

ATMOSPHERIC DISPERSION STUDY FOR SUPPORTING SITE PERTMIT PROCESS OF NUCLEAR REACTOR

THE 5TH ANNUAL MEETING ASEAN NUCLEAR POWER SAFETY RESEARCH
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Content

INTRODUCTION

METHODOLOGY

SOURCE TERM ESTIMATION

DOSE CONSEQUENCES CALCULATION

STUDY ON NORMAL CONDITION

STUDY ON ACCIDENT CONDITION

COUNTERMEASURES

THANK YOU

Introduction

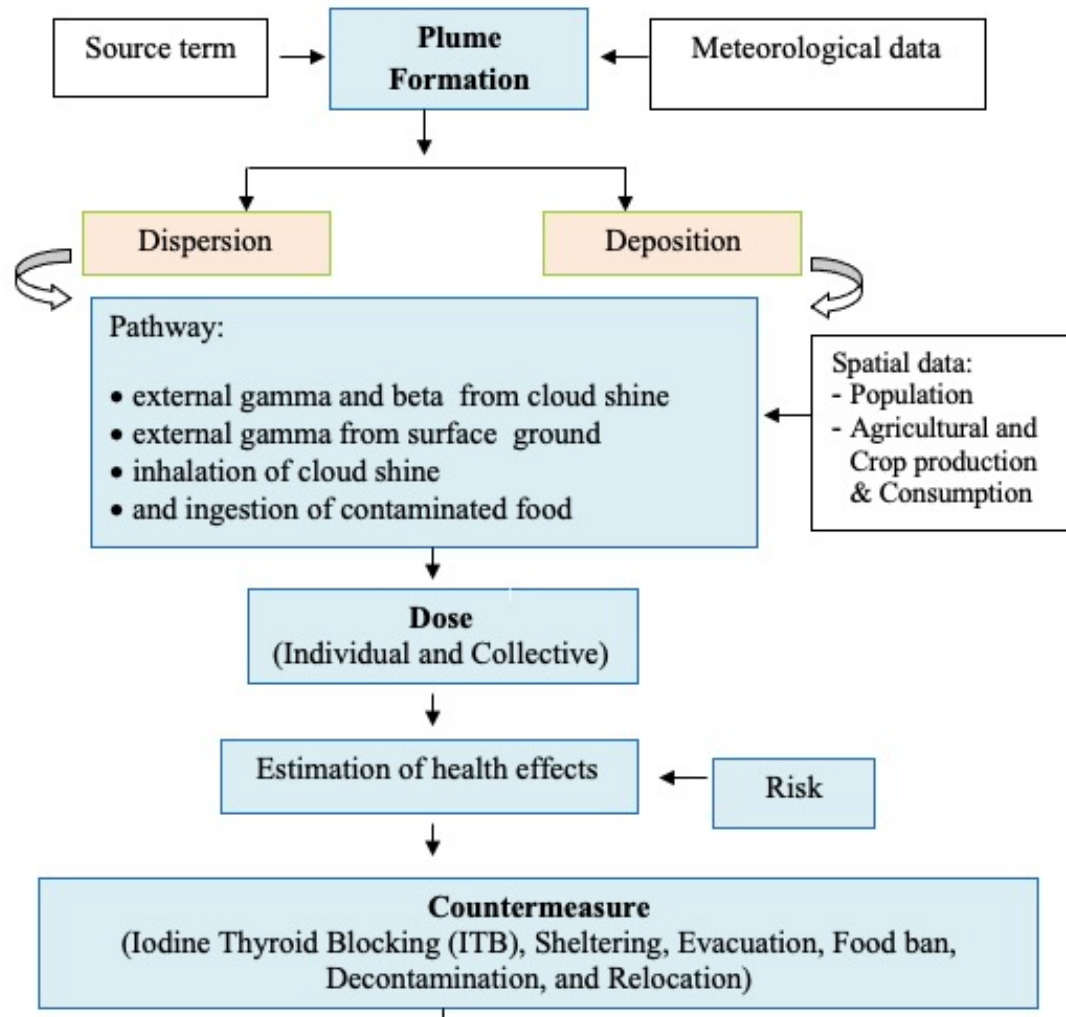
- Most activities in research group of Radiation Dispersion and Consequences of Nuclear Reactor is to support Siting Evaluation from aspect of Radiological Environment.
- Evaluation must fulfil the requirement for Siting Permit from Nuclear Energy Regulatory Agency of Indonesia
- Perform research, development, and innovation on Radiation Dispersion and consequences of Nuclear Reactor

Introduction

The evaluation activities include:

- To calculate source term that may be released from the reactor in both normal operating conditions and accidents
- Meteorological Data Collection: wind direction and speed, solar exposure, night and day conditions, rain or dry
- To predict population growth over the lifetime of the reactor
- To predicting an environmental condition change, including land use, plants, livestock and infrastructure
- To perform radiation dispersion and dose acceptance analysis for normal and accidental conditions
- To plan environmental radiation monitoring and management
- Emergency planning (emergency preparedness)

Methodology Approach



Source Term Estimation

- Core inventory is the amount of fission products and other radionuclides in the reactor core
- Analyses were performed using the program with ORIGEN2
- Input Data : geometry reactor, Highest/Average Burn-up, composition of Uranium, Irradiation time, Reactor power
- The core inventory calculation is based on the conditions at the end of a full power cycle
- In the output of ORIGEN2.1, the radionuclides are divided into three groups which are: activation products (720 nuclides), fission products (850 nuclides), and actinides (130 nuclides).
- The series of studies performed on the first core and transition core configurations until the equilibrium core is reached.

Dose Consequences Calculation

- The calculations of atmospheric radioactivity were done by using an atmospheric disperse approach with a Gaussian Model
- Meteorological input data and environmental data such as population distribution, farm-livestock production is taken from available data of site-specific in Indonesia
- PC-CREAM were used to estimate the radiological doses of the released radionuclide during normal operation
- PC-COSYMA were used to estimate the radiological doses of the released radionuclide during accident condition.
- The segmented Gaussian plume model is accurate on the 0-50 km scale.

Study on Normal Condition

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Environmental Consequences of Routine Releases from Small Medium Reactor at Babel Site

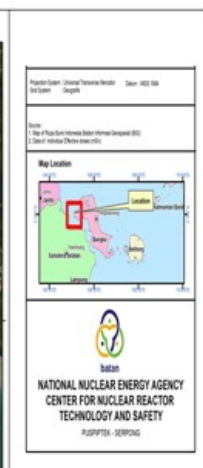
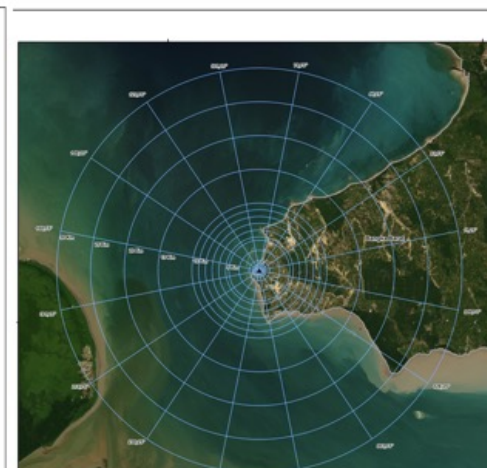
Pande Made Udiyani*, M. Budi Setiawan, Anik Purwaningsih, Nursinta Adi Wahanani, Amir Hamzah, Hery Adrial, Jupiter S. Pane, Muksin Aji Setiawan

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Environmental Consequences of Routine Releases from Small Medium Reactor at Babel Site (Sebagin and Muntok)

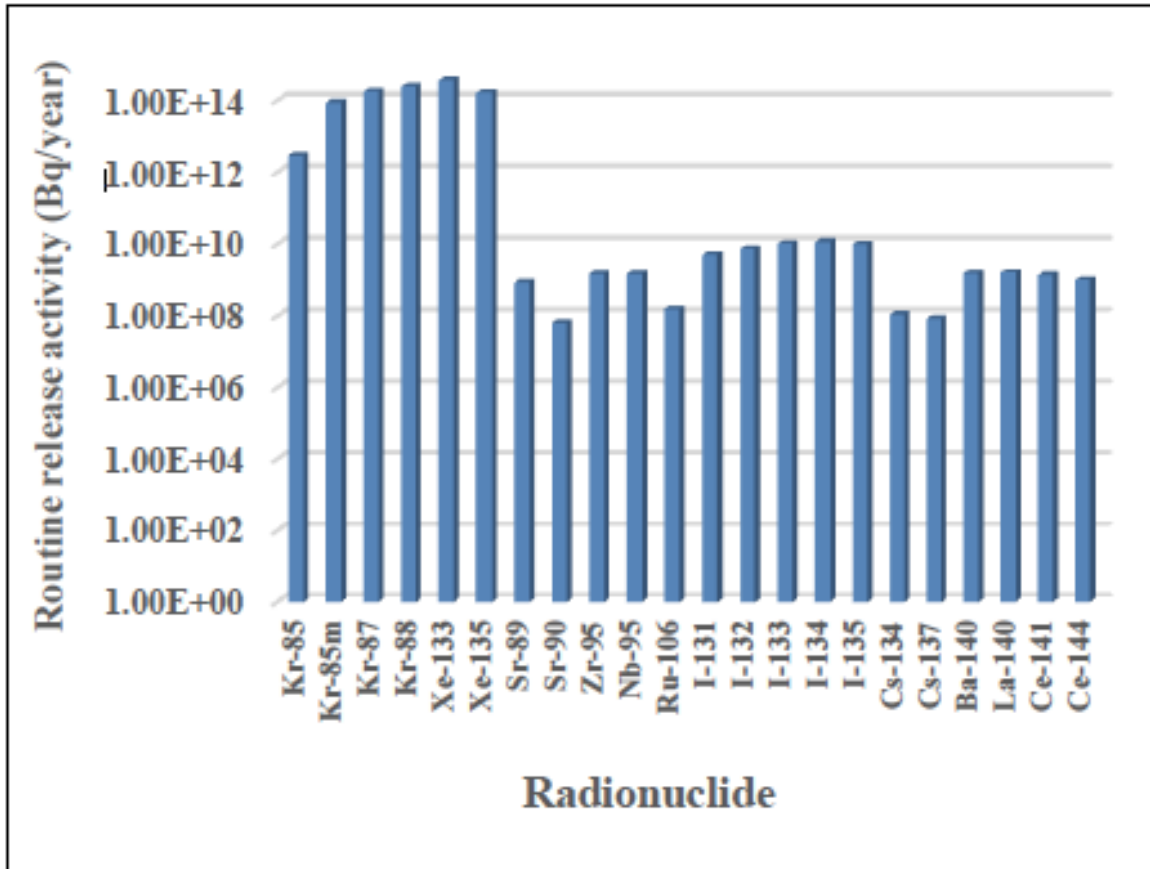


SOUTH BANGKA Island Site (Sebagin)



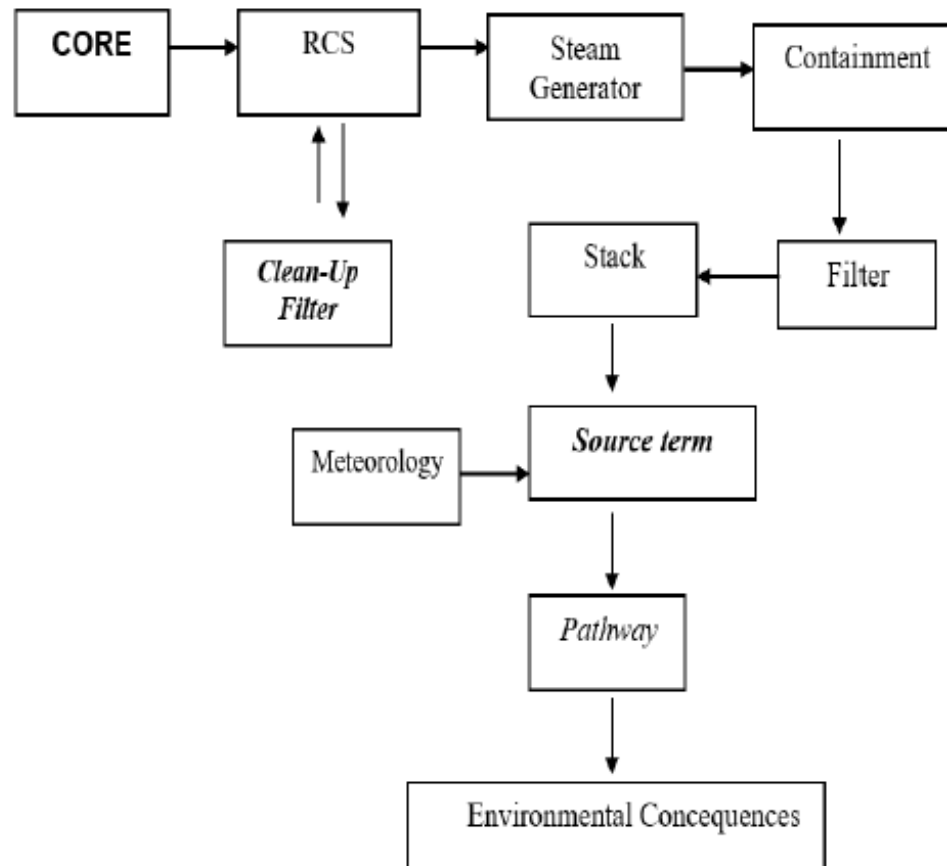
WEST BANGKA Island Site (Muntok)

Source Term



The estimation results of the source term resulting from the routine discharge of the 3 units SMR of 100 MWe PWR.

Source Term Calculation Mechanism



Distance Sector	Individual dose for adult ($\mu\text{Sv}/\text{yr}$)							
	100 m	300 m	500 m	1 km	2 km	3 km	4 km	5 km
1	7.59E+00	3.18E+00	2.75E+00	1.39E+00	6.13E-01	3.98E-01	2.95E-01	2.35E-01
2	4.86E+00	2.00E+00	1.63E+00	8.76E-01	4.06E-01	2.69E-01	2.02E-01	1.62E-01
3	6.23E+00	2.58E+00	2.06E+00	1.08E+00	5.03E-01	3.37E-01	2.55E-01	2.06E-01
4	5.85E+00	2.50E+00	2.06E+00	9.69E-01	4.27E-01	2.83E-01	2.13E-01	1.72E-01
5	6.56E+00	2.72E+00	2.20E+00	1.17E+00	5.46E-01	3.59E-01	2.67E-01	2.13E-01
6	9.54E+00	4.07E+00	3.49E+00	1.81E+00	7.81E-01	4.81E-01	3.40E-01	2.61E-01
7	1.33E+01	5.52E+00	4.59E+00	2.71E+00	1.24E+00	7.67E-01	5.42E-01	4.14E-01
8	1.77E+01	7.30E+00	6.00E+00	3.55E+00	1.67E+00	1.06E+00	7.67E-01	5.96E-01
9	1.26E+00	4.89E-01	3.31E-01	1.92E-01	1.08E-01	8.18E-02	6.65E-02	5.63E-02
10	5.76E+00	2.24E+00	1.52E+00	9.18E-01	5.19E-01	3.87E-01	3.10E-01	2.59E-01
11	5.38E+00	2.09E+00	1.42E+00	8.13E-01	4.55E-01	3.48E-01	2.85E-01	2.42E-01
12	6.36E+00	2.47E+00	1.64E+00	9.53E-01	5.56E-01	4.29E-01	3.50E-01	2.97E-01
13	1.83E+01	7.26E+00	5.19E+00	3.03E+00	1.69E+00	1.22E+00	9.54E-01	7.83E-01
14	2.29E+01	9.50E+00	7.79E+00	4.23E+00	2.05E+00	1.35E+00	9.89E-01	7.77E-01
15	1.33E+01	5.53E+00	4.64E+00	1.41E+00	1.14E+00	7.46E-01	5.53E-01	2.38E-01
16	6.58E+00	2.73E+00	2.29E+00	1.21E+00	5.52E-01	3.64E-01	2.72E-01	2.18E-01
Mean	9.47E+00	3.89E+00	3.10E+00	1.63E+00	8.29E-01	5.55E-01	4.16E-01	3.19E-01

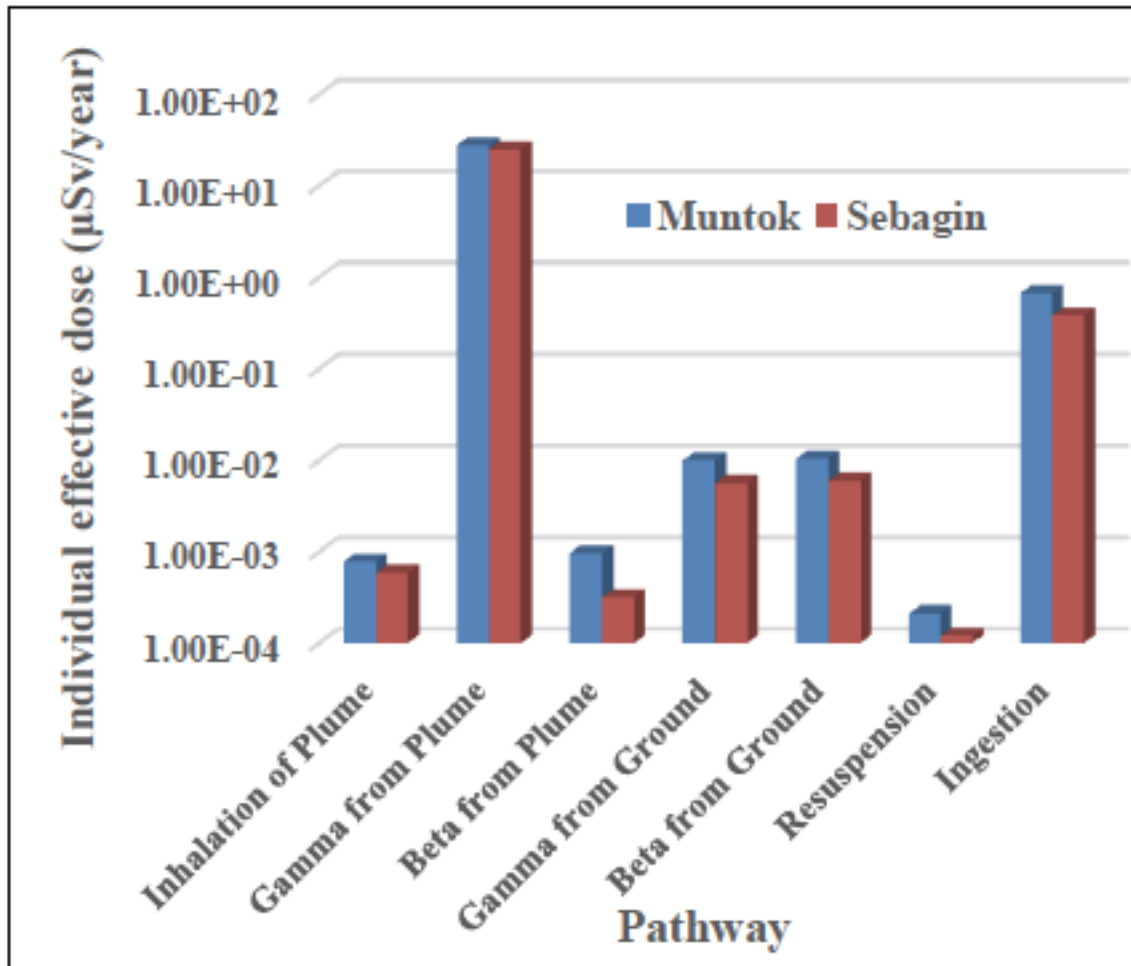
Distance Sector	Individual dose for adult ($\mu\text{Sv}/\text{yr}$)							
	6 km	7 km	8 km	9 km	10 km	12 km	15 km	20 km
1	1.92E-01	1.63E-01	1.40E-01	1.23E-01	1.09E-01	8.69E-02	6.62E-02	4.53E-02
2	1.33E-01	1.13E-01	9.78E-02	8.55E-02	7.59E-02	6.08E-02	4.64E-02	3.18E-02
3	1.69E-01	1.45E-01	1.25E-01	1.10E-01	9.78E-02	7.84E-02	6.00E-02	4.11E-02
4	1.41E-01	1.21E-01	1.05E-01	9.19E-02	8.19E-02	6.58E-02	5.04E-02	3.45E-02
5	1.74E-01	1.47E-01	1.27E-01	1.11E-01	9.82E-02	7.84E-02	5.97E-02	4.07E-02
6	2.08E-01	1.72E-01	1.46E-01	1.26E-01	1.11E-01	8.74E-02	6.56E-02	4.43E-02
7	3.29E-01	2.72E-01	2.31E-01	1.98E-01	1.74E-01	1.37E-01	1.02E-01	6.86E-02
8	4.79E-01	3.99E-01	3.40E-01	2.94E-01	2.59E-01	2.05E-01	1.54E-01	1.04E-01
9	4.77E-02	4.16E-02	3.67E-02	3.25E-02	2.93E-02	2.37E-02	1.84E-02	1.27E-02
10	2.18E-01	1.89E-01	1.66E-01	1.47E-01	1.32E-01	1.06E-01	8.20E-02	5.63E-02
11	2.06E-01	1.80E-01	1.59E-01	1.41E-01	1.27E-01	1.03E-01	8.01E-02	5.52E-02
12	2.52E-01	2.20E-01	1.94E-01	1.72E-01	1.54E-01	1.25E-01	9.69E-02	6.67E-02
13	6.51E-01	5.59E-01	4.87E-01	4.28E-01	3.81E-01	3.06E-01	2.34E-01	1.60E-01
14	6.28E-01	5.27E-01	4.51E-01	3.90E-01	3.44E-01	2.72E-01	2.05E-01	1.39E-01
15	3.57E-01	3.02E-01	2.60E-01	1.15E-01	2.00E-01	1.60E-01	1.21E-01	4.25E-02
16	1.79E-01	1.52E-01	1.31E-01	1.15E-01	1.02E-01	8.15E-02	6.22E-02	7.44E+00
Mean	2.73E-01	2.31E-01	2.00E-01	1.67E-01	1.55E-01	1.24E-01	9.40E-02	5.24E-01

Total adult individual dose of radioactive discharge into the atmosphere in routine operation 3 100 MWe PWR (all nuclides and all pathways); Muntok site

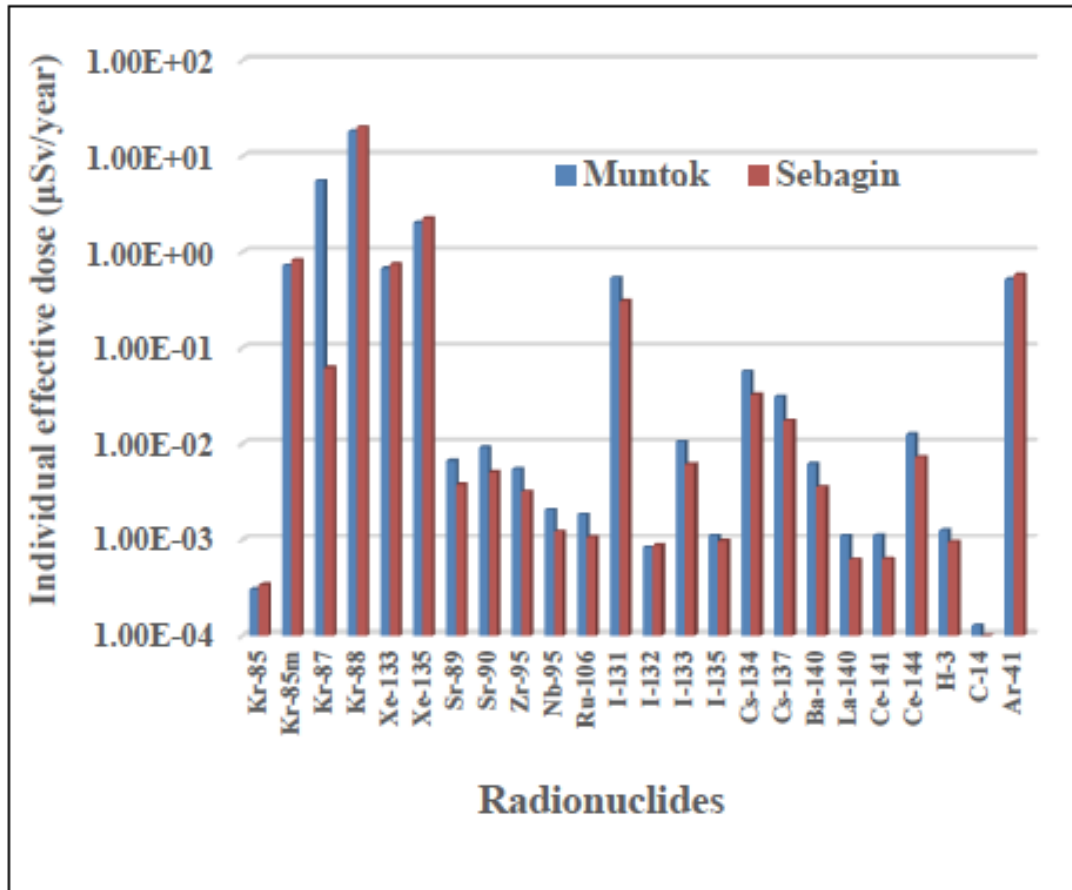
Total adult individual dose

- Total average maximum individual dose in radius of 100 m, within the exclusion zone of 500 m, is $9.47\text{E}+00$ $\mu\text{Sv}/\text{year}$, below the dose limit for radiation workers. For a radius beyond 500 m, the maximum dose is $3.10\text{E}+00$ $\mu\text{Sv}/\text{year}$, well below the constraint for general public.

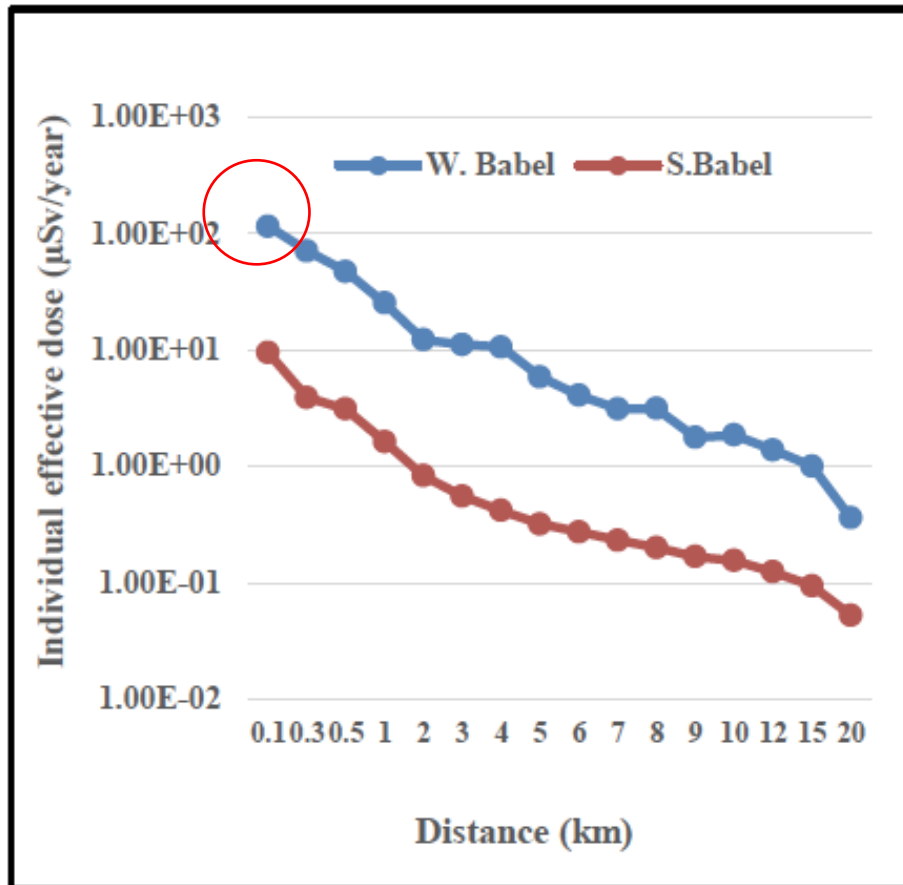
Individual effective Dose



- The maximum total effective individual dose for the various pathways for all radionuclides is received within a radius of 100 m from the reactor. Maximum effective individual dose of West Bangka (Muntok) occurs in the wind direction of sector 14, and for South Bangka (Sebagin) in sector 16. The largest dose contribution is from the gamma component of plume pathway, followed by the ingestion pathway.



The maximum effective individual dose for both sites, for all pathways by radionuclide types. The largest dose contribution was given by the noble gas group (Xe, Kr, Ar), followed by the iodine (I-131) and cesium (Cs-134, Cs-137) group.



The mean effective individual doses for both sites, for all pathways and radionuclide releases.

The received dose decreases with increasing radius from the reactor. In general, the dose for each pathway in both sites, Bangka Barat (Muntok site) was slightly higher than Bangka Selatan (Sebagin site).

Study on Accident Condition

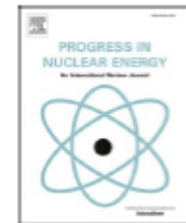
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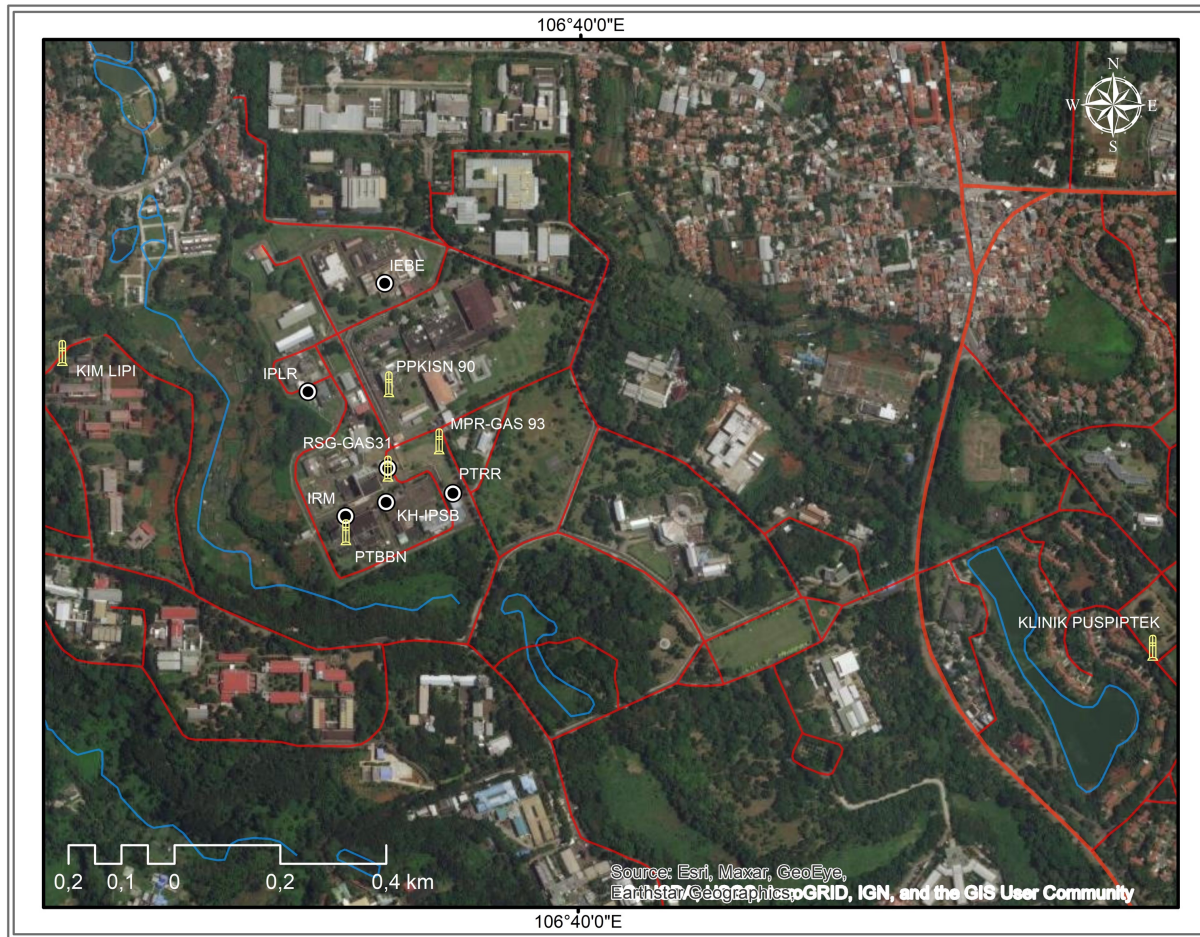


Assessment of dose consequences based on postulated BDBA (beyond design basic accident) A-30MWt RSG-GAS after 30-year operation

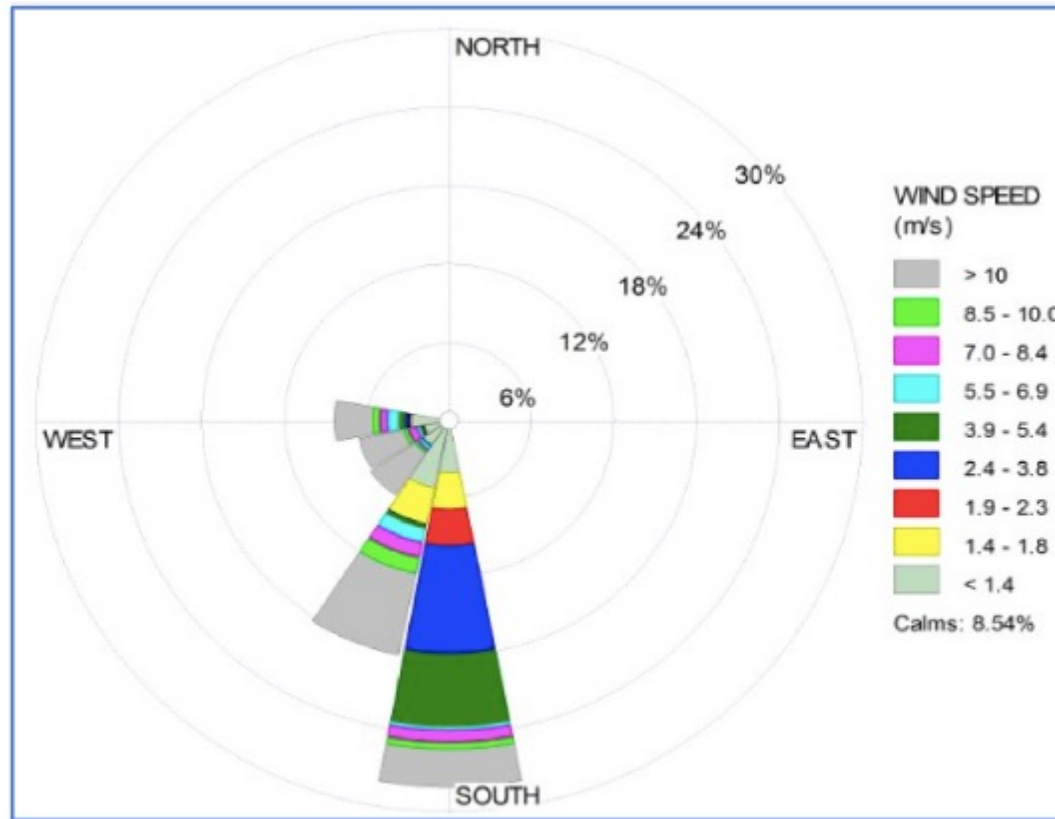
P.M. Udiyani, M.B. Setiawan^{*}, M. Subekti, S. Kuntjoro, J.S. Pane, E.P. Hastuti, H. Susiati

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Assessment of dose consequences based on Postulate NDBA (beyond design basis design accident) at Serpong Nuclear Facilities Area



Windrose in the SNFA



Wind rose in the SNFA of RSG-GAS Site

Source Term

Fuel inventory and source terms for BDBA postulation of RSG-GAS.

Radionuclide group	Nuclide	Fuel Inventory (Bq)	Source term (Bq)	Radionuclide group	Nuclide	Fuel Inventory (Bq)	Source term (Bq)
Noble Gas	Kr-85	8.38E+12	8.38E+12	Strontium and Barium	Sr-89	3.34E+15	1.67E+10
	Kr-85m	6.31E+14	6.31E+14		Sr-90	6.66E+13	3.33E+08
	Kr-87	8.64E+14	8.64E+14	Noble Metal	Ba-139	3.74E+15	1.87E+10
	Kr-88	1.63E+15	1.63E+15		Ba-140	3.62E+15	1.81E+10
	Xe-133	3.89E+15	3.89E+15		Ru-105	6.44E+14	3.22E+09
	Xe-135	6.27E+14	6.27E+14		Ru-106	1.16E+14	5.82E+08
Halogen	I-131	1.65E+15	4.11E+11	Rh-103m	2.01E+15	1.00E+10	
	I-132	2.48E+15	6.20E+11	Rh-105	5.36E+14	2.68E+09	
	I-133	3.92E+15	9.79E+11	Lanthanides	La-140	3.68E+15	1.84E+10
	I-134	4.40E+15	1.10E+12		Y-90	7.15E+13	3.57E+08
	I-135	3.66E+15	9.15E+11		Y-91	4.04E+15	2.02E+10
Alkali Metal	CS-134	1.82E+13	9.08E+07	Nb-95	4.30E+15	2.15E+10	
	CS-137	6.91E+13	3.45E+08	Pr-143	3.39E+15	1.69E+10	
	Rb-88	2.09E+15	1.05E+10	Nd-147	1.31E+15	6.56E+09	
Tellurium	Te-132	2.47E+15	1.23E+10	Cerium	Ce-141	4.01E+15	2.01E+10
	Sb-125	8.00E+13	4.00E+08		Ce-143	3.42E+15	1.71E+10
	Sb-127	8.00E+13	4.00E+08		Ce-144	1.81E+15	9.06E+09

The source term calculation is based on a BDBA accident that was simulated in the RSG-GAS. The worst accident condition which was simulated in the reactor thermo-hydraulic calculation based on the ATWS (Anticipated Transient Without Scram) condition which was triggered by the blockage of the coolant flow in the fuel. This condition causes 5 fuel elements to melt ([Hastowo, 1996](#)).

Mean Concentration of Nuclides on air

Mean concentration of nuclides on air or on ground surface.

Distance (km)	Noble gas		Halogen		Alkali metal		Other Nuclide	
	Air Bq.s/m ³	ground Bq/m ²	air Bq.s/m ³	ground Bq/m ²	air Bq.s/m ³	ground Bq/m ²	air Bq.s/m ³	ground Bq/m ²
0.500	1.93E+10	0.00E+00	7.01E+08	6.93E+06	1.07E+05	1.07E+02	3.37E+06	3.37E+03
1.000	6.37E+09	0.00E+00	2.01E+08	1.99E+06	3.40E+04	3.40E+01	1.08E+06	1.08E+03
1.500	3.35E+09	0.00E+00	9.58E+07	9.45E+05	1.75E+04	1.75E+01	5.56E+05	5.56E+02
2.000	2.01E+09	0.00E+00	5.82E+07	5.73E+05	1.10E+04	1.10E+01	3.46E+05	3.46E+02
2.500	1.44E+09	0.00E+00	4.07E+07	4.01E+05	8.09E+03	8.09E+00	2.53E+05	2.53E+02
3.000	1.24E+09	0.00E+00	3.35E+07	3.30E+05	7.08E+03	7.08E+00	2.27E+05	2.19E+02
3.500	1.07E+09	0.00E+00	2.78E+07	2.73E+05	6.31E+03	6.31E+00	1.94E+05	1.94E+02
4.000	9.35E+08	0.00E+00	2.40E+07	2.36E+05	5.62E+03	5.62E+00	1.72E+05	1.72E+02
4.500	7.67E+08	0.00E+00	1.94E+07	1.91E+05	4.64E+03	4.64E+00	1.41E+05	1.41E+02

The averaged radioactivity in atmospheric air for each radius. The highest activity that is dispersed in sector 9 is the sector that has a radial angle deviation ± 202.50 from the North. From the data it can also be seen that for the same nuclide, radioactivity decreases with increasing radius of the RSG-GAS. The highest radioactivity is at a radius of 500 m, while the lowest is at a radius of 4.5 km from the release center.

Dose consequences

Dose Consequences of RSG-GAS BDBA accidents.

Distance (km)	Mean Individual dose effective (Sv)		Mean Individual dose of thyroid (Sv)		Collective dose (man.Sv)
	Short-term	Long-term	Short-term	Long-term	
0.500	1.31E-03	2.44E-03	1.47E-03	2.68E-04	2.01E+00
1.000	5.12E-04	1.17E-03	5.74E-04	1.02E-04	2.30E+00
1.500	2.85E-04	6.82E-04	3.20E-04	5.59E-05	3.72E-06
2.000	1.86E-04	4.68E-04	2.00E-04	3.62E-05	4.57E+00
2.500	1.46E-04	3.59E-04	1.64E-04	2.83E-05	2.89E-06
3.000	1.34E-04	3.17E-04	1.50E-04	2.57E-05	1.67E+00
3.500	1.03E-04	2.32E-04	1.16E-04	1.99E-05	6.98E-07
4.000	9.38E-05	2.00E-04	1.05E-04	1.81E-05	7.43E-01
4.500	8.12E-05	1.78E-04	9.13E-05	1.56E-05	1.32E-07

The results of the calculation of short-term doses of the external exposure and inhalation received by the community around the RSGGAS (within a 5 km radius).

- Based on the distance of acceptance, the dose is reduced by increasing the radius from the reactor. The maximum short-term individual effective dose is $1.31\text{E-}03$ Sv, and $2.44\text{E-}03$ Sv for long-term dose respectively. This dose value is below the maximum limit for the exclusion area of 0.25 Sv and the limit of 0.005 Sv for certain conditions for the public

Countermeasure

- Countermeasures are carried out, based on estimated radiation doses received by the public at the Serpong Nuclear Facilities Area (SNFA) site. Based on the dosage data, no countermeasure action were taken.
- The Dose data showed that the short-term dose not meet the criteria for Iodine tablet blocking to 0.02 Sv dose; sheltering for receiving doses exceed 0.01Sv; and for evacuation if the dose exceeds reception 0.05 Sv.
- From the results of research for BDBA condition, the emergency zoning of the Serpong nuclear facilities area (SNFA) is not significantly different from the emergency zoning made based on the DBA accident. Communities around SNFA in the same zoning of DBA and BDBA received radiation doses for countermeasure criteria that were not different. i.e. there is no need for particular action of giving iodine tablets, sheltering, or evacuation.



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