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A Comparative Study on the Statutory and Technical Regulations for Controlling Indoor Volatile Organic Compounds in Taiwan and Japan

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Abstract: The objective of this paper was to offer a comparative analysis of currently implemented statutory and technical regulations in Taiwan and Japan for volatile organic compounds (VOC) in indoor atmospheres. The findings should help to manage indoor air quality (IAQ) based on public and occupational health considerations. The first part of the present study summarizes the Indoor Air Quality Management Act in Taiwan and related regulations for building materials. We further highlight that Taiwan became the second country in the world to enact an IAQ management law in 2011. In addition, the permissible exposure limits (PEL) are also addressed to recognize safe levels of VOC concentrations below which adverse health effects are not expected to occur in the workplace environment. In the second part of the paper, the statuses of statutory and voluntary regulations for IAQ issues in Japan are compiled from the official websites of the central ministries, including the Ministry of Education, Culture, Sports, Science and Technology, the Ministry of Land, Infrastructure, Transport and Tourism, and the Ministry of Health, Labor and Welfare. This analysis shows that both countries have adopted similar processes to establish the IAQ standard/guideline values and low-emission building materials, despite slight differences in their methods and central ministries. In contrast, the VOCs regulated by these regulations differ completely, with the exception of formaldehyde. Although the IAQ standards in Taiwan seem to be more stringent than those in Japan, Japan's longer experience shows a diversity of management tools and regulations based on the guideline values.

Keywords: indoor air quality; volatile organic compound; regulatory system; exposure limit; Taiwan; Japan

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1. Introduction

In modern society, indoor air quality (IAQ) is of great importance to human health, as people generally spend 90% of their lifetimes inside buildings. As a consequence, so-called "Sick Building Syndrome", "Sick House Syndrome", "Building-Related Illness" or "Building-Related Symptoms" induced by the indoor air pollutants (IAPs) and environmental factors (e.g., ventilation, humidification and air-conditioning) have received much attention since the 1990s [1]. More noticeably, the air quality in an indoor environment can be even worse than the outdoor air quality when the indoor air is polluted [2,3]. IAQ has been linked to a combination of factors, incorporating the release of a large variety of toxic chemicals from building materials with poor air-conditionings or mechanical ventilation systems. Most of the designated IAPs can be classified as volatile organic compounds (VOCs). It should be noted that these organic compounds (e.g., benzene, formaldehyde) may be carcinogenic to humans when present in indoor air, according to the evaluation by the International Agency for Research on Cancer (IARC) [4]. Internationally, many official or professional organizations have stipulated the standards and guideline values involved in IAQ management [5]. However, the IAQ standards have only been adopted by a few Asian countries (i.e., Korea, Japan, and Taiwan) as statutory regulations for IAQ management. In Korea, the Indoor Air Quality Control in Public Use Facilities, etc., Act was enacted in 2004 [6]. The public use facilities include underground stations, underground shopping malls, libraries, medical institutions, saunas, large stores, etc. Table 1 summarizes the main features of the IAQ laws in Japan, Korea and Taiwan, indicating that the central ministries and IAPs are very different.

Table 1. Summaries of regulations for indoor air pollutants (IAPs) in Japan, Korea and Taiwan.

Country		Japan	Korea	Taiwan
Central ministry		Ministry of Health, Labor and Welfare (MHLW)	Ministry of Environment (ME)	Environmental Protection Administration (EPA)
Relevant law/act		Act on Maintenance of Sanitation in Buildings	Indoor Air Quality Control in Public Use Facilities, etc., Act	Indoor Air Quality Management Act
Effective		1970	2004	2011
Definition		-	Gases and floating matters in the form of particles, etc., which cause air pollution in the indoor spaces.	Substances that are normally dispersed in indoor air, which may directly or indirectly affect public health or the living environment
IAPs	Mandatory	CO_2, CO, formaldehyde, PM_{10}	CO_2, CO, formaldehyde, PM_{10}, bacteria, TVOC [b]	CO_2, CO, formaldehyde, TVOC [c], bacteria, fungi, PM_{10}, $PM_{2.5}$, O_3
	Voluntary/Guideline values	12 VOCs [a]	NO_2, Rn, VOC, asbestos, O_3	-

[a] Including acetaldehyde, chlorpyrifos, diazinon, di-*n*-butyl-phthalate, *p*-dichlorobenzene, di-*n*-ethyl hexyl-phthalate, ethylbenzene, fenobucarb, styrene, tetradecane, toluene, and xylenes; [b] Including benzene, ethyl benzene, styrene, toluene, and xylenes. These mandatory IAPS apply to newly-built collective housings; [c] Including benzene, carbon tetrachloride, chloroform, 1,2-dichlorobenzene, 1,4-dichlorobenzene, dichloromethane, ethyl benzene, styrene, tetrachloroethylene, toluene, trichloroethylene, and xylenes.

Due to the limited residential space and the promotion of the improvement of the living environment in densely populated Japan, the Japanese government initially enacted the Act on Maintenance of Sanitation in Building in 1970, and thus established the Management Standards of Environmental Sanitation for Buildings as an ordinance of the Ministry of Health and Welfare (MHW) [7]. In 1997, the MHW, which was reorganized as the Ministry of Health, Labor and Welfare (MHLW) in January 2000, established a guideline value of 0.1 mg/m^3 (0.08 ppm) for indoor concentration of formaldehyde, in addition to the guideline values of suspended particulate matter, CO_2, and CO [8]. Subsequently, a national survey was conducted by the MHW to determine the concentrations of common VOCs in houses and buildings. Based on the survey results [8], the MHLW further established guideline values for 12 VOCs and a tentative target value for total volatile organic compounds (TVOCs) from 2000 to 2002. Under the Amended Building Standard Act in 2003, a strict regulation, on the other hand, was intended to prevent specified IAPs emitted from the building materials, including a convention on prohibition of chlorpyrifos and the restriction on the use of graded building materials based on the emission rate of formaldehyde. After conducting various countermeasures via enacted regulations, and several measurements by means of a national survey, the indoor VOC levels in Japan have been much improved in recent years [9].

Regarding IAQ management, there are many similarities in terms of their hot and humid climates, as well as frequent exchanges of goods between Taiwan and Japan. In Taiwan, people have begun to show concern about the impact of IAQ on human health in public hearings since the early 2000s, thus leading to the necessity of legislation to protect public health. On 23 November 2011, the Taiwanese Legislative Yuan passed the Indoor Air Quality Management Act (IAQMA), making Taiwan the second nation after Korea to implement statutory regulations for IAQ. The Act was to take effect one year after promulgation. According to Article 3 of the Act, the IAQ standards for designated IAPs are officially announced by the central ministry (i.e., the Environmental Protection Administration, EPA). Currently, the IAPs refer to CO_2, CO, formaldehyde, TVOCs, bacteria, fungi, airborne particles ($PM_{2.5}$ and PM_{10}), and ozone. Meanwhile, the Ministry of the Interior (MOI) formally implemented the green building material (GBM) labeling system in 2004 under the authorization of the Building Act [10]. The core values of the GBM are based on non-toxicity, harmlessness, and relevant specification standards for the healthy improvement of the living environment. Subsequently, the Standards Act was revised by the Ministry of Economic Affairs (MOEA) in 2011, in response to the demand for IAQ management and IAQ-based health issues.

As mentioned above, in many countries, the building codes include certain general regulations to guarantee proper and sanitary conditions in buildings. The organic indicators (i.e., VOCs) in the building code regulations are relatively difficult to assess, because of their diversity, low concentrations and chemical reactivity/sensitivity. As indoor VOCs have attracted increasing concern, regulations for these indoor air contaminants have been developed in recent years. These IAQ standards/guidelines are based on the occupational exposure limits (OEL) and/or ambient air-quality standards (such as the Environmental Air Quality Standards in Japan). More significantly, no previous studies have addressed the state-enforced laws or acts governing IAQ management in Asian countries. Therefore, the main objective of this paper is to establish a comparative study of the regulatory aspects of IAQ that are currently promulgated by Japan and Taiwan.

2. Statutory and Technical Regulations for Indoor Air Quality in Taiwan

2.1. Indoor Air Quality Management Act

In Taiwan, people have become increasingly concerned about the impact of IAP on human health; sick-building or sick-house syndrome has attracted social attention since the early 1990s [11]. This IAQ issue has resulted in the necessity to promulgate regulations for the purposes of IAQ and public health. As a result, the EPA first announced its "*Suggested Values for Indoor Air Quality*" in 2005. Subsequently, the IAQMA was drafted and further discussed through the public hearing and legislative procedures. On 23 November 2011, the Act was promulgated and was to come into effect one year later. Therefore, Taiwan became the second nation after Korea to establish a specific law for IAQ management and control [12]. According to Article 1 of the Act, it aims to improve IAQ and to protect public health. Under the authorization of the IAQMA, the EPA further announced several regulations to facilitate IAQ implementation. They include the *Indoor Air Quality Act Enforcement Rules*, the *Indoor Air Quality Standards*, the *Regulations Governing Dedicated Indoor Air Quality Management Personnel*, the *Regulations Governing Indoor Air Quality Analysis Management*, and the *Fine Determination Criteria for Violations of the Indoor Air Quality Act*. Table 2 lists Taiwan's IAQ standards, including 0.06 ppm for formaldehyde (HCHO) and 0.56 ppm for TVOC (a combination of 12 different VOCs). Based on the premises' crowd capacity, entry and exit capacity, risk of IAP hazards and their special needs, the EPA announces public and private premises batch by batch as complying with the IAQMA. At present, there are sixteen premises subject to the Act and regulated IAPs, as listed in Table 3.

Table 2. Indoor air quality standards in Taiwan.

Indoor Air Pollutants	Standard	
	Concentration	Sampling Time
Carbon dioxide (CO_2)	1000 ppm	8 h
Carbon monoxide (CO)	9 ppm	8 h
Formaldehyde (HCHO)	0.06 ppm	1 h
TVOC	0.56 ppm	1 h
Bacterial	1500 CFU/m^3 [a]	Ceiling
Fungi	1000 CFU/m^3	Ceiling
Particulate matter (PM_{10})	75 μg/m^3 [b]	24 h
Particulate matter ($PM_{2.5}$)	35 μg/m^3	24 h
Ozone (O_3)	0.06 ppm	8 h

[a] Colony-forming unit (CFU); [b] Not limited to the ratio of outdoor fungi concentration to indoor fungi concentration ≤1.3.

Table 3. The premises subject to the IAQMA and the regulated IAPs in Taiwan.

Category	Premise	Controlled IAP				
		CO	CO_2	HCHO	Bacteria	PM_{10}
Colleges and universities	Main library		•	•	•	•
Libraries (Floor area > 1000 m^2)	Central, city or county libraries		•	•	•	•
Museums and art museums (Floor area > 2000 m^2)	Large museums		•	•	•	•
Medical institutions	Medical centers, regional hospitals		•	•	•	•
Social welfare institutions	Elder care centers	•	•	•	•	•
Government agencies	Central government agencies		•	•		•
Transportation stations	Large railway stations	•	•	•		•
	Large civilian airports		•	•	•	•
	Metro stations	•	•	•		•
Business operation sites for financial institutions	Headquarters		•	•	•	•
Performance halls (Floor area > 5000 m^2)	National-level operas/concert halls/theaters/performance centers		•	•		•
Exhibition rooms (Floor area > 5000 m^2)	Large exhibition rooms	•	•	•		•
Cinemas (Floor area > 1500 m^2)	Large cinemas	•	•	•		•
KTV/MTV premises (Floor area > 600 m^2)	Large KTV/MTV premises	•	•	•		•
Shopping malls	Department stores, hypermarkets (Floor area > 3000 m^2)	•	•	•		•
Sports and fitness centers (Floor area > 2000 m^2)	Large sports and fitness centers		•	•	•	•

2.2. *Occupational Safety and Health Act*

The most important law relevant to occupational health in Taiwan is the Occupational Safety and Health Act (OSHA) [13], which was first promulgated in 1974 and was recently amended in 2013. This law was enacted for the purposes of protecting workers' safety and health and also preventing occupational accidents. According to Article 12 of the Act, the environmental monitoring of designated workplaces (e.g., indoor work sites where central air conditioning is available) shall be adopted so as to understand the actual operation conditions and assess the exposure of laborers. To ensure that laborers' hazard exposure falls under the permissible levels, the central ministry (i.e., the Ministry of

Labor, MOL) shall establish the permissible exposure limits (PELs) for hazardous substances in the workplace air. Basically, most of Taiwan's PELs were directly adopted from the updated threshold limit values (TLVs) [14], which were developed by the American Conference of Governmental Industrial Hygienists (ACGIH). Although the TLVs were not developed for use as legal standards, they are often used as guidelines to assist in the control of health hazards by industrial hygienists.

At present, about 500 airborne hazardous substances have been listed in Taiwan's PEL standards, including the time-weighted average for an 8-h workday (TWA), the time-weighted average for short-term exposure limits (STEL), and the ceiling limits (C). Because the TLV values are health-based values, they indicate that nearly all workers may be repeatedly exposed without adverse health effects. It should be noted that the PEL values are not used for the relative index of toxicity between two different hazardous substances, or as the unique basis for the identification of occupational diseases. On the basis of the IAQ standards in Table 2, Table 4 further lists the corresponding PEL and TLV values for these organic IAPs. Table 4 also lists their TLV bases, representing a field reference for symptoms (adverse effects) of overexposures upon which the TLV is based [15].

Table 4. Occupational exposure limits of VOCs designated as IAPs in Taiwan and Japan.

VOCs	Occupational Exposure Limit			TLV-Basis
	Taiwan-PEL [a]	Japan-ROEL [b]	ACGIH-TLV [c]	
Acetaldehyde	100 ppm [c]	50 ppm	25 ppm (ceiling)	Eye & Upper respiratory tract (URT) irritation
Benzene	1 ppm	1 ppm	0.5 ppm	Leukemia
Carbon tetrachloride	2 ppm	5 ppm	5 ppm	Liver damage
Chloroform	10 ppm	3 ppm	10 ppm	Liver & embryo/fetal damage; central nervous system (CNS) impairment
Chlorpyriphos	– [d]	–	0.01 mg/m^3	Cholinesterase inhibition
Diazinon	0.01 mg/m^3	0.1 mg/m^3	0.01 mg/m^3	Cholinesterase inhibition
O-Dichlorobenzene	50 ppm	25 ppm	25 ppm	URT & eye irritation; kidney damage
p-Dichlorobenzene	75 ppm	10 ppm	10 ppm	Eye irritation; kidney damage
Dichloromethane	10 ppm	50 ppm	50 ppm	Carboxyhemoglobinemia; CNS impairment
Di-*N*-butylphthalate	5 mg/m^3	5 mg/m^3	5 mg/m^3	Testicular damage, eye & URT irritation
Di-2-ethylhexylphthalate	–	5 mg/m^3	5 mg/m^3	Lower respiratory tract (LRT) irritation
Ethyl benzene	100 ppm	50 ppm	20 ppm	URT & eye irritation; kidney damage (nephropathy); cochlear impairment
Fenobucarb	–	5 mg/m^3	–	–
Formaldehyde	1 ppm	0.1 ppm	0.3 ppm (ceiling)	Eye & URT irritation
Styrene	50 ppm	20 ppm	20 ppm	CNS impairment; URT irritation; peripheral nephropathy
Tetrachloroethylene	50 ppm	(Pending)	25 ppm	CNS impairment
Tetradecane	–	–	–	–
Toluene	100 ppm	50 ppm	20 ppm	Visual impairment; female reproductive; pregnancy loss
Trichloroethylene	50 ppm	25 ppm	10 ppm	CNS impairment; cognitive decrements; renal toxicity
Xylene	100 ppm	50 ppm	100 ppm	URT & eye irritation; CNS impairment

[a] Permissible exposure limit; [b] Recommended occupational exposure limit; [c] Threshold limit value; [d] Not available.

2.3. Building Act

In order to implement building management and also maintain public security and public health, the Building Act was enacted in Taiwan. According to Article 97 of the Act, the central ministry (i.e., the Ministry of the Interior, MOI) further stipulates the technical building regulations related to building planning, design, construction, structure, and equipment. In order to establish sustainable, comfortable and healthy living environments, the Architecture and Building Research Institute (ABRI), under the MOI, launched the Green Building Material (GBM) Evaluation and Labeling System in the early 2000s to be in accordance with the revised Building Technical Regulations [10]. Herein, the GBM must be non-hazardous to the environment, non-toxic to human health, and be in accordance with the national specifications/standards. Currently, there are four GBM types, including ecological, healthy, high-performance, and recycled GBMs.

Healthy GBMs refer to those featuring low emissions of formaldehyde and TVOC, including benzene, carbon tetrachloride, chloroform, 1,2-dichlorobenzene, 1,4-dichlorobenzene, dichloromethane, ethyl benzene, styrene, tetrachloroethylene, toluene, trichloroethylene, and xylenes. Based on their TVOC and formaldehyde emission rates (Table 5), the rating system of healthy GBMs further established the categorizes of E1, E2 and E3. Their emission rates should meet the E3 rating of healthy GBMs (Table 5), in which the rating standards are less than 0.05 and 0.19 mg/m^2·h for formaldehyde and TVOC, respectively. These categories are very similar to those used in Japan [16].

Table 5. Rating system of healthy GBMs in Taiwan.

Rating System	Emission Rate (mg/m^2·h)	
	TVOC [a]	Formaldehyde (HCHO)
E1	$\leq$0.005	$\leq$0.005
E2	0.005 < TVOC $\leq$ 0.06	0.005 < HCHO $\leq$ 0.02
E3	0.06 < TVOC $\leq$ 0.19	0.02 < HCHO $\leq$ 0.05

[a] Total volatile organic compounds (TVOC) include benzene, carbon tetrachloride, chloroform, 1,2-dichlorobenzene, 1,4-dichlorobenzene, dichloromethane, ethyl benzene, styrene, tetrachloroethylene, trichloroethylene, toluene, and xylenes.

2.4. Standards Act

For the purposes of establishing uniform standards for products, materials, processes, and services, and also promoting productivity and public well-being, the Standards Act was enacted in Taiwan to set the so-called National Standards of the Republic of China (CNS). According to Article 7 of the Act, the central ministry (i.e., the Ministry of Economic Affairs, MOEA) further stipulates the Regulations Governing the Establishment of National Standards for the procedure of establishing national standards, as well as the procedures for its amendment, reaffirmation and revocation. In response to the demand for IAQ management and IAQ-based health issues since the 1990s, the Bureau of Standards, Metrology & Inspection (BSMI), under the MOEA, launched 22 national standards (i.e., CNS 16000 series) regarding indoor air sampling and determination methods for emission rates of IAPs (e.g., formaldehyde, VOCs) in 2011. In recent years, the BSMI has also developed or revised national standards for decoration materials (e.g., plywood, and particleboards) and body-contact articles/goods (e.g., textile, wet wipes, and plastic puzzle ground mats) to be in accordance with the limit of formaldehyde emission or content. As classified by the amount of formaldehyde emission, for example, the labeling classifications of particleboards and plywood are labeled as F1, F2 and F3 based on the CNS 2215 and CNS 1349, respectively.

3. Statutory and Technical Regulations for Indoor Air Quality in Japan

In the past two decades, health problems caused by IAPs have resulted in concern by the public, as well as various actions and countermeasures. Moreover, various laws, regulations, and guidelines have been established in Japan. Table 6 lists these guideline values for 13 VOCs, which were determined by the MHLW between 1997 and 2002. Other than formaldehyde, the guideline values for the 13 chemical substances of emission rates from building materials are not currently regulated legally. With respect to the framework of laws and regulations for IAQ, the following sections were mainly compiled from the official websites.

Table 6. Guideline values of volatile organic compounds (VOCs) designated as IAPs in Japan.

VOCs	IAQ Guideline Value	Year of Enforcement
Acetaldehyde	0.03 ppm (0.048 mg/m^3)	2002
Chlorpyriphos	0.07 ppb (1 µg/m^3); 0.007 ppb (0.1 µg/m^3) for children	2001
Diazinon	0.02 ppb (0.29 µg/m^3)	2002
p-Dichlorobenzene	0.04 ppm (0.24 mg/m^3)	2000
Di-*N*-butylphthalate	0.02 ppm (0.22 mg/m^3)	2001
Di-*N*-ethylhexylphtaalate	7.6 ppb (0.12 mg/m^3)	2000
Ethyl benzene	0.88 ppm (3.8 mg/m^3)	2000
Fenobucarb	3.8 ppb (0.033 mg/m^3)	2000
Formaldehyde	0.08 ppm (0.1 mg/m^3)	1997
Styrene	0.05 ppm (0.22 mg/m^3)	2000
Tetradecane	0.04 ppm (0.33 mg/m^3)	2000
Toluene	0.07 ppm (0.26 mg/m^3)	2000
Xylene	0.20 ppm (0.87 mg/m^3)	2000

3.1. Housing Quality Assessment Act

The Housing Quality Assurance Act enforced by the Ministry of Land, Infrastructure, Transport and Tourism (MLITT) was adopted in 2000 [8]. The main objectives of this law are to promote quality assurance for housing and to protect the benefits of housing purchasers and other parties. It should be noted that the system is a voluntary system, the use of which is at the choice of the housing supplier, purchaser, or traders of existing housing. Therefore, the MLITT sets the Japan Housing Performance Labeling Standard and the Standards of Methods for Housing Performance Evaluation. The standards are based on the performances of housing, including structural stability, fire safety, degradation mitigation, IAQ, thermal environment, air environment, light and visual environment, acoustical environment, and considerations for the elderly. The concentrations of chemical compounds are required by the law, including essential compound (i.e., formaldehyde) and voluntary compounds (i.e., acetaldehyde, toluene, xylene, ethyl benzene, and styrene).

3.2. School Health and Safety Act

Under the authorization of the School Health and Safety Act, the standards for school environmental health were revised by the Ministry of Education, Culture, Sports, Science and Technology in 2002 and 2004. According to Article 5 of the Act, schools must make plans and carry out regular checks in the accordance with the "school environmental health standard". This standard involves metrics related to the classroom environment (quality of air, illumination, and noise levels), quality of drinking/pool water, and so on, as well as their standard values and evaluation methods [17]. More significantly, the standard requires the measurement of concentrations of formaldehyde and toluene in indoor classrooms every year to meet the guideline values of 100 and 260 µg/m^3, respectively (Table 6). Other VOCs (guideline values), including xylene (870 µg/m^3), ethyl benzene (3800 µg/m^3), styrene (220 µg/m^3) and *p*-dichlorobenzene (240 µg/m^3), must also be measured if necessary.

3.3. Act on Maintenance of Sanitation in Buildings

According to Article 5 of the Act on Maintenance of Sanitation in Buildings, the Management Standards of Environmental Sanitation for Buildings were promulgated by the MHLW. In this law, the measurement of formaldehyde (guideline value: below 0.1 mg/m^3) concentration in buildings (e.g., department stores, libraries) equipped with air-conditioning or mechanical ventilation was required, in addition to CO (10 ppm), CO_2 (1000 ppm) and suspended particulate matter (150 µg/m^3). In comparison to those in Table 3, the IAQ standards for designated IAPs in Taiwan are more stringent than those in Japan. Sakai et al. [18] measured indoor air VOC concentrations from large buildings constructed between 2003 and 2007 after the revision of the Act in 2002, finding that the levels of target VOCs in newly built environments are generally good, but a few houses showed high concentrations of 2-ethyl-1-hexanol. In the survey by Azuma et al. [19], it was found that the indoor formaldehyde concentrations in student dormitories were lower than those in the guidelines established by the MHLW. Furthermore, the formaldehyde concentrations in newly built houses were lower than those in previously built houses based on the national survey by the MHLW [20].

3.4. Building Standards Act

The objective of the Building Standards Act is to establish minimum standards regarding the site, structure, facilities, and use of buildings in order to protect life, health, and property of the nation, and thereby to contribute to public welfare promotion. In order to prevent Sick House Syndrome (SHS), this Act was revised in 2003 by the MLITT. This revision stipulates three instructions for the improvement of IAQ: the prohibition of the use of chlorpyrifos (an organophosphate pesticide used to kill a number of pests like termites), the restriction of the use of interior decoration (or finishing) materials based on the emission rate of formaldehyde, and an obligation to install a mechanical (automatic) ventilation system. As shown in Table 7, the building materials are categorized into four classes according to the emission rate of formaldehyde, as determined by the desiccator method. However, four-star building materials have been used in most buildings since the revision of this Act (i.e., 1 July 2003). In order to confirm the effect of the revision of the Act, the MLITT conducted a survey on the indoor concentration of designated VOCs (including formaldehyde, acetaldehyde, toluene, ethylbenzene, xylene, and styrene) in newly built houses (more than 10,000 cases) from 2000 to 2005. It was found that the mean indoor concentrations of these VOCs had dramatically decreased during the period of the survey, while there were few houses in which the measured values for formaldehyde and toluene exceeded their guideline values, especially in the summer season [16,21].

Table 7. Labeling of wooden materials based on the emission rates of formaldehyde in Japan.

Category	Chamber Method (μg/m²·h)	Desiccator Method (mg/L)		Limitation for Indoor Use
		Mean	Max.	
F****	<5	0.3	0.4	No restrictions
F***	5–20	0.5	0.7	Limited use
F**	20–120	1.5	2.1	Limited use
F*	>120	5.0	7.0	Banned

The number of "*" represent to different levels.

3.5. Industrial Safety and Health Act

In Japan, the Industrial Safety and Health Act (ISHA) was firstly enacted in 1972 to ensure the safety and health of workers in workplaces, as well as to facilitate the establishment of comfortable working environment. According to Article 65 of the Act, the employer shall conduct necessary working environment measurements in indoor workplaces, as prescribed by the MHLW. The environmental monitoring results shall be carried out in accordance with the standards for working environment measurement for health hazard prevention. In brief, the Act takes working environment monitoring as one of core management countermeasures designated for occupational health [22]. The MHLW, the central competent authority that regulates occupational exposures in the working environment, thus establishes and supervises the Administrative Concentration Level, which can be viewed as an occupational exposure limit (OEL). However, the Japan Society for Occupational Health (JSOH) recommended the OELs as reference values for preventing adverse health effects on workers caused by occupational exposure to chemical substances [23]. Current values have been listed in the Journal of Occupational Health. Hence, the recommended OEL issued by the JSOH can be considered to be a voluntary guidance value. Table 4 also lists the recommended OELs (ROELs) for these IAPs designated in Japan.

4. Conclusions

Since the term "Sick Building Syndrome (SBS)" was first introduced by the World Health Organization in 1984, indoor air quality (IAQ) problems have led to the practice of promoting sustainable buildings that are healthy, energy-efficient, and environmentally friendly. In order to provide good IAQ for the purpose of public and occupational health issues, the central competent authorities in several countries have stipulated standards and/or guidelines for indoor air pollutants (IAP). In the present study, a comparative analysis of the statutory regulations of Taiwan and Japan for volatile organic compounds (VOC) in indoor workplaces and living environments has been carried out. This analysis shows that both countries used similar processes to establish the IAQ standard and/or guideline values, despite slight differences in their methods and the central competent authorities. However, the VOCs regulated by these regulations differ completely, except for formaldehyde. Although the IAQ standards in Taiwan seem to be more stringent than those in Japan, Japan's longer experience has led to a diversity of effective and efficient management tools (e.g., the self-management system) and regulations that can be based on these guideline values. Among these IAQ solution schemes, IAP source removal or modification appears to be the most efficient approach to resolving IAQ problems. Therefore, green building materials (GBM) are an available management source, along with air cleaning (e.g., high-efficiency air filter) and mechanical ventilation in heating, ventilation and air-conditioning (HVAC) systems. In order to achieve sustainable and healthy living environments, the Taiwanese government, under the authorization of the Building Act, established and launched the Green Building Material Evaluation and Labeling System in 2004, showing a reduction of indoor HCHO concentration by official verification.

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