Journal of Risk Research

ISSN: 1366-9877 (Print) 1466-4461 (Online) Journal homepage: www.tandfonline.com/journals/rjrr20

The regulations for indoor air pollution in Japan: a public health perspective

Kenichi Azuma, Iwao Uchiyama & Koichi Ikeda

Journal of Risk Research
Vol. 11, No. 3, April 2008, 301–314

Routledge
Taylor & Francis Group

The regulations for indoor air pollution in Japan: a public health perspective

Kenichi Azuma[a]*, Iwao Uchiyama[b] and Koichi Ikeda[a]

[a]*Department of Architectural Hygiene and Housing, National Institute of Public Health, Tokyo, Japan;* [b]*Department of Urban and Environmental Engineering, Graduate School of Engineering, Kyoto University, Kyoto, Japan*

In recent years public health problems caused by indoor air pollution, known as 'Sick Building Syndrome in housing', or 'Sick House Syndrome' in Japan, have been drawing strong public concern. After conducting extensive exposure assessment, government authorities have taken effective measures to solve the problem. However, as a result of diversification and increase in quantities of industrial chemicals, existing regulations do not cover enough ranges of various potential hazardous chemicals. Hence, the regulations seek to be changed from hazard-based regulation to a risk-based one. Good indoor air quality (IAQ), which does not pose unacceptable health risks from all pollutants affecting indoor air, should be ensured for all public people. The objective of this study is to clarify the remaining issues to be solved urgently, related to the regulations to ensure a good IAQ. We reviewed enormous numbers of the existing governmental and industrial voluntary standards and/or guidelines, literature and documents concerning IAQ research in the past 40 years. Our results showed six subjects from those remaining issues. Based on these subjects we created a new scheme to control the IAQ; we especially regarded a comprehensive labeling system as one of the important strategies.

Keywords: regulation; indoor air pollution; indoor air quality; health risk; risk-based regulation

Introduction

In recent years public health problems caused by indoor air pollution, known as 'Sick Building Syndrome in housing', called 'Sick House Syndrome' in Japan, have received strong public concern in Japan. The major symptoms of sick house syndrome are irritations to the eyes, nose and throat, headache, nausea and dizziness, which are manifested indoors, while the symptoms disappeared outdoors. The Ministry of Health, Labour and Welfare (MHLW 2000a) reported that the main causes of these symptoms are indoor air pollutants emitted from building materials used in airtight buildings.

After conducting extensive exposure assessment in Japan, government authorities have taken effective measures to solve the problem. For instance, they established 'Guidelines for indoor air quality (IAQ)'. They also revised the National Building Codes and set the formaldehyde emission standards in order to regulate building materials. Reflecting the governmental actions, industry organizations also established voluntary standards and guidelines. However, as a result of diversification and increase in quantities of industrial chemicals, existing regulations do not

*Corresponding author. Email: azuma@kcn.ne.jp

ISSN 1366-9877 print/ISSN 1466-4461 online

DOI: 10.1080/13669870801967119
http://www.informaworld.com

cover enough ranges of various potentially hazardous chemicals. Hence, the regulations seek to be changed from hazard-based regulation to a risk-based one.

People in modern societies spend most of their time in indoor spaces. Most exposure to indoor air occurs in individual homes, where intervention by public regulation is often considered a violation of personal freedom. The inadequate quality of indoor air causes unacceptable health risks for public people, which also include groups vulnerable to chemicals, e.g., infants, elderly people, people with allergies or respiratory illnesses, etc. Therefore good IAQ, that could be healthy and comfortable for occupants, should be ensured. Good IAQ means indoor air quality that would not pose unacceptable health risks from all pollutants affecting indoor air for all public people.

Based on these insights the objective of this study is to clarify the remaining issues needing to be solved urgently, related to the existing regulations for indoor air pollution in Japan, to ensure a good IAQ. We are also aiming at proposing new administrative tactics and strategies, and research subjects on the improvements in IAQ. We reviewed enormous numbers of the existing governmental and industrial voluntary standards and/or guidelines. We also referred to literature and documents concerning IAQ research in the past 40 years. Examining all those literatures and documents, we mapped out the seven issues for good IAQ that are named in alphabetical order from 'Issue A' to 'Issue G'.

Historical background of indoor air pollution in Japan

The regulation for the termiticides - chlordane or chlordane compounds (Issue A)

In accordance with development of pesticides after World War II, the organo-chlorinated pesticides, e.g., chlordane or dieldrin, which had strong pest control and high persistent property in environment, were used for the termiticides in housing. The manufacture, importation or usage of chlordane or chlordane compounds were banned in 1986 because regulation for chemicals that had high persistent property and high bioaccumulation, and might be harmful to human health when ingested continuously, was established in 1973.

The Japanese Termite Countermeasures Association (JTCA 1988) reported that the consumption ratios of termiticides were approximately 76% for chlorpyrifos; and approximately 14% for phoxim. The termiticides had been mainly replaced with chlorpyrifos by the regulation for chlordane or chlordane compounds. The Ministry of Land, Infrastructure and Transport (MLIT) revised the National Building Codes in 2002, and banned the use of chlorpyrifos in buildings having habitable rooms, because chlorpyrifos was widely used in Japan and lots of health hazard cases were reported. This history showed the vicious cycle that once certain chemicals were regulated and the risks were reduced, they were replaced with other substitute chemicals, and then new unacceptable risks by the substitute chemicals appeared, and these chemicals were regulated after that. Hence, we should develop preventive measures which do not create new unacceptable risks from substitute chemicals.

The national field surveys and establishments of the indoor air quality guideline - 1990s (Issue B)

Ando (1997a) showed that indoor formaldehyde concentrations exceeded 0.1 mg/m^3 (0.08 ppm) for more than 25% of 230 houses which was the air quality guideline by the World Health Organization Regional Office for Europe (WHO Europe 1987). Hence, the Ministry of Health and Welfare (MHW 1997; MHLW from January 2000) established a guideline value of 0.1 mg/m^3 (0.08 ppm) for indoor formaldehyde concentration in 1997, which was based on the toxicity endpoint of nose and throat irritation in humans.

In addition, the MHW (1999) reported a national field survey on air concentrations of 44 volatile organic compounds (VOCs) in 180 houses in 1997 and 205 houses in 1998. These VOCs were widely used for the solvents of adhesives or paints, insect deterrents or deodorants, etc. The MHW reported the results of the survey as follows. 1) The ratios of the indoor VOCs concentration to the outdoor (I/O) were high on the whole; 2) Approximately 5% of the surveyed houses exceeded the tolerable average concentration level for p-dichlorobenzene established by MHW; 3) Approximately 6% of the surveyed houses exceeded the air quality guideline for Toluene established by WHO Europe (1987).

Based on this report, the MHLW (2000a, b, 2001, 2002) established guideline values for indoor air concentration of 12 chemicals in addition to formaldehyde and a tentative target value for total volatile organic compound (TVOC) as shown in Table 1. The guideline values for indoor air concentration mean that, according to the currently available scientific knowledge, no adverse health effects would occur to human health, even if exposure to the chemical at the level continued during the lifetime.

In order to decide the priority rating of the indoor air pollutants, and which guideline values should be established, the following six criteria (MHLW 2000a) were considered.

(1) Guideline values for indoor air pollutants have already been given by other government authorities or international organizations; e.g., WHO Air Quality Guideline (WHO 2000).

Table 1. The guideline values for indoor air pollutants.

Chemicals	Guideline value for indoor air concentration (μg/m^3)	Date
Formaldehyde	100 (0.08)	1997.6.13
Toluene[1), 2)]	260 (0.07)	2000.6.26
Xylene[1), 2)]	870 (0.2)	2000.6.26
p-Dichlorobenzene[1), 2)]	240 (0.04)	2000.6.26
Ethylbenzene[1), 2), 3)]	3800 (0.88)	2000.12.15
Styrene[1), 2)]	220 (0.05)	2000.12.15
Chlorpyrifos[4), 5)]	1 (0.00007) for children: 0.1 (0.000007)	2000.12.15
Di-n-butyl phthalate[1), 3), 5)]	220 (0.02)	2000.12.15
Tetradecan[2), 6)]	330 (0.04)	2001.7.5
Di-(2-ethylhexyl) phthalate[3), 5)]	120 (0.0076)	2001.7.5
Diazinone[4), 5)]	0.29 (0.00002)	2001.7.5
Acetaldehyde[1), 2)]	48 (0.03)	2002.1.22
Fenobucarb[3), 5)]	33 (0.0038)	2002.1.22
Nonanal[2), 6)]	Interium value: 41 (0.007)	ongoing
TVOC[1), 3)]	Tentative target value: 400	2000.12.15

1)–6): criteria for priority; ( )ppm: volume concentration at 25°C.

(2) Indoor air pollutants, of which indoor air concentrations have been higher than outdoor, because of the apparent indoor emission sources by the national field survey in residential environment.
(3) There are many complaints from public comments; e.g., TVOC.
(4) New regulations for indoor air pollutants are already established by other foreign governments; e.g., chlorpyrifos or diazinone.
(5) Covering major uses of chemicals in constructions; e.g., solvents, adhesives, insecticides, plasticizers or termiticides.
(6) Covering major chemical structural categories of VOCs; e.g., aldehydes, ketones, aromatic hydrocarbons, halocarbons, alkanes, terpenes, esters or alcohols.

The priority rating should be evaluated by a health risk-based method. Guideline values should also be established for the indoor air pollutants that were evaluated to have unacceptable risks according to the current available risk assessment results. However, in response to complex and difficult situations that had come from a great public concern about indoor air pollution, the MHLW had to implement rapid and effective measures. Therefore, the priority rating was not adequately considered the health risk scale of the indoor air pollutants. Hence, we should develop classifications and countermeasures for indoor air pollutants by health risk assessment so that the pollutants having unacceptable risks for public people are regulated.

Approach to a tentative target value of TVOC (Issue C)

The MHLW (2000b) established a tentative target value of TVOC in indoor air. The TVOC indicates a total amount of individual VOC that is identified from the chromatographic curve of gas chromatography/mass spectrometry (GC/MS) from n-hexane (boiling point, 69°C) to n-hexadecane (boiling point, 287°C).

The individual VOC guideline values were based on the current available toxicological data. However, a number of VOCs were detected in indoor air (MHW 1999), therefore establishing the guideline values for other VOCs was needed. This work would require a great amount of time, while the health risks from potentially hazardous chemicals whose guideline values are not yet established might increase in the future. Hence, the MHLW implemented the TVOC approach as an important indicator to prevent expanding the indoor air pollution. The MHLW did not have reliable scientific knowledge establishing the guideline value of TVOC based on the current available toxicological data. Consequently, the MHW established a tentative target value from the median value calculated on the results of a national field survey on VOCs (MHW 1999).

The TVOC approach is important to manage the potentially hazardous chemicals without established guideline values. On the other hand, Wolkoff (2003) indicated that the application of the TVOC approach should be a concern, because the establishment of the TVOC guideline value due to a health risk-based method is very difficult.

We show the shipments of adhesives and paints in Figure 1 and Figure 2, respectively. The shipments of formaldehyde-based adhesives were decreased notably in 1997, when the guideline value for indoor formaldehyde concentration was established. However, the replacement of solvent-based adhesives or paints with water-based ones has not been prompted since 2000, when a tentative

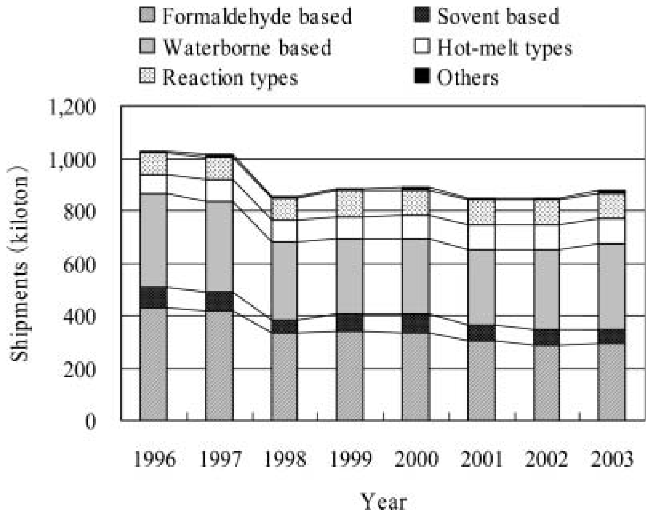

Figure 1. Shipments of adhesives (by Japan adhesive industry association).

target value for TVOC was established. One of the reasons would be that industry organizations have replaced solvent-based adhesives or paints with chemicals with no established guideline values, e.g., ethyl acetate, butyl acetate or n-hexane, because the TVOC target value was not based on toxicological data and was tentative. As a result, new unacceptable risks by such chemicals might increase. By these appearances, the establishment of a TVOC assessment method based on the health risks of the pollutants would be needed.

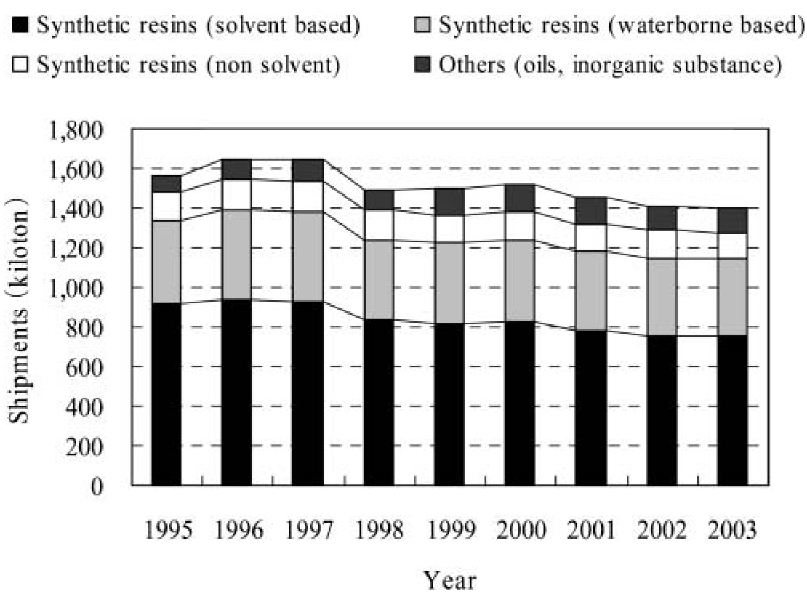

Figure 2. Shipments of paints (by Japan paint manufacturers association).

Revision of the related regulations - 2000s

The revision of the National Building Codes

Chlorpyrifos and formaldehyde were regulated in the amended National Building Codes in 2002, because causal relationships between indoor air concentrations and indoor emission sources were actually obvious and/or the feared excess ratios of their guideline value on public health were identified by field surveys.

The use of building materials containing chlorpyrifos in residential buildings was banned, because the United States Environmental Protection Agency decided to ban the use of chlorpyrifos in residential environments in 2000, and substitute chemicals or pest controls for termiticides were available (Motohashi 2004). The formaldehyde-emitting building materials were regulated into three grades according to formaldehyde emission rate, e.g., F☆☆☆☆, F☆☆☆ or F☆☆, which were defined by Japanese Industrial Standards (JIS) and Japanese Agricultural Standards (JAS) as shown in Table 2. Their symbols with stars show classification of formaldehyde-emitting building materials. The grade F☆☆☆☆ indicates that the formaldehyde emission rate is the lowest. Each grade is labeled on the products, e.g., plywood, laminated wooden floors, particleboards, fiberboards, adhesives, paints or construction materials of built-in furniture. The designers, constructors or home builders can select the lower formaldehyde emission rate building materials in accordance with the classification.

Labeling systems (Issue D)

The classification of products based on emission rate of the pollutants is helpful for construction designers, builders and occupants to ensure good IAQ. They would be able to select the lowest emission level products referring to the classification. We show the labeling systems established in Japan in Table 3. The wallpaper industries established the voluntary standards of VOCs for their products. They referred to the German labeling systems. The adhesives or paints used for wood-based building materials, furniture or waterproof agents might contain the organic chemicals including formaldehyde. However, there are almost no labeling systems for chemicals except for formaldehyde in Japan. If a labeling system that can display the emission level of all pollutants potentially posing an unacceptable risk in indoor spaces could be developed, we would be able to reduce the risks by selecting the lower emission level products.

Table 2. The classification and restrictions on amended National Building Codes.

Formaldehyde emission rate (mg/m^2h)	Formaldehyde-emitting building materials		Building materials approved by the Minister (MLIT)	Restrictions on interior finishing materials
	Type	relevant standard		
over 0.12	1	unclassified		banned
0.02–0.12	2	F☆☆(JIS, JAS)	Approved under the Order (deemed equivalent to type of the left symbol)	Limited use
0.005–0.02	3	F☆☆☆(JIS, JAS)		
up to 0.005	–	F☆☆☆☆ (JIS, JAS)		No restrictions

*Measurement; Temperature: 28°C, relative humidity: 50%, Formaldehyde concentration: 0.1 mg/m^3.

Table 3. Labeling systems for indoor air quality in Japan.

Standards	Related Agencies or industry organizations	Target chemicals	Target products
JIS	METI	Formaldehyde	particleboards, fiberboards, wallpapers, adhesives, paints, heat-insulating materials
JAS	MAFF	Formaldehyde	plywood, laminated wooden floors, laminated lumbers
BL label	Center for Better Living	Formaldehyde	fittings, interior units, vanity units, air conditioning units, kitchen units, etc
ISM	Wallcovering Association of Japan	Formaldehyde, VOCs, Heavy metals, etc	wallpapers, curtains, carpet rags, interior finishing, water-based paints, adhesives used for wallpaper
SV	Standard Value Conference	Formaldehyde, VOCs, Heavy metals, etc	wallpapers
Indoor environment friendly mark	Federation of Japan Furniture Manufactures Association	Formaldehyde	materials used for furniture, e.g., wood-based building materials, adhesives, paints

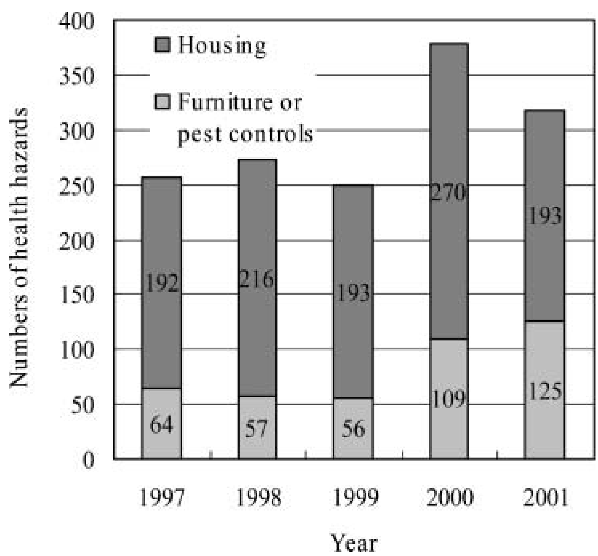

Figure 3. Health hazards caused by indoor air pollution.

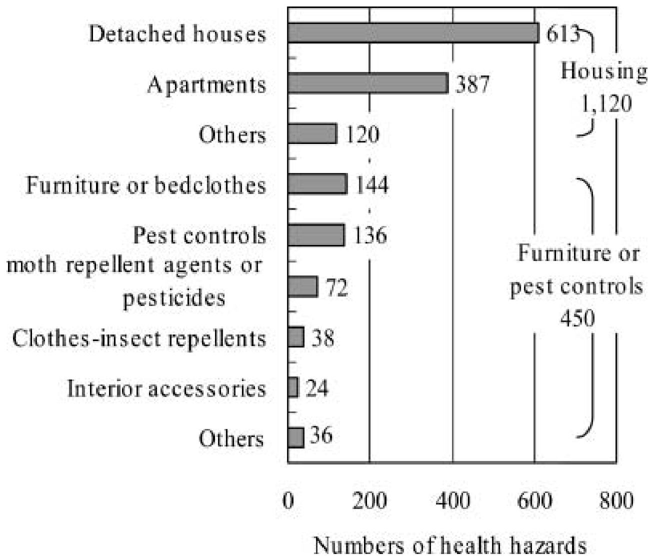

Figure 4. Kinds of health hazards from 1997 to September 2002.

Actual status of the health hazards caused by indoor air pollution (Issue E, Issue F)

(Issue E)

The National Consumer Affairs Center of Japan (JCIC), which works as a consultation office for consumers, has received various complaints or inquiries concerning indoor air pollution. We show the health hazards concerning indoor air pollution in Figures 3 and 4 (JCIC 2002). As shown in Figure 3, the JCIC has received approximately 300 complaints and inquiries since 1997. In particular, the heath hazards caused by furniture or pest controls have increased since 2000. In addition, as shown in Figure 4, the health hazards due to furniture or bedclothes, and moth repellents or pesticides have been reported in approximately 9% and 4.6% cases of all 1570, respectively.

We show the annual numbers of complaints due to chemical products in Table 4, which have been received by the Product Liability Center (PL Center 2003, 2004) of the Japan Chemical Industry Association (JCIA). The PL Center has received lots of complaints due to not only building materials, but also furniture or household products, e.g., pesticides, repellents, deodorants, adhesives and paints. The PL Center reported that most of the causes of these complaints were due to indoor air pollution caused by potentially hazardous chemicals emitted from household products, etc. The regulations related to the elevated indoor formaldehyde concentration might be quite effective in mitigating public concerns caused by indoor air pollution. However, we would have to establish a more comprehensive regulatory framework for multiple emission sources, especially furniture or household products.

(Issue F)

Miyata and Oono (1999) reported the probable causes of developing a disorder of multiple chemical sensitivity (MCS), which is commonly described as an acquired

Table 4. Annual numbers of complaints due to chemical products.

1999		2000		2001		2002		2003	
Building materials	20	Building materials	28	Building materials	16	Detergents	12	Building materials	22
Auto supplies	13	Detergents	22	Detergents	16	Auto supplies	10	Livingware	21
Livingware	12	Livingware	16	Pesticides	14	Adhesives	10	Furniture	12
Furniture	11	Pesticides	15	Auto supplies	12	Livingware	8	Termiticides	11
Termiticides	11	Furniture	14	Livingware	10	Furniture	7	Detergents	11
Paints	9	Termiticides	12	Furniture	9	Pesticides	6	Adhesives	8
Pesticides	8	Paints	9	Deodorants	8	Textiles	5	Paints	6
Hairdye	8	Textiles	8	Adhesives	7	Paints	5	Textiles	6
Bath agents	8	Cosmetics	7	Paints	6	Termiticides	5	Plastics	6
Industrial products	7	Deodorants	7	Repellents	6	Others	62	Deodorants	5
Detergents	7	Hairdye	7	Textiles	6			Pesticides	5
Repellents	7	Others	81	Others	55			Others	52
Others	67								
Total	188	Total	226	Total	165	Total	130	Total	165

Table 5. Probable causes of developing a disorder of MCS.

Probable causes	Number
New construction, Reform	51
Termiticides, Miticides	6
Use of chemicals in individual homes	8
Indoor working environment	7
Specific chemicals	2
Atmospheric pollution	18
Denture	2
Sterilization of livestock	1
Unknown	49
Total	144

disorder triggered by exposure to diverse chemicals at doses far below those documented to cause adverse health effects in humans (Buchwald et al. 1994). A distinct clinical definition of MCS in the medical world is not available, therefore many scientists and medical specialists continue to debate the clinical definition of MCS as a medically unexplained disease. As shown in Table 5, they showed that the probable causes of 144 patients diagnosed with MCS were new construction or reform (51 persons) and termiticides or miticides (six persons) and so forth.

Uchiyama and Murayama (2003) reported the national field survey of MCS in Japan. They interviewed 4000 adults (older than 20 years) using the Japanese version of the Quick Environmental Exposure and Sensitivity Inventory (QEESI), which was developed by Miller and Prihoda (1999). They estimated that a risk for MCS on this survey was 0.74% of 2582 total responders. Thus, the number of public people with the potential MCS disorder was estimated as approximately 700,000 in Japan, therefore MCS is a significant public health issue in Japan. On the basis of this study, we presume that the development of the MCS condition could be influenced by the individual difference of vulnerability to chemicals. The individual difference is considered in common risk assessment. Based on these appearances, the individual difference should be considered larger than traditional scientific knowledge.

Children require special protection because they are more vulnerable to the effects of chemical exposures. For example, they receive greater chemical exposures per unit of body weight than adults, and they are more susceptible to their effects because of their immature and developing systems. The fetus has been found to be particularly vulnerable to the effects of chemical exposures.

In view of the serious possible public health consequences of chemical exposures, the lack of full scientific certainty should not serve to justify inaction. On the contrary, governmental policies should be based on the precautionary principle and seek to prevent harmful health effects to vulnerable groups by reducing exposures to potentially hazardous chemicals and by considering characteristics and susceptibilities of vulnerable groups in regulations covering health and the environment. The application of the precautionary principle is especially focused on children's environmental health (WHO Europe 2004). The existing regulations in Japan do not consider the individual difference for vulnerable groups.

Table 6. The preliminary health risk assessment on an exposure route via indoor air.

Chemicals	Hazard		Exposure	MOE	Categories
	Species	NOAEL, etc	Predictive maximum volume		
Formaldehyde	human	0.1mg/m3	230μg/m3	0.43	A
p-Dichlorobenzene	rats	7.5mg/m3	530μg/m3	1.4	A
Acetaldehyde	rats	4.9mg/m3	140μg/m3	3.5	A
o-Dichlorobenzene	rats	0.024mg/m3	<0.2μg/m3	>12	B
Xylene	human	2.2mg/m3	115μg/m3	19	B
Toluene	human	7.9mg/m3	270μg/m3	29	B
1,2-Dichloropropane	rats	0.12mg/m3	0.36μg/m3	33	B
Acrylonitrile	rats	0.77mg/m3	1.9μg/m3	41	B
n-Hexane	human	1mg/m3	24μg/m3	42	B
1,2-Dichloroethane	rats	8.3mg/m3	12μg/m3	69	B
Monochlorobenzene	rats	0.71mg/m3	0.88μg/m3	81	B
Chloroform	mice	4.3mg/m3	4.7μg/m3	91	B

Preliminary health risk assessment for potential hazardous chemicals in Japan (Issue G)

The Ministry of the Environment (ME 2002, 2003, 2004) has conducted the preliminary health risk assessment for 73 potential hazardous chemicals of which we had sufficient knowledge of health hazards, and the chemicals were regulated based on the Pollutant Release and Transfer Register (PRTR). We show the result on an exposure route via indoor air from these results in Table 6.

The Margin of Exposure (MOE) was estimated from hazard assessment and exposure assessment based on existing literatures. An MOE value lower than 10, which was classified 'A', indicated 'candidate chemicals should be assessed in detail and might be relatively high risk compared with other categories'. The MOE value from 10 to 100, which was classified 'B', indicated 'candidate chemicals should be gathered related information and might be lower risk than A'. As shown in Table 6, the MOE values of o-dichlorobenzene, 1,2-dichloropropane, acrylonitrile, n-hexane, monochlorobenzene, chloroform were less than 100. The MHLW had, however, not established the indoor air guideline values of these chemicals, because the priority rating for the establishment of the guideline values based on a health risk-based method was not considered.

The remaining subjects in the existing regulations for indoor air pollution

We clarified the remaining issues related to the regulations for indoor air pollution in Japan. As a result, we elucidated six subjects remaining in Japanese IAQ research shown below;

(1) Development of preventive measures which do not create new unacceptable risks from substitute chemicals (from issue A).
(2) Development of classifications and countermeasures for indoor air pollutants by health risk assessment (from issues B and G).

(3) Establishment of total volatile organic compounds (TVOC) assessment method based on the health risks of the pollutants (from issue C).
(4) Reinforcement of labeling system for the pollutants except for formaldehyde (from issue D).
(5) Countermeasures for emission control from furniture or household products, etc. (from issue E).
(6) Establishment of regulatory measures for vulnerable groups to chemicals (from issue F).

Conclusions

Ando (1997b) reported that approximately 900 chemicals were identified in indoor air in 1989. The emission sources of these chemicals were lots of industrial products surrounding IAQ, e.g., building materials, household products, furniture, heating equipment, pesticides and air-conditioning equipment. In order to ensure a good IAQ, reducing health risks caused by these chemicals to within an acceptable level was required. Hence developing the following solutions for six subjects would be needed.

First of all, as for 'subject 1', if we could get information about the emission levels and hazardous properties of substitute chemicals, we could find the health risks from substitute chemicals in advance. Secondly, if we could identify all pollutants emitted in indoor air, and could obtain information about the emission levels and hazardous properties of these pollutants, we would be able to solve 'subject 3' without applying the TVOC approach. As a result, the semi volatile organic compounds (SVOCs), whose boiling points are higher than that of VOCs, or Particulate Organic Matters (POMs), could be included in target pollutants for health risk assessment. Those mean that the manufactures or suppliers should provide sufficient information about the pollutants emitted from their products, for 'subjects 1 and 3'.

Some data about the chemicals can be obtained from the material safety data sheet (MSDS) in Japan. The hazard identifications, exposure controls, physical and chemical properties, disposal information and so forth are described in MSDS. However, the emission levels are not described in it. Some emission levels can be provided through the labeling systems as shown in Table 2. However, the subject 4 is still remaining in the systems. Basically, development of a new comprehensive labeling system that displays the emission levels, which include chemical components and their emission rates, would be needed, for 'subjects 1, 3 and 4'. Thirdly, we would be able to solve 'subject 5' by extending the application range of the labeling system to household products. Fourthly, we would be able to solve 'subject 2' by classifying the indoor air pollutants, according to the emission levels from the labeling system. Finally, we would be able to solve 'subject 6' by considering individual difference for vulnerable groups in risk assessment.

Based on these insights, we have developed a new scheme to control the IAQ in Japan in Figure 5. We especially felt that industry organizations should develop a comprehensive labeling system, displaying emission levels of all detectable indoor air pollutants as one of the important future strategies. It will, however, be difficult to display the emission levels because numerous pollutants have been identified in indoor air. Hence we should develop criteria of classification for all detectable indoor air pollutants. We will, therefore,

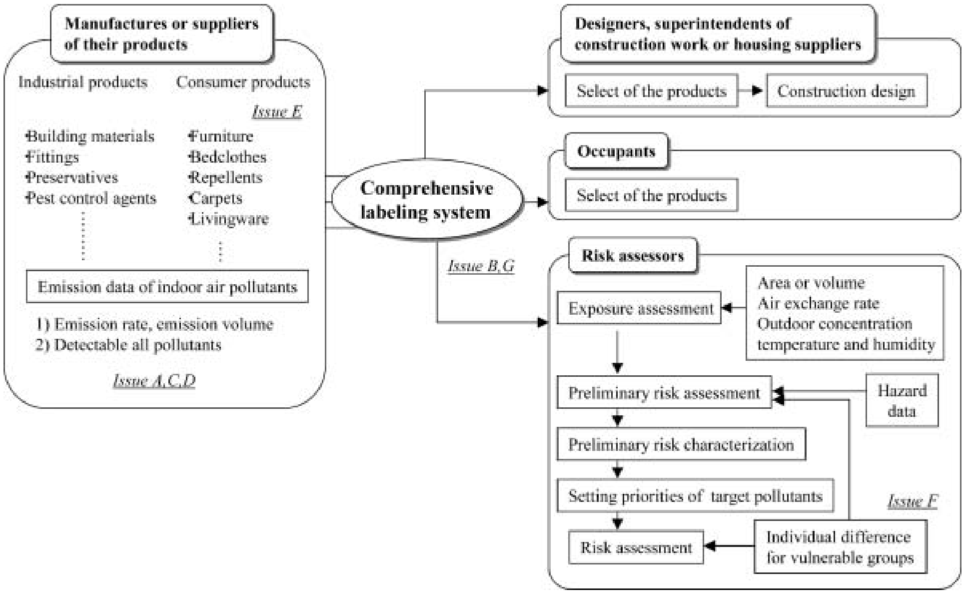

Figure 5. A new scheme to control the indoor air quality.

study the future framework to control the IAQ, comparing with regulations in other countries.

Note: We gave a presentation as part of this study at the 2nd WHO International Housing and Health Symposium in Vilnius on 30 September, 2004. This paper is a full version of this study.

Acknowledgements

This study was financially supported by research grant number H16-health-057 from Grants for Health Science of Ministry of Health, Labour and Welfare of Japan in 2004.

References

Ando, M. 1997a. *Relationship between chemical exposure and chemical sensitivity. Health science studies in 1997. Study for crisis management of chemicals*: 82–7. Tokyo: Ministry of Health, Labour and Welfare. (In Japanese).

———. 1997b. Indoor air pollution and chemicals - 4th Chemicals list existing in indoor air. *Journal of Resources and Environment* 33, no. 8: 737–44. (In Japanese).

Buchwald, D., and D. Garrity. 1994. Comparison of patients with chronic fatigue syndrome, fibromyalgia, and multiple chemical sensitivities. *Archives of International Medicine* 154: 2049–53.

JCIC. 2002. *Sick House Syndrome as seen from incident report*. 6 December. Tokyo: National Consumer Affairs Center of Japan. (In Japanese).

JTCA. 1988. A field survey result for termiticides. *Shiroari* 73: 62–73. (In Japanese).

ME. 2002. *Preliminary assessment of environment risk for chemicals*. Vol. 1, March. Tokyo: Ministry of the Environment. (In Japanese).

———. 2003. *Preliminary assessment of environment risk for chemicals*. Vol. 2, March. (In Japanese).
———. 2004. The result of 3rd Preliminary assessment of environment risk for chemicals. Press Release, 26 July. (In Japanese).
MHW. 1997. *Committee on comfortable and healthy houses*. Final report, 13 June. Tokyo: Ministry of Health and Welfare. (In Japanese).
———. 1999. *National field survey on volatile organic compounds in residential environment*. 14 December. (In Japanese).
MHLW. 2000a. Committee on sick house syndrome: Indoor air pollution. *Summary on the discussions from the 1st to 3rd meetings*. Progress report no. 1, 26 June. Tokyo: Ministry of Health, Labour and Welfare.
———. 2000b. Committee on sick house syndrome: Indoor air pollution. *Summary on the discussions at the 4th and 5th meetings*. Progress report no. 2, 15 December. Tokyo: Ministry of Health, Labour and Welfare.
———. 2001. Committee on sick house syndrome: Indoor air pollution. *Summary on the discussions at the 6th and 7th meetings*. Progress report no. 3, 5 July. Tokyo: Ministry of Health, Labour and Welfare.
———. 2002. Committee on sick house syndrome: Indoor air pollution. *Summary on the discussions at the 8th and 9th meetings*. Progress report no. 4, 22 January. Tokyo: Ministry of Health, Labour and Welfare.
Miller, C.S., and T.J. Prihoda. 1999. The environmental exposure and sensitivity inventory (EESI): A standardized approach for measuring chemical intolerances for research and clinical applications. *Toxicology and Industrial Health* 15: 370–85.
Miyata, M., and K. Oono. 1999. Multiple chemical sensitivity; history, definition and patient numbers. *Allergology & Immunology* 6, no.7: 970–5. (In Japanese).
Motohashi, K. 2004. Latest trend of building materials to respond to sick house issues. *KOUGYOU ZAIRYOU* 52: 22–6. (In Japanese).
PL Center. 2003. *Report on the activity in 2002*. June. Tokyo: Product Liability Center for Chemical Products. (In Japanese).
———. 2004. *Report on the activity in 2003*. June. Tokyo: Product Liability Center for Chemical Products. (In Japanese).
Uchiyama, I., and R. Murayama. 2003. Studies on current situation of chemical sensitivity in Japan. *Proceedings of 2003 International Symposium on Indoor Air Quality and Health Hazards*, 10–11 January, in Tokyo, 186–8. Tokyo: Architectural Institute of Japan.
WHO. 2000. *Guidelines for air quality*. Geneva: WHO.
WHO Europe. 1987. *Air quality guidelines for Europe*. European Series, No. 23. Copenhagen: WHO Regional Publications.
———. 2004. *Fourth Ministerial Conference on Environment and Health, Declaration*. EUR/04/5046267/6, 25 June. Budapest, Hungary: WHO.
Wolkoff, P. 2003. Trends in Europe to reduce the indoor air pollution of VOCs. *Indoor Air* 13, Sup. 6: 5–11.