Dose Prediction for surface nuclear explosions
Case studies for Semipalatinsk and Lop Nur tests

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Abstract. Dose prediction method RAPS after surface nuclear explosion has been developed by using the empirical dose function of USA nuclear test. This method which provides us external total dose, dose rate at any distant, at any time for any yield of nuclear explosion, is useful for radiation protection incase of nuclear events such as terrorism and nuclear war. The validity of RAPS has been confirmed by application to historical surface nuclear test explosions. The first test case study which was done for the first test explosion of the former USSR at the Semipalatinsk Nuclear Test Site on August 29th 1949, shows a good agreement with luminescence dosimetries on a brick. This dose prediction method was applied nuclear tests in Lop Nur. The results indicate dangerous nuclear radiation influences including fatal risk in the wide Uygur area.

KEYWORDS: Dose prediction; Nuclear Explosion; Semipalatinsk; Lop Nur

1. Radioactive fallout disaster after surface nuclear explosion tests

Conspicuous radiation disaster after a nuclear test was noticed by Japanese in 1954 [1]. The biggest thermonuclear explosion with output of TNT 15 megaton(Mt) equibalent was cariied out at Bikini at 6:45 on March 1st, 1954. A Japanese fishing boat 5th Fukuryumaru (Fortune Doragon) was exposed to radiactive fallout at 150km far from the ground zero. It was a surface nuclear explosion. However science such a nucler disaster was unclear in those days, since nuclear explosions were in air for Hiroshima and Nagasaki in 1945.

The Semipalatinsk Nuclear Test Site in Kazakhstan has been opened for foreign scientists in order to investigate the radiation hazard since 1991 the independent of country after the decay of Soviet Union. Serious radiation disasters become clear through international studies [1]. The occurrence rate of cancer has been increased since 1960. The biggest nuclear blast in Semipalatinsk was 400 kilotons. There was no explosion with megaton yield in inland of the USSR and the USA. Both militaries should know such unacceptable risky tests in populated areas.

China conducted twenty one atmospheric nuclear tests including the most dangerous surface nuclear blasts till 1980 at the Lop Nur Test Site. Several surface or near surface nuclear explosions with megaton order yield should affect on populations seriously in Uygur area [2, 3]. The maximum nuclear yield in the Lop Nur Site was 4Mt which was ten times larger than one in the Semipalatinsk Site.

Table 1. Nuclear Weapon Tests on Silk Road

Operation	Test Site	Test Priode	Affected Country	Total Nuclear Tests		Surface Explosions	
				Num.	Megaton	Num.	Megaton
USSR	Semipalatinsk	1949-1989	Kazakstan	459	18	26	0.6
China	Lop Nur	1964-1996	Uygur	44	22	10	8.9

2. Dose prediction for radioactive fallout in a downwind side area by RAPS

A method of dose prediction, called RAPS (radiation protection computing system), for a surface nuclear explosion has been developed based on the approach of Glasstone and Dolan [4]. It was first applied in a case study of a potential terrorist event of involving a 1 kt explosion in Tokyo [5]. The RAPS computer programme calculates the radiation dose for any time period at any distance from the ground zero for any output of surface nuclear explosions and for any value of effective wind velocity.

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The dose calculation under actual conditions of surface nuclear explosion is made by making adjustments to take account of actual output, distance, time and radioactive decay. It is possible to calculate for the thermonuclear bomb using fusion reaction by RAPS. A part of fission yield in this type of bomb is approximately fifty percent according to an USA report [4].

The first calculation by RAPS was applied for consideration of radiation protection for a terrorist operation situation in Tokyo by a portable nuclear weapon. The second application of RAPS was a dose prediction in case of an accidental underground explosion for the first North Korean nuclear test in 2006 [6].

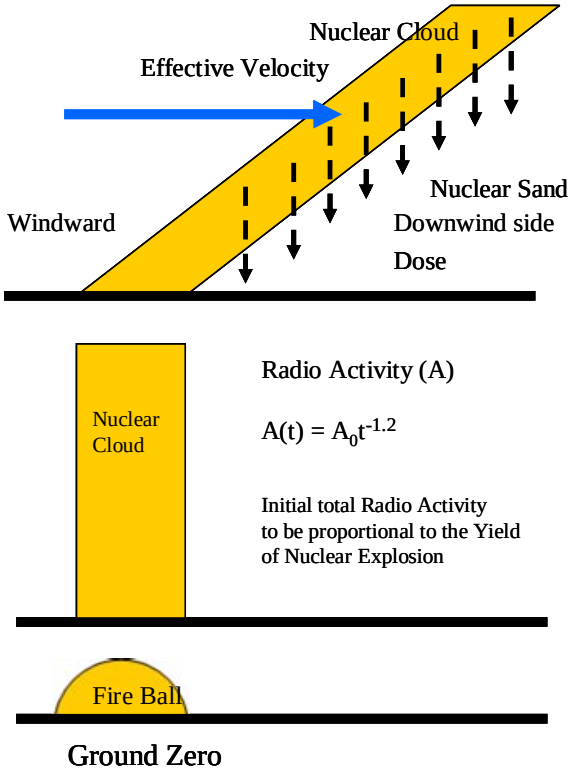

Fig.1 Chart of the dose calculation in a radioactive fallout zone by RAPS

3 Semipalatinsk Nuclear Testing

The Semipalatinsk Nuclear Test Site of the former Soviet Union was located in northeast Kazakhstan. There was no population in the test site of 18,000 km² area was surrounded with barbed wires. However fission products from nuclear explosion went out beyond the fense [1].

A total of 459 nuclear tests were conducted by the former USSR between 1949 and 1989 at the Semipalatinsk Nuclear Test Site, including 87 in air, 26 on the surface, and 346 underground explosions[3)]. The total yield of nucler tests was TNT equivalent of 18 Mt which was eleven hundred times that of the Hiroshima bomb. Because the village and the city are approaching the test site, it is a serious area as health effects for the circumference resident.

The validity of RAPS has been confirmed by application to historical surface nuclear test explosions. Fig. 2 shows a case study of the first test explosion of the former USSR at the Semipalatinsk Test Site on August 29, 1949. The test, with an output of 20 kt fission bomb, was carried out on the surface. The wind velocity was estimated to be about 47 km/h at the time of fallout.

The external dose in the village of Dolon has been evaluated by several groups [1]. The intercomparison of dose estimation using luminescence dosimetry on a brick from an old church gives a dose in air of 0.5 Gy in Dolon, 118 km distant from ground zero [7, 8]. The dose as a function of distance using RAPS is quite consistent with the data from Dolon [6] .

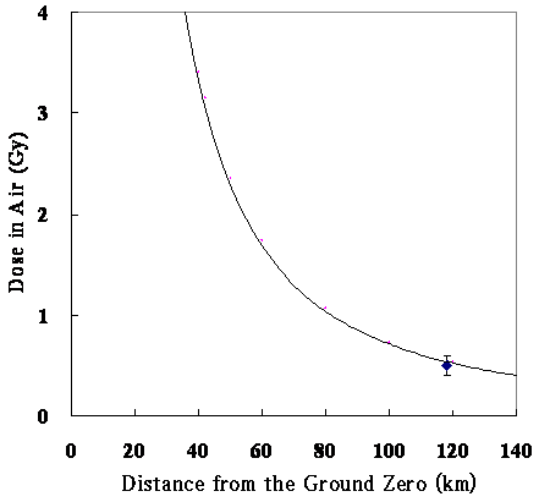

Fig. 2. Inspection of the RAPS calculation on degree of accuracy by a nuclear test case for a twenty kiloton surface nuclear explosion on August 29th 1949. The value of 47 kilometers per hour is applied for an effect wind velocity based on villager's testimony. (●) : the dose value in Dolon Village evaluated for a sample of brick by luminescence.

4. Lop Nur Nuclear Testing

Chinese the Lop Nur Nuclear Test site is located around at the eastern edge of Taklimakan Desert. The safety control of Chinese test has been unclear. The first nuclear test is conducted on the surface on October 16th in 1964. A total of 46 nuclear tests with about twenty megaton yield were conducted till 1996 at the Lop Nur nuclear test site, including about ten surface explosion. The maximam yield of a surface explosion was 4.0 Mt of thermonucler bomb on November 17th 1976.

The monitoring for Chinese nuclear tests was carried out at Kazafkstan near the Chinese bordering in the former USSR periode. A Kazakhstan report on dosimetry study shows us remarkable doses in Kazakhstan due to two thermonucler explosions. The first one was a test explosion with 2.0 Mt on Jun 6th 1967, the second was a test explosion with 2.5 Mt on Jun 17th 1973. The report presents that the doses in air are 0.14 Sv and 0.22Sv for the two tests at Makanchi about 1000 km far from the ground zero.

Dose predictions by RAPS have been applied for two megaton order surfase and near surfase thermonuclear explosions in the Lop Nur Nuclear Test Site [9]. A Kazafkstan report was used mainly for the initial values for calculations such as explosion yields, exposion hight, and wind velosities.

Internet survise of Google Earth has been used for determin of global positions of ground zeros, investigation objects, and distances. The difference of distance between values of Kazakhstan and of the present work is 40 km of 4% for a distance between Makanchi and Ground zero. It is acceptable for dose evaluation.

Doses values by RAPS with 50% of total yield as fission yield have a good agreement with values of Kazafkstan report. Then portion of fission yield in RAPS was modified slightly to make better agreement. The portion for fallout activity depends on the explosion height and technology of weapon devices.

Table 2. Comparizn for external dose at Makanchi

Test Date	Yield	Exp. Altitude	Ext. Dose (Sv)	
y.m.d	megaton	meter	Kazakhstan	JT
1967.06.17	2.0	100	0.14	0.14
1973.06.27	2.5	1000	0.22	0.21

JT: This work

5. Dangerous doses in Uygur

Good agreement between dose values of Kazakhstan and RAPS suports validity in dose evaluation in Uygur area near the ground zeros. Capital Urmuchi and Turpan are along a line between Ground zero and Makanchi. These cities are located 380 km and 250 km far from the Ground zero.

Doses in air around Urmuchi are estimated to be 0.8 Sv (for Jun 17th, 1967 Exp.) and 1.5 Sv (for Jun 27th, 1973 Exp.). Doses in air around Turpan are estimated to be 0.8 Sv (for Jun 17th, 1967 Exp.) and 1.5 Sv (for Jun 27th, 1973 Exp.) [9]. These doses causes acute disease or fetus influence. Populations in those cities are 1.6 million and 0.24 million respectively at present. People in those area shoud be suffered not only externally but also internally by radioactive fallout.

Sites with fatal risky doses more than 4 Sv in downwind side are estimated to be within 250 km (for Jun 17th, 1967 Exp.) and 290 km (for Jun 27th, 1973 Exp.) in Chinese tests. Such accidental cases are recorded in history of nuclear tests in the USA and in the former USSR.

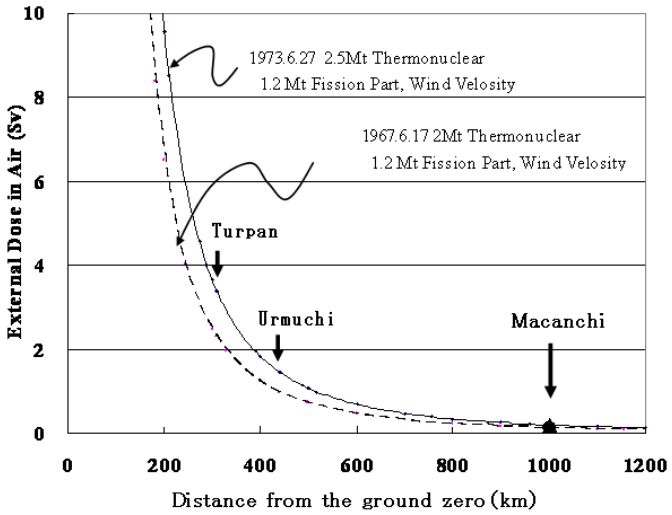

Fig.3 External dose in air as a function of distance from ground zero in the radioactive fallout area after the megaton order surface nuclear explosion [9].

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