Xe	5 days

Source: own research

These radioactive isotopes are released during nuclear tests, and led a major impact on the environment and irradiation of the human body; these isotopes were predominantly found in most of the nuclear test sites worldwide. Such verifications couldn't be verified on the territory of the DPRK. Since approximately two thirds of the Globe's surface is covered by water, a significant share of these radionuclides has been transferred into the marine environment, as in the cases of radionuclides 137Cs and 90Sr, with negative consequences being primarily related to the bioaccumulation through food chain cycles10. We can deduce that some DPRK seafood was contamined by the DPRK nuclear tests. The Punggye-ri Nuclear Test Site is localized 50 kms from the Sea of Japan. For safety reasons, there should be an exclusion zones of 30-50 km around the former destroyed Nuclear Test Site.

10 *Prăvălie, R. (2014). Nuclear weapons tests and environmental consequences: a global perspective. Ambio,* 43(6), p. 745.

Table 5. Risks associated to isotopes

Main isotope of the chemical element	Emitted particles	Emitted rays	Main associated risks
Am-241	Alpha	Gamma	Health risks when inhaled or ingested
Cs-137	Beta	Gamma	Higher incidence rate of cancer; Skin burns; Penetration of the body by gamma emissions
I-131	Beta	Gamma	Higher incidence rate of thyroid cancer, skin burns; Penetration of the body by gamma emissions
Pu-239	Alpha	Gamma	Lung cancer

Source: own research

In the case of the DPRK, there are some quantities of contaminated soil and water over a distance of 100 kilometers within the Punggye-ri Nuclear Test Site. According to some sources, About 80 per cent of trees that are planted die at the area of the Punggye-ri Nuclear Test Site11. I would underestimate these defectors' assessments unless they had some technical skills to provide such assumptions. However, these assumptions can be verified through testimonials of North Korean nuclear scientist who defected recently from North Korea. The management of DPRK nuclear waste can be also discussed with DPRK scientists who defected during the Weasel operation such as Kyong Won-ha12, a junior nuclear scientist, who defected during this operation and worked later at the Los Alamos Nuclear Research Center in the USA13. Another important testimony may come from senior KPA officials who defected either to South Korea or to the USA.

11 *North Korea's nuclear test site is 'a wasteland with deformed babies'*, „The Telegraph", 7 November 2017.

12 Kyong Won-ha was for a while inappropriately considered as the father of the DPRK nuclear programme.

13경원하, 북미에서 활동한 세계적 핵공학자, „Hankyoreh Ilbo", 20 April 2003. http://legacy.www.hani.co.kr/section-009010000/2003/04/009010000200304202210775.html. (accessed: 1 January 2019). Giorgio Comerio denied later his implication with any DPRK issues.

4. DPRK NUCLEAR WASTE

This report aims also to analyze consequences of latest nuclear weapons tests conducted by North Korea, highlighting the impact of radioactive pollution on the atmospheric, aquatic, and underground environments. Special attention was given to the concentration of main radioactive isotopes which were released, such as 241Am, 14C, 137Cs, 131I, 210Po, 238Pu, 239Pu, 240Pu, and 90Sr, generally stored in the atmosphere and marine environment. The quantity of nuclear waste emitted after each nuclear test is difficult to be estimated.

Nuclear wastes are a subject of cooperation between the DPRK and Taiwan. In the late 90's one Italian businessman named Giorgio Comerio14 was accused having organized the dumping in 1995 of 200 000 barrels of DPRK nuclear waste into the sea near Taiwan15. In the past, Giorgio Comerio tried to export DPRK nuclear wastes to African countries and more precisely to water exclusive zone through his company Oceanic Disposal Management.

In 1996 the DPRK authorities signed a deal with Taiwan to dispose of its nuclear waste from atomic power plants. South Korean authorities and Taiwanese public organizations reacted furiously to the deal and Taiwan was eventually forced to back down and cancel the agreement16. A similar agreement was supposed to be signed in 200117. Taiwan nuclear wastes were supposed to be send to closed DPRK coal mines18. The close relation between the DPRK and Taiwan is due to the fact that Taiwan is not a member of the United Nations. Therefore, fields of cooperation are wider and applied sanctions toward the DPRK does not apply to their bilateral relations until September 2017. Starting from September 2017 Taiwan has banned all trade activities with North Korea to comply with the United Nations Security Council Resolution 2375 adopted on the 11 September 2017.

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14 In the past, Giorgio Comerio tried to export DPRK nuclear wastes to African countries and more precisely to sub seaded of exclusive zone through his company Oceanic Disposal Management.

15 Helmut Sorge, *Running the Risk of Turning the Planet into a Garbage Dump*, 9 August 2018, „Policy Center for the New South".

16 Sheryl Wudunn, *North Korea Agrees to Take Taiwan Atom Waste for Cash*, „New York Times", 7 February 1997; Michael Rank, *North Korea in bid to recycle toxic waste*, „The Telegraph", 30 June 2008; Jeong Yeon-kuk, 대만의 핵 폐기물 북한 반입 반대운동 확산[정연국], „MBC News", 5 February 1997.

17 *Taiwan renews efforts to ship nuclear waste to N. Korea,* 14 February 2001, „KBS World Radio".

18대만, 북한과 무역 전면 중단…"핵폐기물 처리협약도 무효""(종합), „Yonhap News Agency", 26 September 2017.

There is a risk of Nuclear exposure after North Korean nuclear tests. As of now o far there are no abnormal increase of radioactivity levels. Nevertheless, it's requested to continue to monitor the surrounding region with a large amount of highly sensitive equipment and analyse the data in state-of-the-art laboratories." For this purpose, the North Korean government shall allow scientists to evaluate and secure the site. Another site to be inspected is the Yongbyon Nuclear Scientific Research Center, which is still functioning in North Korea, but it didn't participated to the last nuclear tests. The Yongbyon area is considered as a sensitive one. The IAEA inspectors were refused permission to inspect two sites at the Yongbyon facility that inspectors had visited briefly in September 1992 and that were believed, reportedly on the basis of satellite photos provided by U.S. intelligence, to contain reprocessing waste not declared by the DPRK. The DPRK denied that the sites contained nuclear waste and refused to permit inspection of the facilities on the grounds that they were military sites not related to the nuclear program19. Furthermore, IAEA inspectors noticed that the Spent fuel is processed in batch mode in two process lines of the main reprocessing facility of the Yongbyon Nuclear Scientific Research Center did not contain any nuclear waste reduction facility20. This latest issue is related to the nuclear decommissioning which is the process whereby a nuclear facility is dismantled to the point that it no longer requires measures for radiation protection. Finally in 1999, US authorities made a concession, and financed the management of hundreds of DPRK nuclear waste through the company NAC International21. Further DPRK nuclear waste (8.000 spent fuel elements) were hypothetically managed by DPRK authorities in the first half-year of 2003.

Unfortunately, according to Satellite images as of 2017 North Korea has failed to dispose safely of nuclear waste22. Evidence suggests that North Korea stores its high-level nuclear waste (HLW) in liquid form in tanks on the same site where it is made, and has not invested in infrastructure to reduce, denitrify, or vitrify this waste. Evidence suggests

19 Leventhal, P., Dolley, S., (1994). *The North Korean Nuclear Crisis*. Nuclear Control Institute, 16 June.p. 166.

20 Jooho, W., & Baldwin, G. T. (2005). *Dismantlement and radioactive waste management of DPRK nuclear facilities.* Cooperative Monitoring Center Occasional Paper Series. Sandia National Laboratories. April, p. 13.

21북한 핵폐기물처리, 미국 회사가 맡아, „Radio Free Asia", 30 November 1999.

22 *The first casualty of North Korean nuclear tests?,* „Los Angeles Times", 6 October 2017.

that North Korea stores its HLW in liquid form in tanks on the same site where it is made, and has not invested in infrastructure to reduce, denitrify, or vitrify this waste. No information is available concerning the decommisionning process of the Punggye-ri Test Site.

5. TECHNICAL RISKS ASSOCIATED TO DPRK NUCLEAR TESTS

According to Remus Prăvălie, a researcher at the Faculty of Geography of the University of Bucharest, DPRK nuclear tests are responsible for the current environmental contamination with radioactive waste which resulted in ecologically and socially destroyed sites, due to high levels of radioactivity23.

The danger presented by a radioactive substance is often rated through an indicator called "potential radioactive toxicity" or radiotoxicity. This radiotoxicity concerns internal expositions, external expositions. Internal expositions is associated to the work realized through nuclear facilities of the DPRK. External expositions are related to geographical zones where nuclear tests were realized. Their radiotoxicity is emitted through the emission of short range alpha particles24.

Risks associated to the considered DPRK population are hard to be quantified as the ingestion or inhalation of a radioactive element results in a so-called committed dose, because its effects are oncoming and would be spread over long periods of time, may be up to our whole lifetime. One must take into account how radioactive materials are eliminated, how they are fixed by our body, the type of radiation and the radioactive decay half-life.

Some kind of risks are also associated to the Chinese geographical side. For instance, there is an increasing the risk of eruption of the Changbai Mountain (长白山,백두산)," a large, active volcano at China-Korean border.

23 Prăvălie, R. (2014). *Nuclear weapons tests and environmental consequences: a global perspective. Ambio,* 43(6), p. 735.

24 Prăvălie, R. (2014). *Nuclear weapons tests and environmental consequences: a global perspective. Ambio,* 43(6), p. 735.

FINDINGS

Findings can be summarized as follow:

- As of February 2019, the DPRK has neither abandoned its existing nuclear programme according to CVID procedures, nor ceased all related activities. As of September 2018, activities were observed near the Kuryong River25 close to the Yongbyon Nuclear Scientific Research Center.
- It must be underlined that the dismantlement of the Yongbyon Nuclear Scientific Research Center would still leave the DPRK with a nuclear weapons stockpile and the technical ability to produce weapons based on the production of HEU elsewhere. But it would definitely means that the DPRK won't be able to produce plutonium and HEU.
- As of March 2018, it has been determined that the reactor of the Yongbyon Nuclear Scientific Research Center is operating again, as the evidence suggests, it means North Korea has resumed production of plutonium presumably for its nuclear weapons program and therefore, resumed the production of nuclear waste26.
- As of December 2018, DPRK authorities presented no goal of cleaning all presently contaminated sites successfully by 2025. Geomelting technology may be used. A first step is the closure of the nuclear sites. Next step is cleaning, through for instance geomelting technology27.
- The whole process is a consuming-time issue. In comparison, the verification of South Africa's dismantlement by the IAEA was complicated by lack of knowledge of the nuclear weapons program infrastructure, and took approximately two years28. When the US authorities proceeded to the dismantlement of some of their plutonium recovery facilities, the whole proces required years of work and hundreds of millions of dollars.

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25 The Kuryong river is the main source of water for reactor cooling systems of the Yongbyon Nuclear Scientific Research Center.

26 Pabian F., Bermudez Jr., Liu Jack, *North Korea's Yongbyon Nuclear Complex: 5 MWe Reactor is Likely Operating, New Military Encampment Established,* „38 North", 5 March 2018.

27 *General Overview of the Effects of Nuclear Testing*, https://www.ctbto.org/nuclear-testing/the-effects-of-nuclear-testing/general-overview-of-theeffects-of-nuclear-testing. CTBTO (undated), (accessed: 11 December 2018).

28 Jooho, W., & Baldwin, G. T. (2005). *Dismantlement and radioactive waste management of DPRK nuclear facilities.* Cooperative Monitoring Center Occasional Paper Series. Sandia National Laboratories. April, p. 4.

- The states' responsibilities of the DPRK for ensuring the safety and security of their populations in the event of a nuclear test or explosion is fundamental. Furthermore, a radioactive waste treatment facility would cost hundreds of milion of dollars29.
- In a two- and-a-half-year period from 1959, over 61,000 teeth were not only collected but also analysed in the US to assess the accumulation of strontium-90 in children30. A such research may be applied through collection of teeths of people who defected to South Korea. Interestingly, the Hanawon Center has a fully equipped stomatology treatment room. Another element would help researchers. A collection of samples of soil, water or leaves coming from the region of Punggye-ri can be analyzed in order to check their radioactivity degree. These soil samples can be collected by tourists or any foreigners travelling to the DPRK for private or business purposes. Then the main issue is the ability of DPRK customs to check foreigners ownings when leaving the DPRK.
- More conferences on the humanitarian impacts of nuclear weapons shall be held in order to increase the society conscious. In March 2013, Norway hosted the first international conference on the humanitarian impacts of nuclear weapons. Two followed in Nayarit (Mexico), and Vienna.
- Inspections in the DPRK shall be done by CBCTO, the IAEA or representatives from the P-5 nuclear weapon. Zhao Guodong, a government nuclear waste confinement specialist at the University of South China, said the North Korean government should allow scientists from China and other countries to enter the test site and evaluate the damage31. Unfortunately as of now, there are no IAEA safeguards nuclear facilitiesfollowing the DPRK decision to cease all cooperation with the IAEA in April 200932. In June 2018, the The IAEA management infor-

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29 Chesser R., Wit J., Pitz S., *A How-To Guide for Disabling and Dismantling Yongbyon, „38North"*, https://www.38north.org/2019/02/rchesserjwitspitz021519/ (accessed 18.02.2019).

30 Unal, B., Lewis, P., Aghlani S., *The Humanitarian Impacts of Nuclear Testing: Regional Responses and Mitigation Measures,* Chatam House, 2017, p. 8.

31 *Stephen Chen, Chinese scientists say North Korea's nuclear test site has collapsed – and could pose a radioactive risk,* South China Morning Post, 25 April 2018, https://www.businessinsider.com/n-koreas-nuclear-site-may-have-collapsed-poses-radioactive-risk-2018-4?IR=T, (accessed: 01.02.2019)

32 *Fact Sheet on DPRK Nuclear Safeguards,* https://www.iaea.org/newscenter/focus/dprk/fact-sheet-on-dprk-nuclear-safeguards, (accessed: 01.02.2019)

med about its willingness to resume nuclear verification activities in North Korea33 if political agreement makes this possible

- Chinese autorities are also monitoring the DPRK nuclear situation through a technical cooperation which is barely mentioned in media. For instance, Lee Doh-sik, the director of the Geological Research Institute at the State Academy of Sciences and formally top North Korean geologist, visited the Institute of Earth Science at the Chinese Academy of Sciences in Beijing, two weeks after the 2017.
  In 2002 IAEA directions proposed to invite a DPRK nuclear team to Vienna. The proposal was officialy refused. As of 2019, IEAE specialists monitor the development of the DPRK nuclear programme mainly through satellite imagery34.
- The majority of DPRK nuclear facilities are localized in the North Pyongan Province.

33 Dixit, A., *IAEA Ready to Play Essential Verification Role in North Korea, Director General Tells Board of Governors,* https://www.iaea.org/newscenter/news/iaea-ready-to-play-essential-verification-role-in-north-korea-director-general-tells-board-of-governors, (accessed: 31.10.2018)

34 Types of activities monitored through satellite images: movements of cooling water at nuclear facilities, milling&mining activities, movement of vehicles, renovation of buildings.

ABOUT THE AUTHOR

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LIST OF ACRONYMS

CTBTO - Comprehensive Nuclear Test Ban Treaty Organization
CVID - Complete, Verifiable & Irreversible Dismantlement
DPRK - Democratic People's Republic of Korea
HEU - Highly Enriched Uranium
HLW - High-Level Nuclear Waste
IAEA - International Atomic Energy Agency
ICBM - Intercontinental Ballistic Missile
KPA - Korean People's Army
LWR - Light Water Reactor
NPT - Non-Proliferation of Nuclear Weapons Treaty
USA - United States of America

LIST OF TABLES

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