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The Study of Radiological Environmental Impact Assessments for G. A. Siwabessy Nuclear Research Reactor in Indonesia

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Abstract

Abstract

The National Nuclear Energy Agency (BATAN) in Indonesia is responsible for using the Radiological Environmental Impact Assessment to periodically assess radioactive gaseous and liquid effluents released from the G.A. Siwabessy Nuclear Research Reactor (RSG-GAS) 30 MWt.

The radioactive gaseous and liquid effluents are released into the environment, but the effluents discharge has to meet environmental release levels permit. This study provides an extensive general review of the radioactive effluents release from RSG-GAS reactor and the effect of that release on the annual effective dose to the public.

The environmental impact assessment was performed using computer code INDAC 2.1 (Integrated Dose Assessment Code Package) created by Korea Institute of Nuclear Safety (KINS) to be used for licensing process in the normal operation of nuclear power plants or nuclear research reactors.

The average radioactive doses to the public were approximate in the range order between 10^{-2} to 10^{-3} mSv. Although RSG-GAS reactor discharges some radioactive substances into the environment gaseous and liquid effluents were inside the regulatory of safety limits permit and the resulting effective doses were much less than effective dose limits.

The annual effective doses to the public under normal operating conditions are taken into account insignificant when compared to the dose limit permit or even the radiation dose of natural background while the public doses have been practically kept at greatly low levels.

Keywords

Radiological Impact,

Dose Estimation,

Gaseous Effluent,

Liquid Effluent,

Nuclear Research Reactor.

1. Introduction

Indonesia has 3 nuclear research reactors which are currently in operation and an additional Experimental Power Reactor (RDE) planned in the near future.

Outstandingly, thorough periodic monitoring and management of safety for radioactive substances are organized to ensure radiation protection for the public living members around nuclear research reactors, considering the reactor process on a single site.

In this study, only gaseous and liquid effluents were analyzed and presents radiological environmental impact assessment done by periodically evaluating radioactive gaseous and liquid effluents released from G. A. Siwabessy Reactor (RSG-GAS) 30 MWt

This assessment is done in order to protect the public and the environment from radiation exposure using computer code INDAC 2.1 (Integrated Dose Assessment Code Package). INDAC 2.1 provides many output data but the focus in this paper is on the individual effective dose by age group to meet the annual dose limit

1. Introduction (Cont'd)

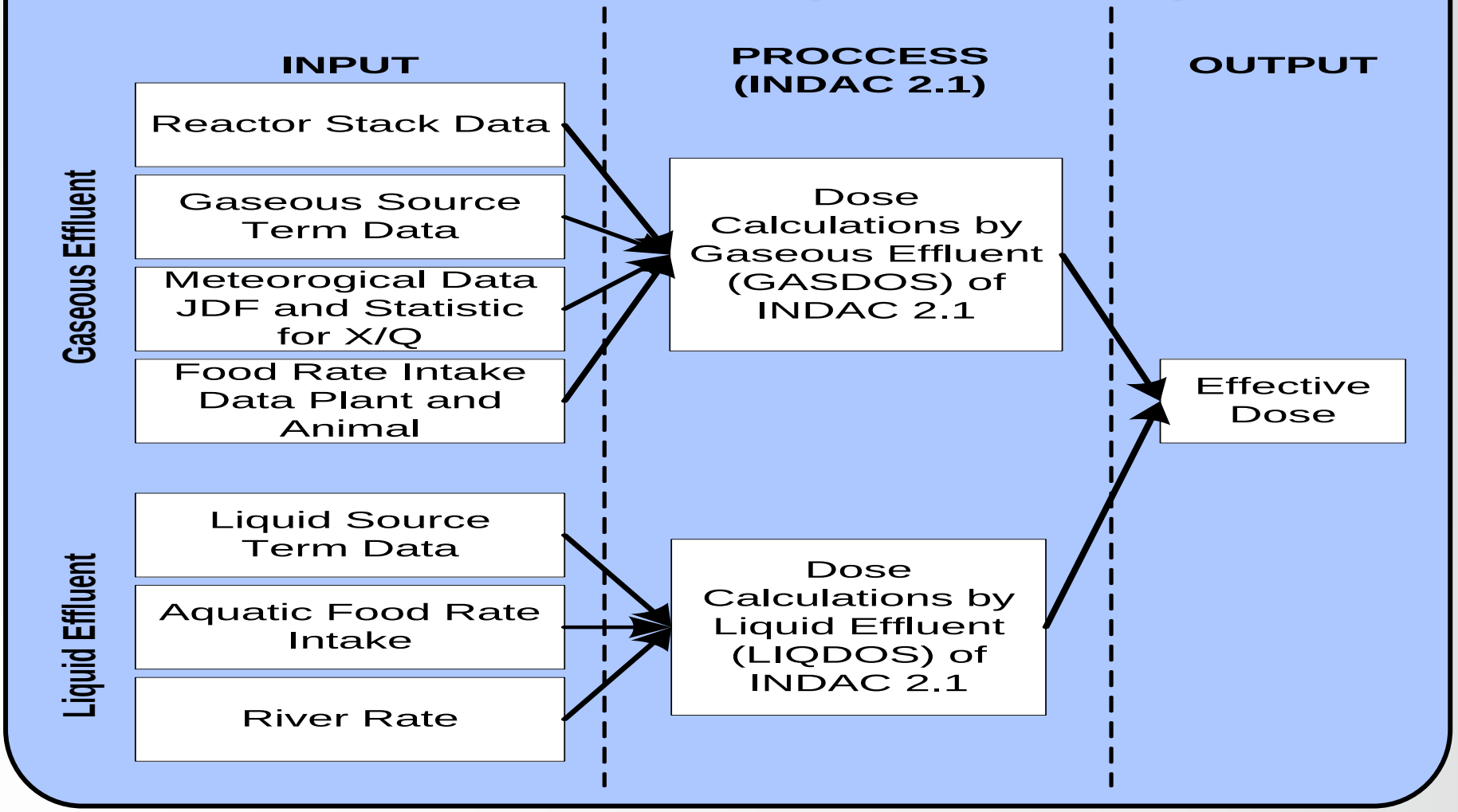
The purpose of this study is to comprehend the radioactive effluents present status of RSG-GAS reactor release.

In order to achieve this purpose, these quantities of radioactive effluents released into the environment and the total of effective doses to the public members living around RSG-GAS reactor were analyzed for the year 2016-2017.

The results of the study analysis can also be used for comparing the changes of the release of the radioactive substances and the effective dose to the public.

2. Material and Methods

The radiological environmental impact assessment procedure:



2. Material and Methods (Cont'd)

The RSG-GAS reactor stack and liquid discharge rate

Stack	Specification
Stack Height	60 m
Stack Diameter	1 m
Stack Speed	20000 m^3/s
Distance to nearest residence village	500 m
Liquid effluent discharge rate	5.84×10^{-5} ft^3/sec

2. Material and Methods (Cont'd)

The RSG-GAS reactor gaseous effluents souce term released

Radionuclide	Amount [Bq/yr]	Contribution From
Ag-110m	7.85E+03	RSG-GAS, RMI
Am-241	3.98E+02	RMI
Am-243	5.38E+01	RMI
Ba-137m	1.84E+05	RMI
Ba-140	2.76E+05	RSG-GAS
Br-82	4.40E+04	RSG-GAS
Br-83	5.99E+05	RSG-GAS
Ce-141	8.21E+03	RSG-GAS
Ce-144	1.50E+06	RSG-GAS, RMI
Cm-242	6.93E+04	RMI
Cm-243	5.88E+01	RMI
Cm-244	7.98E+03	RMI
Cs-134	3.19E+05	RMI
Cs-137	3.02E+05	RSG-GAS, RMI
I-125	1.16E+05	RRI
Eu-154	2.31E+04	RMI
Eu-155	1.47E+04	RMI
H-3	7.00E+09	RMI
I-131	1.23E+12	RSG-GAS, INUKI, RRI, RMI
I-132	2.79E+12	RSG-GAS, INUKI
I-133	4.31E+12	RSG-GAS, INUKI
I-134	1.31E+06	RSG-GAS
I-135	2.55E+12	INUKI
Kr-83m	5.99E+11	RSG-GAS
Kr-85	1.21E+13	RSG-GAS, INUKI, RMI
Kr-85m	7.65E+13	RSG-GAS, INUKI
Kr-88	1.29E+14	RSG-GAS, INUKI
La-140	1.26E+05	RSG-GAS
Nb-95	1.37E+06	RSG-GAS, RMI

Radionuclide	Amount [Bq/yr]	Contribution From
Nd-147	8.07E+03	RSG-GAS
Pr-144	1.49E+06	RSG-GAS, RMI
Pu-238	5.75E+03	RMI
Pu-239	5.59E+02	RMI
Pu-240	8.82E+02	RMI
Pu-242	4.41E+00	RMI
Rh-103m	3.21E+04	RSG-GAS
Rh-106	9.19E+05	GAS, RMI
Ru-103	2.25E+05	RSG-GAS
Ru-106	9.16E+05	RSG-GAS, RMI
Sb-125	2.63E+04	RSG-GAS, RMI
Sm-151	5.70E-01	RSG-GAS
Sn-125	5.48E+01	RSG-GAS
Sr-89	5.96E+03	RSG-GAS, RMI
Sr-90	9.47E+10	RSG-GAS, INUKI, RMI
Te-125m	6.17E+03	RMI
Te-127	1.31E+04	RMI
Te-127m	1.43E+04	RSG-GAS, RMI
Te-129	5.07E+04	RSG-GAS, RMI
Te-131m	1.01E+05	RSG-GAS, RMI
Te-132	4.70E+04	RSG-GAS, RMI
U-238	4.91E-01	RMI
Xe-131m	6.29E+11	RSG-GAS, RMI
Xe-133	6.55E+14	RSG-GAS, INUKI
Xe-133m	3.39E+13	RSG-GAS, INUKI
Xe-135	2.64E+14	RSG-GAS, INUKI
Xe-135m	7.70E+13	RSG-GAS, INUKI
Xe-138	1.54E+07	RSG-GAS
Y-90	2.44E+05	RSG-GAS, RMI
Y-91	6.40E+03	RSG-GAS
Zr-95	7.96E+05	RSG-GAS, INUKI

2. Material and Methods (Cont'd)

The average of meteorological data around RSG-GAS reactor in periods 2016-2017

Radionuclide	Amount [Bq/yr]	Radionuclide Dominant or Non Dominant
Co-60	8.69E+07	Dominant
Zn-65	7.53E+07	Dominant
Na-24	8.24E+06	Dominant
I-125, I-13, Gd-153, Ho-166, Au-198, Re-188, Hg-203, Lu-177, Tc-99m, Ir-192, P-32, Sm-153, Pd-103, Br-82, F-18 Yb-169, Re-186, Sr-90, Y-90, W-188, Mo-99, Cu-64, Co-58	-	Non Dominant

2. Material and Methods (Cont'd)

The RSG-GAS reactor liquid effluents souce term released

Meteorological Level	2016	2017	Average
Level 2m (ground)			
• Temperature [ºc]	26.76	26.8	26.78
• Humidity [%]	85.07	75.57	79.95
• Precipitation [mm]	0.37	4.08	2.37
Level 10m			
• Wind Direction [º]	166.47	177.42	172.39
• Wind Speed [m/s]	1.02	1.02	1.02
• Temperature [ºc]	26.6	26.78	26.70
Level 60m			
• Wind Direction [º]	190.2	191.95	190.99
• Wind Speed [m/s]	2.80	2.73	2.77
• Temperature [ºc]	26.76	26.53	26.65

2. Material and Methods (Cont'd)

Atmospheric food rate intake of plant [kg/year]

Age Groups	Crop	Fruit	Root Veg.	Green Veg.	Inhalation [m^3/yr]
3 Months	0.36	0.84	0.00	0.00	1100
1 Years	0.92	1.04	0.85	0.00	1900
5 Years	3.62	2.07	5.53	1.92	3200
10 Years	6.42	3.17	10.35	4.22	5600
15 Years	8.56	4.07	14.02	6.18	7400
Adult	10.06	4.77	16.54	7.78	8100

Age Groups	Beef	Lamb	Chicken	Milk	Powder Milk
3 Months	0.00	0.00	0.00	0.27	1.35
1 Years	0.00	0.00	0.00	0.27	1.23
5 Years	0.03	0.06	0.08	0.22	0.65
10 Years	0.07	0.13	0.18	0.17	0.00
15 Years	0.11	0.20	0.28	0.11	0.00
Adult	0.15	0.27	0.38	0.06	0.00

2. Material and Methods (Cont'd)

Aquatic food and shoreline rate intake

Age Groups	Fish [kg/hr]	Shore-line [hr/yr]	Crop, Fruit, Root Veg. [kg/yr]	Leaf Veg. [kg/yr]	Milk [l/yr]
3 Month	0.63	0.00	1.20	0.00	0.27
1 Years	1.08	0.00	2.81	0.00	0.27
5 Years	3.34	194.6	11.23	1.92	0.22
10 Years	5.80	475.5	19.95	4.22	0.17
15 Years	7.86	692.3	26.67	6.18	0.11
Adult	9.52	844.9	31.39	7.78	0.06

2. Material and Methods (Cont'd)

Dose estimation using INDAC 2.1 for members of the public around RSG-GAS reactor

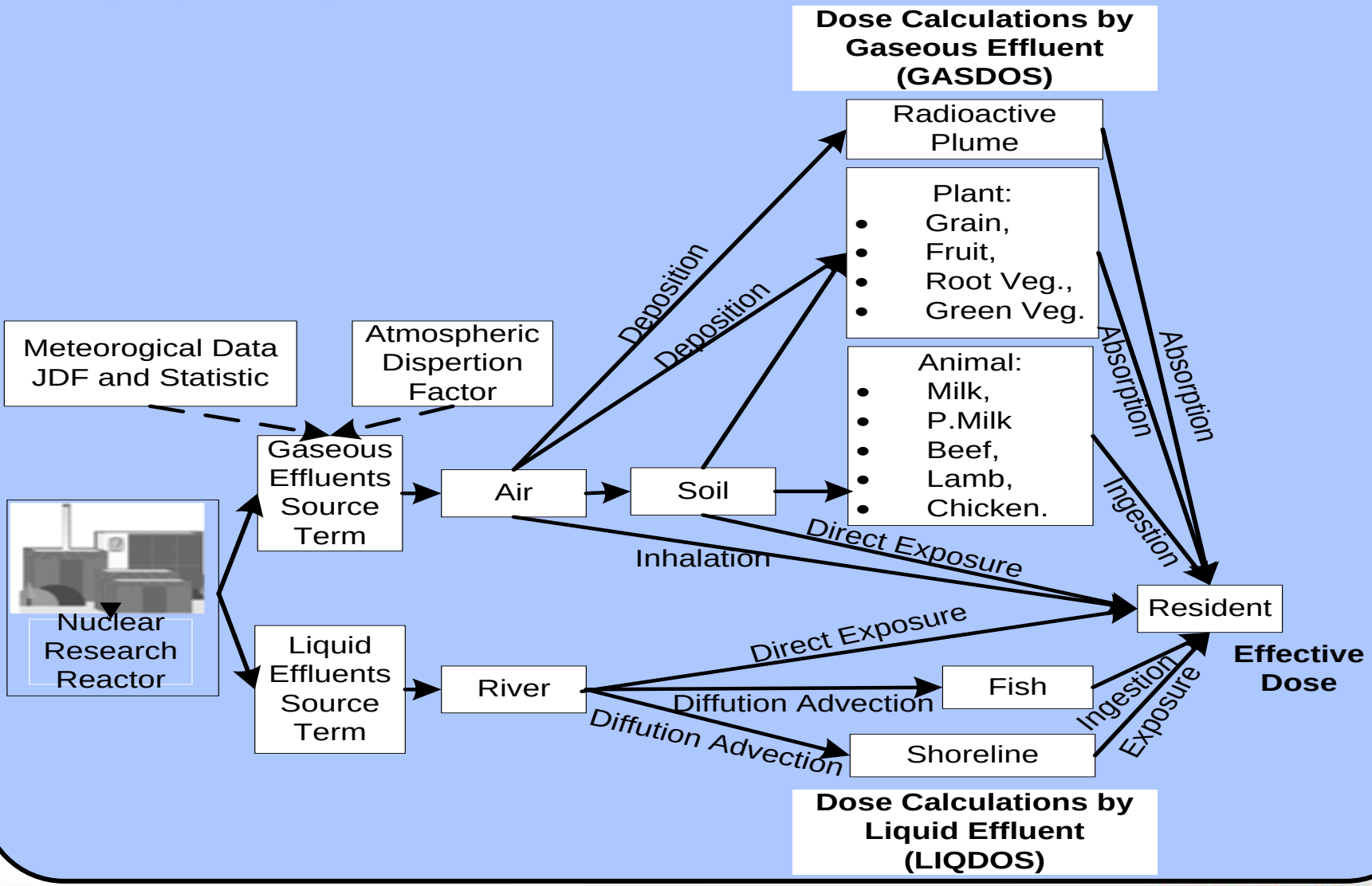
The computer code, INDAC is presently used to perform dose estimations and calculations for the public members living around nuclear power plants or nuclear research reactors in Korea and it was used for this study.

INDAC is a program for assessing the exposure dose of the population residing in the vicinity of the site in the licensing process and normal operation of nuclear power plants or research reactor. INDAC 1.0 is originally released by Korea Institute of Nuclear Safety (KINS) in 1999, and the upgraded version, INDAC 2.1 is developed in 2014.

INDAC 2.1 consist of the following 2 codes: GASDOS for dose estimations and calculations in consequence of the gaseous effluents, LIQDOS for dose estimations and calculations in consequence of the liquid effluents.

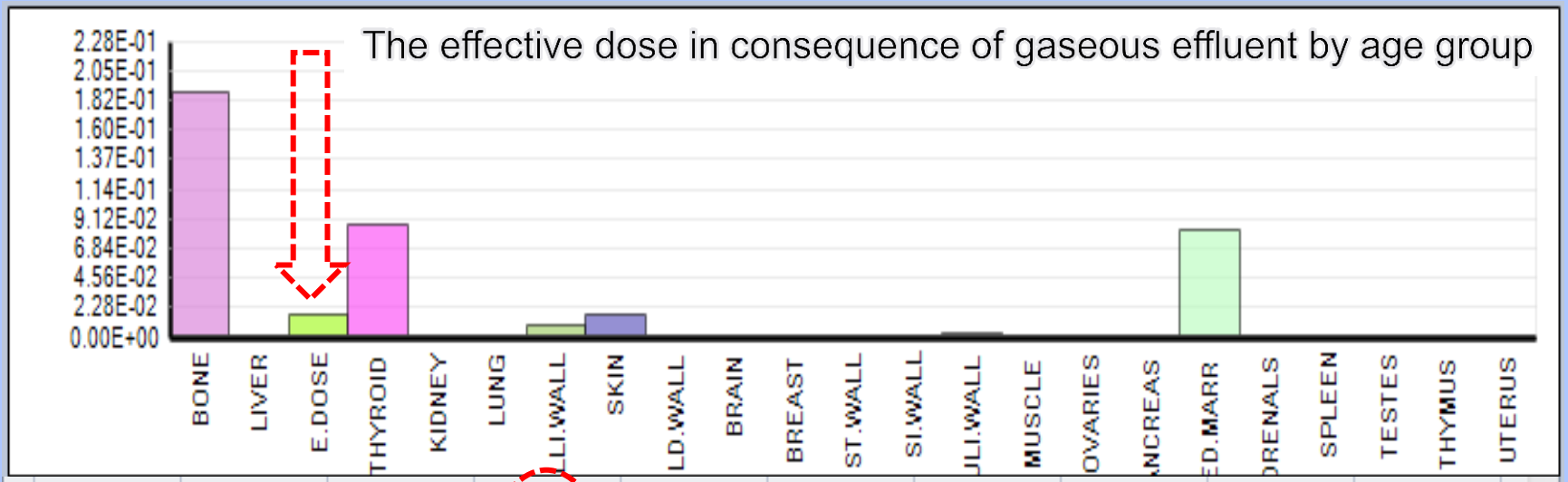
3. Results and Discussion

Analysis pathway of radioactive effluents released from RSG-GAS reactor



3. Results and Discussion (Cont'd)

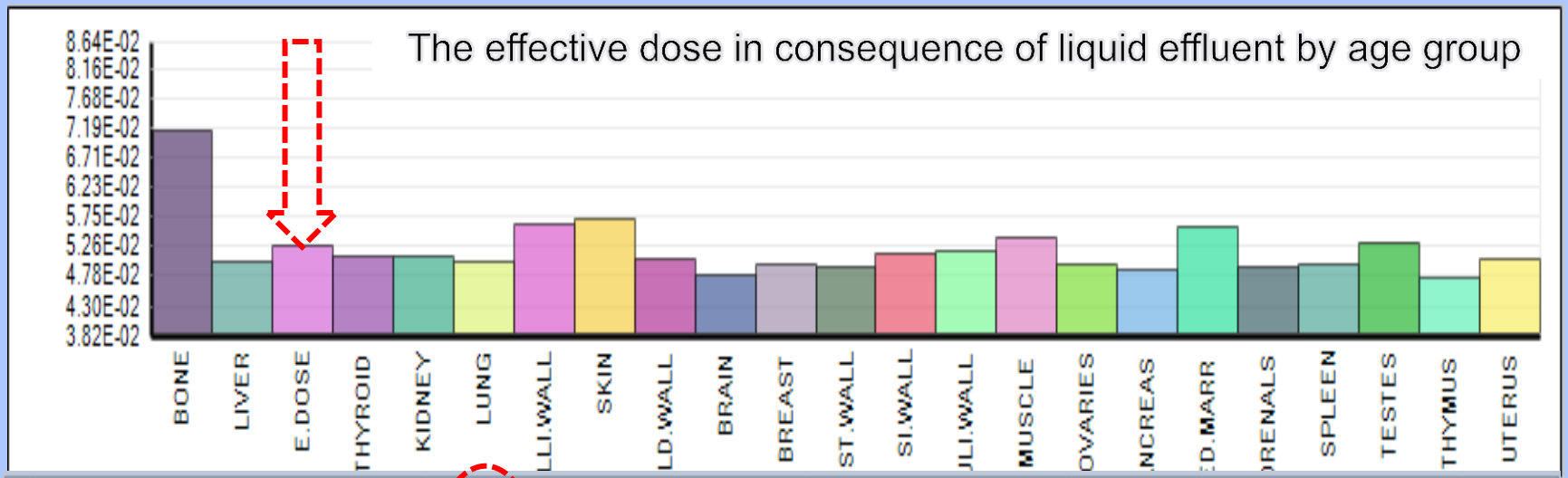
Results of the effective doses in consequence of radioactive effluents released from RSG-GAS reactor



Age Group	BONE	LIVER	E.DOSE	THYROID	KIDNEY	LUNG	LLI.WALL	SKIN	BLD.WALL
ADULT	1.90E-01	1.22E-03	1.86E-02	8.72E-02	1.23E-03	2.65E-03	1.11E-02	1.77E-02	2.09E-03
15 YR	6.93E-01	1.34E-03	3.81E-02	1.22E-01	1.35E-03	2.77E-03	1.06E-02	1.78E-02	2.54E-03
10 YR	2.81E-01	1.43E-03	2.50E-02	1.37E-01	1.43E-03	2.80E-03	1.33E-02	1.79E-02	2.44E-03
5 YR	9.54E-02	1.36E-03	1.61E-02	1.61E-01	1.36E-03	2.50E-03	1.23E-02	1.78E-02	2.00E-03
1 YR	2.15E-02	1.07E-03	9.49E-03	1.25E-01	1.08E-03	2.16E-03	5.11E-03	1.75E-02	1.31E-03
3 MON	2.38E-02	1.04E-03	7.22E-03	7.58E-02	1.04E-03	1.80E-03	2.86E-03	1.75E-02	1.20E-03

3. Results and Discussion (Cont'd)

Results of the effective doses in consequence of radioactive effluents released from RSG-GAS reactor



Age Group	BONE	LIVER	E.DOSE	THYROID	KIDNEY	LUNG	LLI.WALL	SKIN	BLD.WALL	BRAIN	BREA
Adult	7.20E-02	5.04E-02	5.32E-02	5.11E-02	5.13E-02	5.06E-02	5.64E-02	5.73E-02	5.08E-02	4.83E-02	4.98E
15Years	6.10E-02	4.34E-02	4.53E-02	4.35E-02	4.40E-02	4.34E-02	4.74E-02	4.81E-02	4.18E-02	4.10E-02	4.22E
10Years	4.72E-02	3.36E-02	3.48E-02	3.37E-02	3.41E-02	3.29E-02	3.82E-02	3.52E-02	3.18E-02	3.17E-02	3.10E
5Years	2.56E-02	1.86E-02	1.92E-02	1.87E-02	1.88E-02	1.76E-02	2.26E-02	1.75E-02	1.83E-02	1.74E-02	1.57E
1Year	6.96E-03	5.01E-03	5.17E-03	5.11E-03	5.13E-03	4.48E-03	7.04E-03	3.20E-03	4.19E-03	4.46E-03	3.20E
3Months	8.96E-03	6.70E-03	6.31E-03	6.63E-03	6.81E-03	5.76E-03	7.15E-03	4.36E-03	5.43E-03	5.91E-03	4.20E

4. Results and Discussion (Cont'd)

Annual dose limit [mSv/yr] from contribution of Atmospheric and Aquatic Dispersion

Effluents	Category	Annual Dose Limit
Gaseous	Atmospheric Dispersion	1×10^{-1}
Liquid	Aquatic Dispersion	1×10^{-1}
Others	Reserves: Experimental Power Reactor (RDE)	1×10^{-1}
	Total Amount	3×10^{-1}

The effective dose to the public members living around the nuclear reactor should be lower than the annual dose limits.

The effective doses to the public members in consequence of radioactive effluents released from RSG-GAS reactor met both the effective dose limit permit and the BAPETEN on the regulation of standard effective dose.

4. Results and Discussion (Cont'd)

Comparison Result with the Other Country

Country	Nuclear Reactor	Periods	Assessment Result [mSv/yr]
Indonesia	Research Reactor: ~ G. A. Siwabessy Reactor	2016-2017	10^{-2} to 10^{-3}
Korea	Nuclear Power Plant: ~ Hanbit, ~ Kori, ~ Wolsong, ~ and Hannul	2011-2015	10^{-2} to 10^{-3}
Vietnam	Nuclear Power Plant: ~ Ninh Thuan 1	2009-2013	10^{-2} to 10^{-5}

4. Conclusions

The averages of the effective doses to the public members living around RSG-GAS Nuclear Research Reactor in 2016-2017 were approximately on the range order between 10^{-2} to 10^{-3} mSv and the resulting effective doses were much less than dose limits on the order 10^{-1} mSv.

The annual effective doses to the public members from radioactive effluents released from RSG-GAS Nuclear Research Reactor under normal operating conditions are taken into account insignificant when compared to the dose limit permit or even the radiation dose of natural background while the public doses have been practically kept at greatly low levels.

5. Acknowledgment

The authors acknowledge to KINS for the Computer Code INDAC 2.1 supporting throughout this work.

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Terima Kasih

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