Quantification of chronic inhaled exposure induced by dioxin emissions from some municipal waste incinerator using Monte-Carlo simulation

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1. Introduction

Combustion processes are presently regarded as the one of important environmental emission sources of dioxin. It is continuously rising to concern about the health risk being induced by dioxin from people living close to the municipal waste incinerator. Regulation of dioxin in management point related with incinerator also is very important including pollutants such as heavy metal, chlorinated phenols and polyaromatic hydrocarbons.[1)]

This paper was conducted to estimate the impact distance of dioxin discharged from one of municipal solid waste(MSW) incinerator site which is located at Mokdong, Seoul using a Gaussian plume dispersion model, and to quantify the chronic inhaled dioxin exposure using Monte-Carlo simulation with calculating the cancer risk caused by dioxin inhalation.

2. Emission Data

It was used emission data of dioxin that have monitored the MSW incinerator built in the metropolitan area of Seoul by Environment Research Center, Korea Institute of Science and Technology.[2)] The average dioxin emission value of the MSW incinerator was 3.98 ng TEQ/Nm^3

calculated using toxicity equivalent factor proposed by U.S.EPA (1989).[3)] The capacity of some MSW incinerator was 150 ton/day and the method of incineration is VonRoll stoker. The 5 years(1990-1994) average meteological data including temperature, wind speed, wind direction et al. was used for the dispersion model.

3. Dispersion Modeling

To estimate the impact distance of dioxin discharged from incinerator, it was used dispersion model, ISC-LT (Industrial Source Complex long-term).[4)] Dioxin was regarded as particulate matter and it was estimated ground-level atmospheric dioxin as dry deposition. Range of estimated dilution rate by distance from incinerator were 1.25×10^5 - 9.3×10^6. Figure 1 summarizes the annual average concentrations simulated by ISC-LT. There is some along-river to the east of the stack and the residential area is centering around the incinerator. Dispersion model requested input concentration of dioxin in condition of 110 ℃ incinerator temperature. Thus, it was revised 3.98ngTEQ/Nm^3 to the 2.83ng/Nm^3 in condition of 110 ℃ as follows ; 3.98ng/Nm^3 × [273/(273+110)]℃ = 2.83ng/m^3 (Nm^3 ; at 0 ℃, 1013mb)

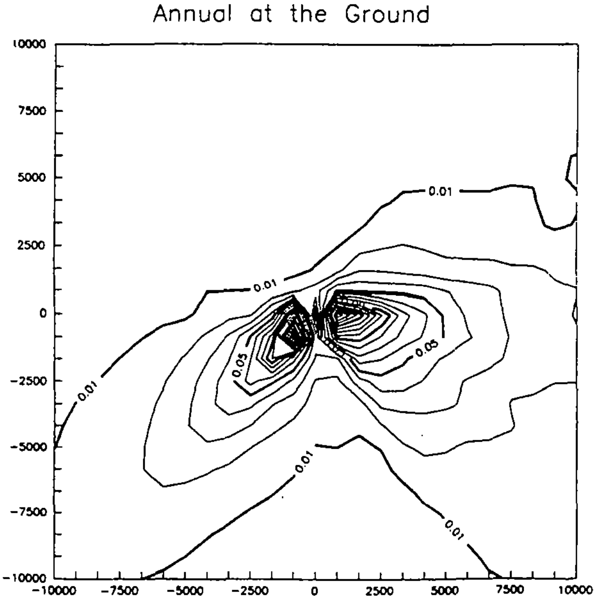

Figure 1. Annual average concentration (ug/m^3) for the incinerator stack (ISC-LT, at ground level - weighted pollutant distribution). Modeling domain out to 50 km is displayed.

4. Quantification of chronic inhaled exposure

For the quantification of chronic inhaled intake, it was used various exposure parameter such as body weight, lifetime, exposure duration and inhaled air volume to the subject of healthy adult using Monte-Carlo simulation.[5,6] The exposure duration of 10 years was applied to exposure scenario settle through considering operation years of incinerator. The body weight (mean 70kg) and inhaled air volume (mean $20m^3$/day) were used as distribution value after simulation of mean $\pm$ 10% range. Figure 2 illustrates basic type of Monte-Carlo simulation and the percentile value of chronic daily intake (CDI) by distance is shown in Table 1. The range CDI value of percentile 95 was from 1.12×10^{-3} pg/kg/day(highest) to 1.56×10^{-5} pg/kg/day (lowest)

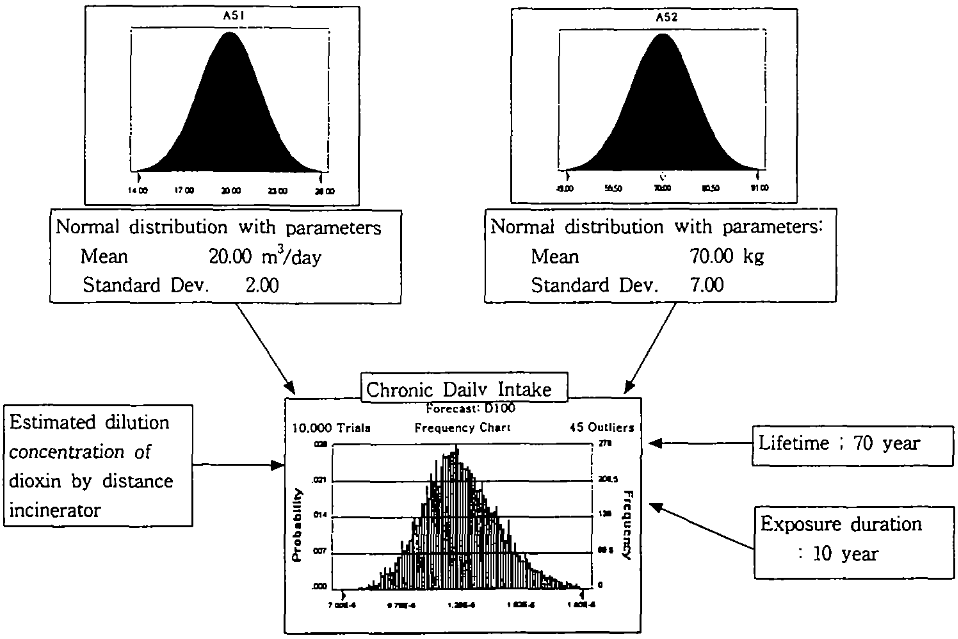

Figure 2. Various parameter using for estimation of chronic daily intake in Monte-Carlo simulation

5. Calculation of cancer risk

Dioxin, classified as group B2 (probable human carcinogen) from IRIS, have shown lung, tongue and skin cancer in animal test and liver, respiratory system and skin cancer in human.[7,8,9] It was proposed $Q1^*$ respiratory value of dioxin, $1.5^6 \times 10^5$(mg/kg/day)$^{-1}$, as geometric mean value

of 1.51 $\times$ 10^5(mg/kg/day)$^{-1}$ from Kociba et al.(1978) and 1.61 $\times$ 10^5(mg/kg/day)$^{-1}$ from Squire(1980) by U.S.EPA(1985) using multistage model[7,10,11]
The actually absortion rate of 75%, as internal absorption rate to the total inhaled exposure, was also conducted for the calculation. Therefore, it was used Q_1* respiratory value(1.17 $\times$ 10^5(mg/kg/day)$^{-1}$ = 1.56 $\times$ 10^5(mg/kg/day)$^{-1}$ $\times$ 0.75) for the calculation of cancer risk.[11] Table 2 summarized percentile value calculated excess cancer risk to the lung, tongue, and skin cancer by distance from incinerator. The range of excess cancer risk value of percentile 95 was from 1.31 $\times$ 10^{-7} to 1.83 $\times$ 10^{-9}

6. Conclusion

The highest CDI value of percentile 95 was 1.12 $\times$ 10^{-3} pg/kg/day in modeling domain out to 50km from incinerator and then, the calculated excess cancer risk value to lung, tongue, and skin cancer was 1.31 $\times$ 10^{-7}. Generally, it was regarded that carcinogenic chemical should be controlled below 1 $\times$ 10^{-6} of excess risk value in veiw of risk specialist. Therefore, this value is regarded as negligible level in management aspect.

7. Reference

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Table 1. Percentile value to the chronic daily intake of dioxin by distance from some municiple waste incinerator

Percentile CDI value / By distance from incinerator(m)	Chronic daily intake (pg/kg/day)				
	5%	25%	50%	75%	95%
100	9.80×10^{-6}	1.13×10^{-5}	1.24×10^{-5}	1.36×10^{-5}	1.56×10^{-5}
200	3.69×10^{-4}	4.25×10^{-4}	4.67×10^{-4}	5.14×10^{-4}	5.90×10^{-4}
300	5.70×10^{-4}	6.55×10^{-4}	7.20×10^{-4}	7.93×10^{-4}	9.10×10^{-4}
400	6.65×10^{-4}	7.64×10^{-4}	8.40×10^{-4}	9.26×10^{-4}	1.06×10^{-3}
500	6.99×10^{-4}	8.03×10^{-4}	8.84×10^{-4}	9.74×10^{-4}	1.12×10^{-3}
1000	5.69×10^{-4}	6.54×10^{-4}	7.20×10^{-4}	7.93×10^{-4}	9.09×10^{-4}
2500	3.65×10^{-4}	4.20×10^{-4}	4.62×10^{-4}	5.09×10^{-4}	5.83×10^{-4}
7500	1.74×10^{-4}	2.00×10^{-4}	2.20×10^{-4}	2.42×10^{-4}	2.77×10^{-4}
40000	4.45×10^{-5}	5.11×10^{-5}	5.62×10^{-5}	6.19×10^{-5}	7.10×10^{-5}
50000	3.95×10^{-5}	4.54×10^{-5}	5.00×10^{-5}	5.51×10^{-5}	6.31×10^{-5}

Table 2. Percentile value to the excess cancer risk induced by dioxin inhalation from some municiple waste incinerator(based on lung, tongue and skin cancer incidence)

Percentile CDI value / By distance from incinerator(m)	Chronic daily intake (pg/kg/day)				
	5%	25%	50%	75%	95%
100	1.15×10^{-9}	1.32×10^{-9}	1.45×10^{-9}	1.60×10^{-9}	1.83×10^{-9}
200	4.32×10^{-8}	4.97×10^{-8}	5.46×10^{-8}	6.02×10^{-8}	6.90×10^{-8}
300	6.67×10^{-8}	7.66×10^{-8}	8.43×10^{-8}	9.28×10^{-8}	1.06×10^{-7}
400	7.78×10^{-8}	8.94×10^{-8}	9.83×10^{-8}	1.08×10^{-7}	1.24×10^{-7}
500	8.18×10^{-8}	9.40×10^{-7}	1.03×10^{-7}	1.14×10^{-7}	1.31×10^{-7}
1000	6.66×10^{-8}	7.66×10^{-8}	8.42×10^{-8}	9.28×10^{-8}	1.06×10^{-7}
2500	4.27×10^{-8}	4.91×10^{-8}	5.40×10^{-8}	5.95×10^{-8}	6.82×10^{-8}
7500	2.03×10^{-8}	2.34×10^{-8}	2.57×10^{-8}	2.83×10^{-8}	3.25×10^{-8}
40000	5.20×10^{-9}	5.98×10^{-9}	6.58×10^{-9}	7.25×10^{-9}	8.31×10^{-9}
50000	4.63×10^{-9}	5.32×10^{-9}	5.85×10^{-9}	6.44×10^{-9}	7.39×10^{-9}