DEVELOPMENT OF HEALTH RISK ASSESSMENT SYSTEM FOR INTEGRATED ENVIRONMENTAL MANAGEMENT OF PAHs (POLYCYCLIC AROMATIC HYDROCARBONS) AT INDUSTRIAL AREAS IN KOREA

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Introduction

Health risk assessment is a process of estimating the qualitative and quantitative effects that might occur when a person is exposed to environmental hazards. The ultimate objective of risk assessment is to provide rational and scientific information for risk management, especially in the areas of environmental policy making and regulatory control. The objectives of this study were to develop available ‘system software’ in health risk assessment of POPs (Persistence Organic Pollutants) such as PAHs (Polycyclic Aromatic Hydrocarbons) for multimedia and multiroute scenarios and to serve it as Decision Support System (DSS) for effective management of environmental risk in industrial areas in Korea. We planed to develop a prototype of system software in the phase I (2001~2004) and generic type of that including Geographical Information System (GIS) in the phase II (2004~2007).

Materials and Methods

1) Development of multimedia and multiroute health risk assessment (MM-HRA) model for DDS

We developed the user-friendly software for estimating integrated health risk through multimedia and multiroute of 16 PAHs (Acenaphthene, Acenaphthylene, Anthracene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)flouranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-cd)pyrene, Naphthalene, Phenanthrene, Pyrene) (figure 1 (a)). The MM-HRA model has been constructed to environmental fate module and estimating health risk module. The environmental fate module at the MM-HRA model has been designed to have dynamic mass balance equations concerning the partitioning, transport, and removal process at unsteady state. The environmental fate module comprises the drainage basins (area less thant 5km*5km), including five bulk compartments (air, water, sediment, soil, and vegetation) (Figure 1 (b)). The multimedia and multiroute health risk module at MM-HRA model could estimate health risks from human exposure considering environmental multimedia (ambient air, indoor air, surface water, drinking water, and ground soil) and 12 multiroute via ingestion, inhalation, and dermal contact

(Figure 1 (C)). The risk estimated module could evaluate individual and population risk.

We have established the several databases for MM-HRA model that physico-chemical properties of 14 PAHs, metrological data and geographical information for environmental fate module, and toxicological data, dose-response relationship date, demographic information at study area and human exposure factors in Korea for health risk module.

2) MM-HRA model evaluation

The MM-HRA model was evaluated using concentration of four PAHs of three, four, five, and six rings (i.e. Phenathrene, Pyrene, Benzo(a)pyrene, and Benzo(g,h,i)perylene, respectively) in environmental media at the Sihwa/Banwol-complex industry and the Deagu-dyeing industry study area. In sampling area, the multimedia concentrations of PAHs were monitored and parameters for model evaluation were measured for 3 years from 2001 to 2003. The PAHs analysis, quality assurance, and control methods were based on the GERG Trace Organics Contaminant Analytical Techniques of the US NOAA (NOAA, 1993).

3) MM-HRA model application to industrial complexes in Korea

The MM-HRA model domain included 5 industrial complexes area (Sihwa/Banwol-complex industry, Deagu-dyeing industry, Inchon-chemical complex industry, Ulsan-petrochemical industry, Pohwang-iron&steel industry, and Kwangyang-steel industry). In this study, the estimation of the 16 PAHs was performed using the source-oriented on the basis of emission factors and activity levels (Table 1).

Results and discussion

1) MM-HRA model evaluation

The predictability of the model was evaluated by comparing the predicted values and the measured ones of the concentrations and the relative concentrations. In the Sihwa/Banwol-complex industry and the Deagu-dyeing industry study area, the predicted relative concentrations for PAHs agreed with the measured within one or two orders of magnitude (Figure 2). The predicted relative concentrations for the vegetation, sediment, soil tended to be overestimate, while the predicted were lower than the measured for the gas and particles phases.

2) MM-HRA model application to industrial complexes in Korea

For risk evaluation to 16 PAHs, we used the simulated data by the multimedia fate model and field monitoring data in study areas. The level of individual excess cancer risk was $3.6*10^{-3}$ at the Ulsan (petrochemical industrial complex city) was higher than that of the other areas (Figure 3). The levels of individual excess cancer risk for the Deagu and Inchon industrial cities were $8.8*10^{-6}$ and $3.1*10^{-6}$ respectively. The levels of individual excess cancer risk for rest areas were lower than $1.0*10^{-6}$. The population of Ulsan city was about 28 hundreds thousand, and the level of population excess cancer risk was 14 persons per year at the Ulsan city. The levels of population excess cancer risk were lower than 0.01 persons per year at the other areas. The benzo(a)pyrene (about 67% to PAHs concentration) was the predominant PAH and the total PAHs in ambient air and ground soil were the predominant pollutants at Ulsan city.

The developed MM-HRA model can prevent environmental accidents induced chemicals used in local regions. Priority for health risk would be listed in terms of regions, media, and chemicals based on the health risk assessment model. The MM-HRA model is available identification and management for environmental pollutants and can be more efficiently and reasonably resource allocation more for risk management.

References

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Table 1. Emission rate for 16 PAHs in study areas

PAHs	Emission rate in the ambient air (kg/year)					
	Sihwa/Banwol	Deagu	Inchon	Ulsan	Pohwang	Kwangyang
Acenaphthene	0	1	0	2	0	0
Acenaphthylene	5	8	50	48	4	4
Anthracene	60	75	126	363	18	27
Benzo(a)anthracene	16	29	34	20	8	11
Benzo(a)pyrene	9	21	40	88	5	8
Benzo(b)flouranthene	67	98	52	206	11	3
Benzo(g,h,i)perylene	9	21	32	80	5	8
Benzo(k)fluoranthene	25	98	51	203	0	11
Chrysene	21	38	39	41	10	15
Dibenz(a,h)anthracene	0	0	0	1	0	0
Fluoranthene	65	135	3,179	1,646	43	700
Fluorene	3	3	4	24	1	2
Indeno(1,2,3-cd)pyrene	5	11	10	8	3	4
Naphthalene	1,534	2,347	3,198	14,638	815	1,279
Phenanthrene	211	453	10,343	59,911	145	169
Pyrene	51	101	869	4,393	24	37

(a) Main MM-HRA (b) Environmental fate module (c) Health risk assessment module

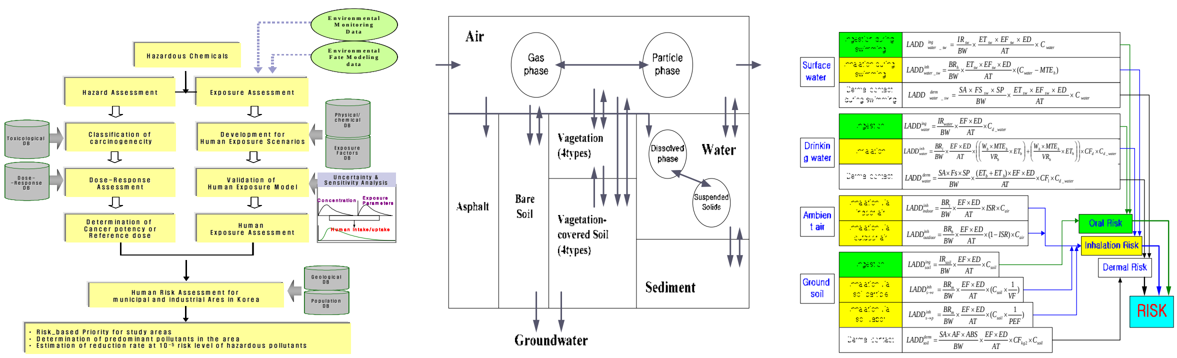


Figure 1. Main flowchart and algorism for MM-HRA

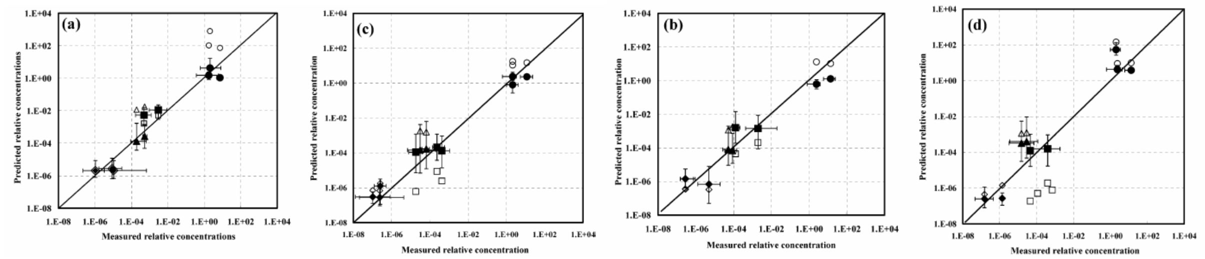
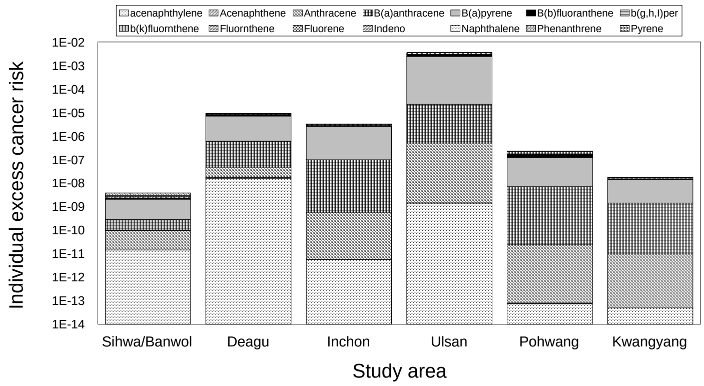


Figure 2. Comparisons of the relative concentrations between the measured and the predicted before (open symbols) and after (closed symbols) calibration for (a) phenanthrene, (b) pyrene, (c) benzo(a)pyrene, and (d) benzo(g,h,i) perlyene. (◆/◇) C_{air}/C_{soil}, (■/□) $C_{dissolved}/C_{soil}$, (▲/△) $C_{suspended\ solids}/C_{soil}$, and (●/○) $C_{sediment}/C_{soil}$ (C_i denotes the concentration in medium i, in mol/m^3). Error bar denotes the concentration ranges.

(a) individual risk



(b) population risk

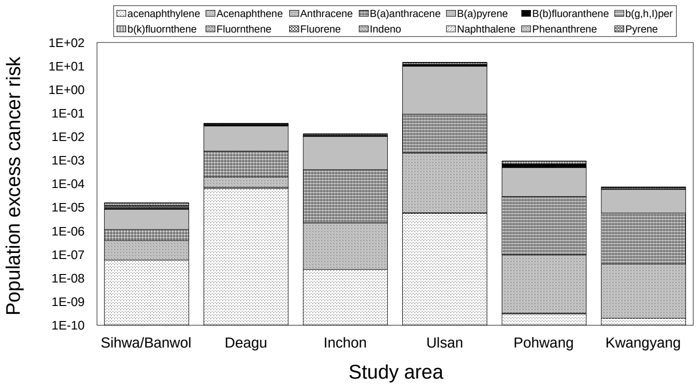


Figure 3. Comparisons of health risk for PAHs in the study areas using the MM-HRA model