HUMAN HEALTH RISK ASSESSMENT FOR MANAGEMENT OF PCB-CONTAMINATED TRASFOMER OIL

YW Lim[1], JY Yang[1], YJ Lee[1], JS Jung[2], JY Kim[2], DC Shin[3]

[1]Institute for Environmental Research, Yonsei University College of Medicine, P.O. Box 8044, Seoul, Korea, [2]Korea Institute of Science and Technology, Seoul, Korea, [3]Department of Preventive Medicine, Yonsei University College of Medicine, P.O. Box 8044, Seoul, Korea

Introduction

PCBs had numerous uses such as hydraulic fluid, heat exchange fluid, sealant, lubricant, and carbonless copy paper. They are most likely found in electric utilities, power stations, industrial facilities, electronic manufacturing plants, petrochemical plants, railroad systems, electric equipment repair facilities, mining sites (active or abandoned), and military camps. Due to their outstanding chemical and thermal stabilities and electrical insulation properties, the commercial and industrial products of PCBs, such as Aroclors, Kaneclors, Clophens, Phenaclors etc., had been widely used as thermal oil and transformer oil from 1930s until the 1970s.

Transformer and capacitor are two major dominant sources of PCBs; therefore, transformer and capacitor are the highest priority to investigate. PCBs were ubiquitously found in the environment and even in many kinds of food since these were widely used in various industrial applications.[1,2,3] The widespread release of PCBs into the environment presents a serious problem due to their persistency and toxicity. PCBs are industrial chemicals adopted for use in electrical appliances such as electrical transformers, capacitors and thermal oil.[4]

Approximately, 61% of PCBs are in electrical transformers still in use, another 12% in electrical capacitors and 27% in storage waiting for disposal. Therefore, electrical transformers are considered to be one of the sources of environmental contamination by PCBs. Furthermore, in developing countries, transformer oils are one of the major sources of PCB release to the environment. Analysis of soil collected from under transformers showed greater PCB concentrations than soil and sediment collected from other regions.[5]

In 1999, Republic of Korea the Environmental Law regarding PCBs in transformer oil limit was changed from 50 mg/L to 2 mg/L for liquid waste.[6] According to the Stockholm Convention on Persistent Organic Pollutant (POPs) entered into force on May 17, 2004, the Ministry of Environment in Korea started new survey on PCBs concentration existing transformers at Power station, and launched an initiative to set up a project on environmental sound management of end-of-life transformer oils with regard to the elimination of the use of PCBs in equipment by 2015.[7]

In this study, we collected data of PCBs concentration from multi media and modeled their future concentration by transformer oil limit using half-life model and also we assessed health risk from modeled data for management of PCB-containing waste.

Materials and Methods

We used the transformer survey results of the electric power station, including information regarding transformer type, manufacture's name, country of manufacture and year of manadfacture.[8] And we collected PCBs concentration data in each media from NIER national survey project.[9]

Table 1. Environmental concentration of PCBs from NIER data

PCBs	Years	Water (μg/L)	Sediment (μg/kg)	Soil (μg/kg)
Total PCBs	2000	ND(<0.01)	ND(<0.05)	ND(<0.05) ˜ 1.2
	2001	ND(<0.1)	ND(<0.5) ˜ <0.5	ND(<0.5) ˜ 1.7
	2002	ND(<0.1)	ND(<0.5) ˜ 3.9	ND(<0.5) ˜ 2.6
	2003	ND(<0.1)	ND(<0.5)	ND(<0.5) ˜ 1.6

	2004	ND(<0.01)	ND(<1.0) ~ 1.00	ND(<1.0)

To predict environmental concentration of PCBs in future regulation, we accepted half-life model from study of Schneider.[10] In this study, author assessed the half-life of PCBs in ambient air, water and sediment, and the results was 6 years for ambient air, 4 years for water, and 22 years for sediments.

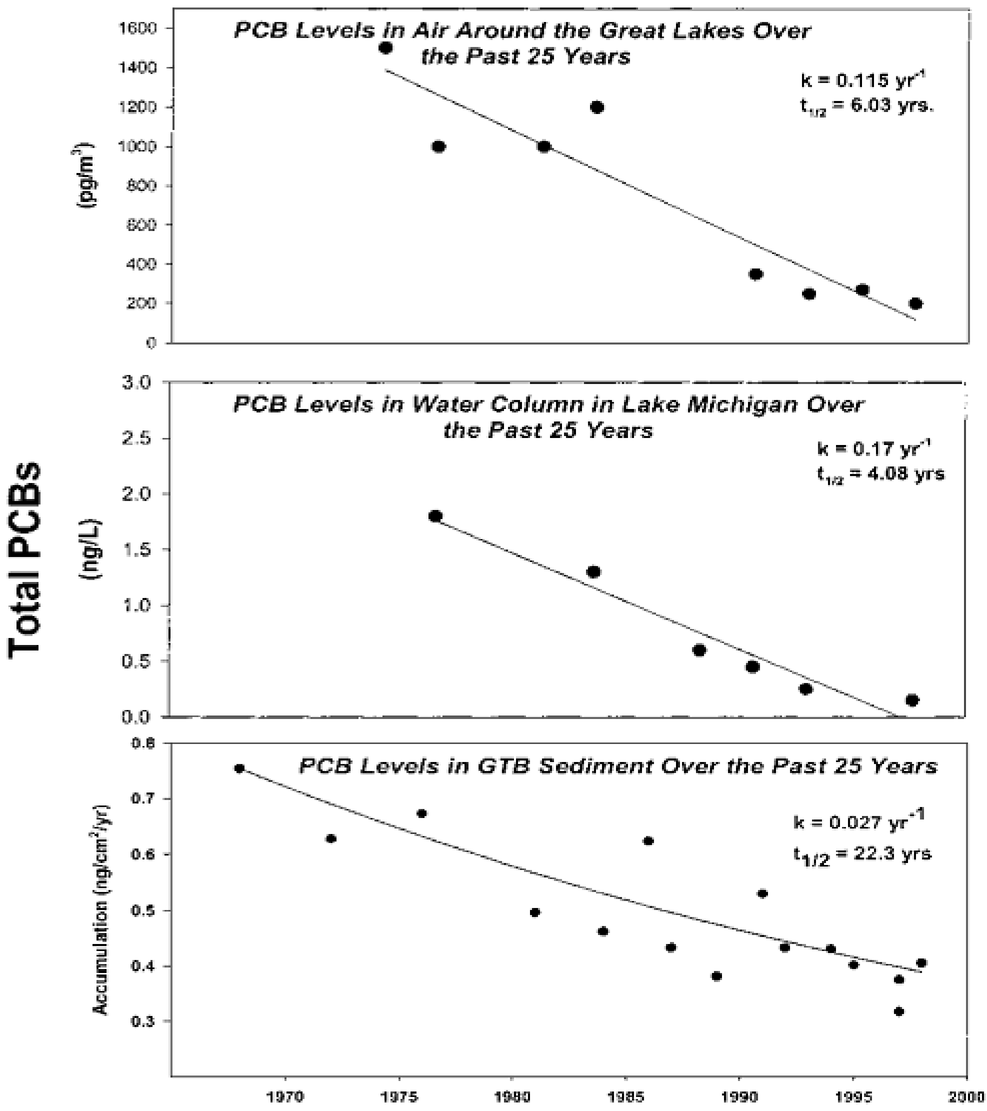

Figure 1. Total PCB concentrations over the past 25 years and their associated rate of decline in the air, water, and sediment (Schneider et al., 2001).

Using Schneider's method, we calculated half-life of each regulation scenario(50 ppm vs. 2 ppm). The half-life of ambient air PCBs was 20 years for regulation 50 ppm, and 6.03 years for regulation in 2ppm. And half-life of water PCBs was 12 years for regulation 50 ppm, and 4.08 years for regulation 2 ppm. Also we calculated half-life year of sediment and soil.

Table 2. Half-life year of PCBs for environmental media from each regulation scenario

Regulation	Air	Water	Soil
50 ppm	20	12	67
2 ppm	6.03	4.08	22.3

We estimated exposure to PCBs and the consequent health risk by using the equations originally presented by US EPA. The lifetime average daily dose(LADD) was calculated for each exposure route, and incremental cancer risk was further defined by multiplying the LADD by the cancer slope factor. In selecting the parameters for the exposure calculation, we primarily followed the recommendations presented by the US EPA data.
And for uncertainty analysis, we used Monte Carlo simulation from Crystall 2000 program.

Results and Discussion
We used half-life model from Schnider to predict environmental concentration of PCBs from each regulation scenario (50 ppm / 2 ppm).

Table 3. Environmental concentration of PCBs using half-life year model

Regulations		Air(pg/m^3)	Water(ng/L)	Soil(ng/g)
50 ppm	Concentration (2005)	148.23	27.5	1.67
	Predicted concentration (2015)	104.79	15.4	1.50
2 ppm	Concentration (2005)	148.23	27.5	1.67
	Predicted concentration (2015)	46.68	4.9	1.22

In health risk assessment, we used US EPA's cancer potency factor and calculated lifetime average daily dose. According to our calculations, the cancer risk of ambient air PCBs was 1.48e-8 now, but if regulation limit maintained of 50 ppm, the future cancer risk reduced by 1.05e-8, and if regulation limit strengthened of 2 ppm, the future cancer risk reduced by 4.67e-9. The cancer risk of water PCBs was 2.75e-7 now, but if regulation limit strengthened of 2 ppm, the future cancer risk reduced by 4.90e-8. And the cancer risk of soil PCBs was 1.17e-9 now, but if regulation limit strengthened of 2 ppm, the future cancer risk reduced by 8.54e-10.

Table 4. Risk reduction of regulation limit

Regulations		Air	Water	Soil
50 ppm	Cancer risk (2005)	1.48e-8	2.75e-7	1.17e-9
	Cancer risk (2015)	1.05e-8	1.54e-7	1.05e-9
2 ppm	Cancer risk (2005)	1.48e-8	2.75e-7	1.17e-9
	Cancer risk (2015)	4.67e-9	4.90e-8	8.54e-10

Acknowledgement
This study was supported by the PCBs research project from KIEST (Korea Institute of Environmental Science and Technology) and MOE(Ministry of Environment, Republic of Korea).

References
1. Hutzinger O, Safe S, Zitko V. *The Chemistry of PCBs*. CRC Press, Cleveland, OH, 1974
2. Schecter A, Li L. *Chemosphere* 1997;34:1449
3. Abad E, Llerena J, Saulo J, Caixach J, Rivera J. Chemosphere 2002;46:1435
4. NAS. Polychlorinated biphenyls. Nat. Res. Coun., Nat. Acad. Sci., Washington DC, 1979
5. Senthil Kumar K, Kannan K, Subramanian A, Tanabe S. *Environ. Sci. Pollut. Res.* 2001;8:35
6. Shin SK, Kim HJ, Chung D, Kim JK, Kim KS, Chung YH, Chung IR, *A study on the Appropriate Management of PCBs-Containing Wastes*, NIER, Republic of Korea, 2003
7. Ministry of Environment in Korea. *Management of Waste Act*, 2004
8. Shin SK, Kim TS. *Journal of Hazardous Materials*. 2006;proceeding
9. NIER. EDCs national monitoring
10. Schneider AR, Stapleton HM, Cornwell J, Baker JE. *Environ. Sci. Technol*. 2001;35:3809