Excessive indoor air pollution can cause sick building syndrome (SBS), cases of which still occur in Japanese homes despite strict regulations on the value of indoor chemical substances established by the Ministry of Health Labour and Welfare. Idiopathic environmental intolerance (IEI), so-called multi-chemical sensitivity (MCS) has become another issue because it is caused by an extreme low concentration of chemical substances. These problems are discussed from the viewpoint of environmental hygiene in the present study. First, indoor air quality and its adverse effect on health is reviewed according to the history of sick buildings. Next, the factors concerning indoor air quality are indicated, and then measures to combat these problems are considered to improve the indoor environment. No ideal solution has been found: however, we summarize important knowledge on research to regain patient health as a result SBS and MCS.

Key words —— sick building syndrome, indoor air quality, volatile organic compounds, sick house syndrome, multi-chemical sensitivity, health

INTRODUCTION

Indoor air pollution by chemicals and its adverse effect on human health are a global subject of public concern. Much attention has focused on sick building syndrome (SBS), chemical sensitivity (CS), and mycotoxicosis.\(^1\) In Japan, these issues were addressed by establishing guideline values for indoor formaldehyde concentration in 2000\(^2\)) and the Ministry of Land Infrastructure and Transport amended the Building Standard Law in 2003 to control indoor chemical pollution.\(^3\)) According to this law, architectural materials that emit a significant amount of formaldehyde must not be used and the air exchange rate must exceed 0.5 h\(^{-1}\) consistently with a mechanical ventilation system. Historically, back-to-back houses were common in England in 19th century as the industrial revolution led to the rapid urbanization. Housing such as these back-to-ba...
Overcrowded dwelling can cause health problems easily. Miura observed that the infectious incidence of tuberculosis was higher in houses with narrow rooms compared to wider rooms in 1950s. People living in metropolitan areas complained of narrowness of their houses in the 1960s. At the time, airtight houses started to be built in urban area, and air pollution due to a lack of fresh air because of the low ventilation rate had been recognized. Higher airtight window frames were made from aluminum instead of iron or wood in those days.

Egyptian and Syrian forces launched coordinated attacks on Israeli forces in the Sinai and Golan Height in 1973. Known as the October war (called the Fourth Middle Eastern war in Japan), the conflict lasted until late October. This war had a great impact on international society. Energy crises were caused by the Organization of the Petroleum Exporting Countries (OPEC), who took oil as a strategic move against the war and restricted the global trade in oil export. This is still known as the Arab oil embargo. The idea of saving energy spread throughout the world as a result of this incident. Architectural methods were also influenced, and the highly airtight construction method became common. Urea formaldehyde resin was introduced and utilized in the insulation material; however, Elinson discussed the scientific evidence on adverse effects of urea foam insulation on human health. A report from World Health Organization (WHO) revealed that some people of new and remodeled buildings worldwide might be linked to symptoms of SBS, which is a combination of ailment associated with an individual’s place of work or residence.

In Japan, the environmental conditions of buildings with over 3000 m² floor area have been controlled to improve public health since 1970 by the “Act for Maintenance of Sanitation in Buildings”; however, small buildings and individual residences are not included, and the substances in indoor air and their concentrations from the 1970s to 2000 in Japan have been summarized by Arashidani et al. Outdoor air pollution was also a serious issue from the 1960s to early 1970s in Japan. On this basis, the committee on sick house syndrome (SHS) by the Ministry of Health, Labour, and Welfare of Japan announced the guideline value of formaldehyde first and individual volatile organic compounds (VOCs).

In Japan, occupants of newly built residence, small buildings, schools, and cars, have reported SHS. The definition of SHS was proposed as “health impairments caused by indoor air pollution, regardless of the place, causative substance, or pathogenesis.” The health effect of air pollution in schools has been discussed in Japan. The main cause is inefficient ventilation of tightly sealed rooms; however, the symptoms are similar between SBS and SHS. In Japan, SBS is named as SHS, because most patients complain of similar symptoms of SBS occurring in its early history in people living in houses. SBS is therefore here described as SHS. A pilot study revealed that VOCs and carbonyl compounds in Chinese indoor environments were influenced by factors inside the house, such as furniture and decoration.

**SYMPTOMS OF SHS**

Building-related symptoms are as follows: “tired or stained eyes,” “dry, itching, or irritated eyes,” “unusual tiredness, fatigue, or drowsiness,” “headache,” “tension, irritability, or nervousness,” “pain or stiffness in the back, shoulders, or neck,” “stuffy or runny nose, or sinus congestion,” “sneezing,” “sore or dry throat,” “difficulty remembering things or with concentration,” “cough,” “dry or itchy skin,” “feeling depressed,” “dizziness or lightheadedness,” “chest tightness,” “nausea or upset stomach,” “shortness of breath,” and “wheezing” by the Building Assessment Survey Evaluation study. These symptoms are almost identical to those of SBS.

The prevalence of symptoms is higher among individuals living in poorly ventilated dwellings built in the 1990s. It is difficult to confirm that SBS is identical to SHS, which is defined in Japan based on diseases related to habitation. The cause of the disease onset relates to a house, symptoms occur within the house, symptoms are less serious or disappear when the patient is away from the house, and when the patient enters the house, the symptoms always occur. SHS is also classified into four types: type 1 (symptoms of chemical intoxication), type 2 (symptoms developed possibly due to chemical exposure), type 3 (symptoms developed not because of chemical exposure but rather because of psychological or mental factors) and type 4 (symptoms developed due to allergies). Imai et al. identified the psychosocial aggravating factors of SHS. The Japanese Society for Hygiene presented their opinion about “sick house syndrome” in 2005 in response to the controversy.
MULTI CHEMICAL SENSITIVITY

There is another ailment, known as multi-chemical sensitivity (MCS), which is a chronic medical condition characterized by symptoms that the affected person attributes to exposure to low levels of chemicals. A report indicated that the rate of school children with MCS-like symptoms, allergies, particularly to offensive odors, increased with age. Consensus criteria were identified by researchers for the diagnosis and definition of MCS, and were later revised in 1999. “The symptoms are reproducible with (repeated chemical) exposure.” “The condition is chronic,” “Low levels of exposure (lower than previously or commonly tolerated) result in manifestations of the syndrome.” “The symptoms improve or resolve when exposure is removed.” “Responses occur to multiple chemically unrelated substances.” And “symptoms involve multiple organ systems.” In 1996 WHO/International Program on Chemical Safety (IPCS) Workshop suggested replacing MCS with the broader term “idiopathic environmental intolerances (IEI),” in order to incorporate “a number of disorders sharing similar symptomatologies.” In Japan, it is sometimes assumed that SHS and MCS as the same, because they have been confused by the media. A systematic literature review was conducted to confirm and extend the U.S.A. case definition of MCS. The results showed a significant overlap of MCS, chronic fatigue syndrome (CFS) and fibromyalgia, and that no standard diagnostic procedure based on the pollution above had been established. There are arguments against MCS truly depending on exposure to chemicals. When a chemical exposure test was performed as the most reliable test to diagnose MCS, some subjects showed no symptoms; furthermore, other subjects claimed symptoms before exposure to volatile organic compounds. A systematic review of provocation studies concluded that individuals with MCS reacted to chemical challenges, suggesting that the mechanism of action is not specific to the chemical itself and might be related to expectations and prior beliefs. It was reported that the quick environment exposure sensitivity inventory (QEESI) was able to screen “patients suffering from a low level of environmental chemicals such as multiple chemical sensitivity (MCS) in Japan” from obscure subjects suffering from affective chemicals.

A POLLUTED ENVIRONMENT: CAUSE OF A SICK HOUSE

Wet/Dampness/Humidity

Dampness can cause condensation, not only on the interior surface of the room but also inside walls. This phenomenon enables mold to grow, which is related to a pronounced increase of symptoms compatible with SHS. An investigation in Japan revealed that higher humidity causes symptoms to increase. Occupants of apartment buildings and condominiums with damp problems could have their health affected by microbial contamination. On the other hand, physiological and psychological effects of low humidity and low air pressure in aircrafts have been reported, suggesting that special attention should be paid to low humidity in consideration of public health. The relationship between moisture and temperature on skin and upper airway symptoms was investigated and showed that skin dryness and rashes, pharyngeal dryness, and nasal dryness and congestion are alleviated by higher humidity, and steam humidification results in a risk for increase perception of disorder and stuffiness. The effect of building materials regulating indoor humidity on the indoor environment was studied to identify the influence on the psycho-physiologic condition of the occupants.

Temperature

The relationship between buildings-related symptoms and thermal metrics was investigated by U.S. Environmental Protection Agency (US-EPA). The result suggested that a higher indoor temperature in winter was associated with an increase in most symptoms analyzed, and an indoor temperature of over 23 in summer, decreased most symptoms.

Particulate Matter

Particulate matter is suspended in the air in solid and liquid states. Previous investigations have noted that particles smaller than 2.5 µm (PM2.5) mainly contribute to an elevated death rate in polluted cities. The WHO published the “Air quality guidelines. Global update 2005. Particulate matter, ozone, nitrogen dioxide and sulfur dioxide.” The guideline for PM2.5 is 10 µg/m³ annual mean in outdoors, but the guideline remains under consideration.
Combustion Products

Air pollution due to combustion products can cause health problems. Carbon monoxide (CO), nitrogen dioxide (NO₂), and sulfur dioxide (SO₂) are common combustion gases in residences and buildings. CO is well-known to cause poisoning by CO-hemoglobin (Hb) formation, inhibiting oxygen utilization by internal organs. NO₂ sources in buildings include gas stoves, furnaces, fireplaces and kitchen devices, and it is linked to asthma morbidity. NO₂ emitted from biomass, wood, crop residues and animal dung has a significantly higher concentration in rural houses. Direct vent-type heating and enclosed wood burners emit significantly lower levels of NO₂ in buildings than un-vented burning appliances. Using kerosene space heaters with a diffuser fan, the combustion of fuel for heating and power generation is considered the main source of SO₂ and particulate contamination, which damage human health. Domestic sources of SO₂ are associated with the use of coal and other fuels for heating and cooking.

Biological Pollutants

Dander, mold, dust, and other organisms carried into by animals and people are biological air pollutants in buildings. Air pollutants are related to higher humidity due to flooding, bathroom or kitchen exhausts, air conditioning machines, and ventilation systems. SHS is sometimes related to microbial contamination of buildings.

Mold/Fungi

Summer-type hypersensitivity pneumonitis is induced by exposure to trichosporon cutaneum as antigen for 2 months. Regarding indoor airborne fungi, a patient with pulmonary aspergillus inhaled Aspergillus fumigatus mostly in the bedroom. Saito et al. reported chladospopriumew and uloaladium herbarum associated with the residents’ symptoms in newly built dwellings. Mold damage can occur as a result of incorrect utility work, in air conditioners, and by using a heat exchange type of ventilator equipped with dehumidifier. Indoor mold affects occupants’ health and causes building-related symptoms. Despite many reports on mold problems, no causal relationship between microbial contamination and health effects has been identified, however, in the U.S.A., there are legal cases involving health problems caused by microbial contamination.

House Dust Mites

It is said that it is difficult for mites to exist at not only high but also low temperature. Household cloth dryer run at lethal temperature that will kill mites in 10 min. It is also reported that indoor air is contaminated with house dust mite allergens in most Japanese dwellings. Dermatophagoides pteronyssiums, and Dermatophagoides farinae are important allergens causing allergies in Japan.

Chemical Factors

VOCs are organic compounds that have high vapor pressure under normal conditions. VOCs are numerous and varied, and also harmful or toxic. Considering indoor air pollution, the air concentration of some organic compounds is regulated. The WHO has proposed guideline value of organic compounds, as has The Ministry of Health, Labor and Welfare in Japan. The effect of volatile organic compounds, such as toluene, on fetuses and newborns has been discussed. It was found that indoor air concentrations of 1-butanol, trichloroethylene, trimethylbenzene, and decane were significantly increased after the revision of the building standard law in 2003 in Japan. The ratio of indoor (I) concentration to outdoor (O) concentration (I/O ratio) were higher than 1 for almost all organic compounds. The sources of indoor contamination were attributed to outdoor air pollution, such as automobile exhaust gas. Semi-volatile organic compounds (SVOCs) with a high boiling point of 260–380°C are considered to vaporize poorly but are detected in not only indoor air but also in house dust. Phthalates and pesticides among the SVOCs are supposed to be associated with allergies or bronchial obstruction. The individual chemicals are discussed below.

Formaldehyde is a flammable, colorless and readily polymerized gas at ambient temperature with the chemical formula of CH₂O (systematic name: methanal), and is the simplest aldehyde. It is classified as a probable human carcinogen. Formaldehyde, and other organic substances have significantly higher indoor air concentrations in dwellings with SHS than in those without. Various papers have been published related to indoor air quality in schools after renovation or when newly built. From the results, schoolrooms should be renovated early in the holidays, and VOCs should be allowed to volatize at least in part during the hot summer holidays. Formaldehyde concentration often increases with summer temperature and
is positively correlated with indoor temperature. The concentration of formaldehyde in newly built houses is higher than in the outdoor environment around houses, and the concentration in Japanese Tatami room is lower than that in other types of room.

Toluene is an organic solvent with a typical smell of paint thinners and its chemical formula C7H8. It is widely used as raw material and as a solvent, and is the common name for methylbenzene. Its major metabolite, hippuric acid, is eliminated in urine. Toluene and other chemicals, such as phenol, 2-ethylhexanol, formaldehyde, and styrene are so-called stealth chemicals emitted from old personal computers (PCs), and may influence indoor air quality.

Xylene is aromatic hydrocarbon isomer which exists as ortho-, meta-, and para-isomers of dimethyl benzene, and is used as a solvent and in printing ink.

Para-dichlorobenzene, 1,4-dichlorobenzene, is an organic compound with the chemical formula C6H4Cl2. It forms colorless to white crystals with a characteristic odor, and is toxic to aquatic organisms. It is used as a pesticide in place of traditional naphthalene. Para-dichlorobenzene emitted from repellents is classified in the highest risk category and has a high I/O value.

Ethyl benzene is an aromatic hydrocarbon with the chemical formula C8H10. At room temperature, it is a colorless liquid with a sweet gasoline-like odor. It is reported that ethyl benzene is significantly related to eye symptoms.

Styrene, ethenyl benzene, is an organic compound with the chemical formula C8H8. It is produced by dehydrogenation of ethyl benzene in a reaction with a catalyst. Potential sources of exposure by the general population include motor vehicle exhaust, tobacco smoke, and other combustion. Chemicals analysis was performed to determine the pollutants emitted by PCs serviced for 3 months and styrene was detected with phenol, toluene, 2-ethylhexanol and formaldehyde. It is estimated that the indoor air concentration of styrene monomer residues from expanded polystyrene used as insulation would be 10.1 µg/m3. Exposure to low-dose styrene results in physical and neurobehavioral development delays, as well as decreased enzyme activity and neurotransmitter secretion level.

Chlorpyrifos forms colorless to white crystals with a characteristic odor, and inhibits acetylcholinesterase to control insect pests. It has the chemical formula C8H11Cl3NO3PS, and may have effects on the nervous system, resulting in convulsion and respiratory depression. Children exposed to prenatal to chlorpyrifos are significantly more likely to score in the clinical range for attention problems, attention-deficit/hyperactivity disorder (ADHD) problems, and pervasive developmental disorder (PDD) problems at age 3. Metabolites of chlorpyrifos were higher in children living on farm where chlorpyrifos was applied than in those where it was not applied prior to urine sampling. Chlorpyrifos concentration in polished rice reflected its concentration in the air of a residence treated by termicide application. Chlorpyrifos was detected in household dust from houses treated with an insecticide.

Di-n-butyl phthalate (DBP, DnBP), is soluble in most organic solvents, e.g. in alcohol, ether and benzene, but is only slightly soluble in water. DBP is a commonly used plasticizer for nitrocellulose, polyvinyl acetate and polyvinyl chloride, and so on. DBP and di-2-ethylhexyl phthalate (DEHP) among phthalates were detected predominantly in indoor air samples. The dominant path of phthalates intake was the ingestion of foodstuffs compared to inhalation of indoor air by children.

n-Tetradecane is an alkane with the chemical formula C14H30. It is found in vinyl flooring together with n-pentadecane and phenol.

DEHP is an organic compound with the chemical formula C24H38O2, and is a benzene dicarboxylic acid ester, which at room temperature is a colorless to yellow oily liquid. DEHP, polycyclic aromatic hydrocarbons (PAHs) and lead via household dust ingestion by children are considered to affect their health. The maximum estimated tolerance daily intake (TDI) is 40–140 g/kg per day for pregnant women in Japan, set by the Ministry of Health and Welfare. These phthalates, within the range of what is normally found in indoor environments, are associated with allergies in children.

Diazinon is a colorless to dark brown liquid with the chemical formula C12H21N2O3PS, and is a contact organ phosphorus insecticide with a wide range of insecticide activity; it does not occur as a natural product. A study reported the potential for pet dogs to be an important pathway for transporting diazinon residue into homes and onto its occupants following residential lawn applications.

Nonanal is an alkyl aldehyde with chemical formula C9H18O, a colorless to light yellow liquid
with a strong fatty order. The concentration of nonanal was higher in western-than Japanese-style room.

Acetaldehyde is a colorless, volatile liquid with a pungent suffocating odor. The threshold is 0.09 mg/m$^3$. It is a highly flammable and reactive compound that is miscible in water and one of the most common solvents, with the chemical formula C$_2$H$_4$O.$^{104}$ It occurs naturally in ripe fruit, coffee, and bread, and is produced by plants as part of their normal metabolism.$^{104}$ It is said that acetaldehyde from refrigerator may cause an indoor air pollutant.$^{105}$

Fenobucarb is one of carbamate pesticides and is used as an agricultural insecticide by disturbing activity of acetylcholine-esterase.$^{106}$ It is classified as “Moderately hazardous (class II) technical grade active ingredients in pesticides continued” by IPCS.$^{107}$ Kubota et al. reported that fenobucarb showed a delayed action even in the 21-day exposure test.$^{108}$

Total volatile organic compounds (TVOCs) refers to total concentrations of multiple indoor air pollutants. It is used as a complementary indicator to decrease indoor pollution level in total and achieve healthy indoor air environment.$^{109}$ The indoor air concentration of TVOCs reached to equilibrium in three hours in a regular dwelling with full-time ventilation.$^{110}$

**2-ethyl-1-hexanol**

2-ethyl-1-hexanol is thought to be an indicator of alkaline degradation of a plasticizer, DEHP, in polyvinyl chloride (PVC) floor material on concrete floor constructions.$^{111, 112}$ It was found to be one of the predominant volatile organic compounds in the indoor air of large-scale buildings.$^{113}$ Some studies have shown that 2-ethyl-1-hexanol caused acute symptoms in susceptible individuals at a concentration range of 408 µg/m$^3$.$^{114}$ and could be a possible causative chemical for SBS.$^{115}$ 4-Heptanone is a major DEHP metabolite in humans through 2-ethyl-1-hexanol in haemodialysis patients.$^{116}$

**Nano-particles and Nano-materials**

The health effects of nano-particles and nano-materials have been reviewed.$^{117-121}$ Nano-materials are divided into two types: environmental nano-particles emitted from automobiles, and manufactured nano-particles, such as fullerenes, carbon nano-tubes, and ultra-fine metals/metal oxides.$^{117}$ Methods for measuring nano-particles have been reported on the basis of number, surface area, or mass.$^{118}$ General nano-particles (<100 nm) are supposed to be permeable through the cell membrane and tissues, and may cause health effect.$^{119}$ Carbon nano-tubes aggregates, a type of nano-particle, might be correlated with asthma incidence; however, there are contradictory reports on the health effects of these particles.$^{119}$

**Heavy Metal/Lead**

Although the lead concentration in indoor air is lower in Japan than in other developed countries, the source of lead contamination in dwellings is controversial.$^{122, 123}$ A paper has indicated that lead in house dust and playground soil deserves attention when considering lead exposure in children in Japan.$^{124}$

**Odor**

The application of semiconductor-based odor sensors can evaluate indoor air quality by measuring formaldehyde and VOCs levels in low concentrations in residential spaces.$^{125}$ A moldy order is considered one of the dampness indicators related to sick buildings.$^{126}$ Certain odors may result in psychological effects and a lack of concentration. Some building materials continually cause perceivable odors because their odor thresholds are low.$^{127}$

**Gas/Radon**

Radon is a chemically inert, naturally occurring radioactive gas that has no smell, color or taste.$^{128}$ Radon enters homes through cracks in concrete floor-wall junctions, gaps in the floor, small pores in hollow-block walls, and sumps and drain.$^{128}$ Radon-induced lung cancers are mainly caused by low and moderate rather than indoor radon in homes at such low concentrations.$^{128}$ Many houses in Hokkaido, in the northern part of Japan, are built airtight and equipped with basements to conserve heating energy. As a result, the concentration of radon and its metabolites is increased in concrete single-family homes.$^{129}$

**Light**

Blue light from light emitting diode (LED) is supposed to suppress melatonin secretion, which affects the circadian rhythm.$^{130}$ Koyama proposed that light exposure during night might cause asynchronisation, and recommended a morning-based lifestyle as a way to reduce behavioral/emotional problems, and to lessen the likelihood of falling into
asynchronization.\textsuperscript{131)}

**Living Style**

Nakayama and Morimoto revealed the risk factors of lifestyle on symptoms of sick building syndrome, and suggested that modification of life style can alleviate symptoms.\textsuperscript{132)} Furniture and electrical appliances in each room of Japanese residences was surveyed to identify information about indoor air pollution.\textsuperscript{133)} Allergen-avoidance daycare centers used daily floor cleaning, weekly furniture wiping, and washing of pillows, mattresses, and curtains to improve have environments.\textsuperscript{134)}

**ANALYTICAL METHODS**

The committee on SHS supported by Japanese Ministry of Health, Labour and Welfare released a progress report describing, “Indoor air pollutants subject to the analysis.” This report includes sampling and analytical methods. Sampling and analysis procedures for formaldehyde involve the collection of air into cartridges coated with 2,4-dinitrophenylhydrazine (DNPH) and subsequent analysis by high performance/pressure liquid chromatography (HPLC) with detection by ultraviolet absorption. Sampling and analysis procedures for VOCs involve the collection of air into sorbent tubes or stainless sampler (canister) and subsequent analysis by gas chromatography with mass spectrometer.\textsuperscript{109)}

**MEASURE FOR THE POLLUTION**

**Ventilation**

Ventilation is an effective method to reduce the concentration of pollutants in indoor air.\textsuperscript{135)} A ventilation system including a dielectric barrier discharger (DBD) and UV-photo catalyst (UVP) filters effectively decreased the concentration of VOCs, such as benzene, toluene, and xylene.\textsuperscript{136)} Day nurseries in Japan that take care of preschool children for a long time need to maintain good-quality indoor air by ventilation.\textsuperscript{137)} Appropriate air ventilation in facilities such as Internet Cafes is also needed as part of a tuberculosis control program in metropolitan areas.\textsuperscript{138)}

**Bake-out Method**

The bake-out method could allow VOCs to escape from building materials at an early stage, by keeping the entire room heated as at 30°C or higher for several consecutive days, and subsequently ventilating the room to accelerate VOCs emission.\textsuperscript{139)} Intermittent bake-out using air conditioner is thought to be a practical process for reducing indoor air pollution.\textsuperscript{140)} A filter system with an air cleaner effectively decreased airborne microbes compared to a system using ion emission.\textsuperscript{141)} It has been found that VOCs can be adsorbed by charcoal carbonized at temperature exceeding 600°C.\textsuperscript{142)} A paper has reported that running air conditioners at 40 for 10 min per a day by operating the air conditioner in heating mode effectively regulated fungal contamination.\textsuperscript{143)}

**Titanium Dioxide**

A study reported the potential of water photolysis using a titanium dioxide (TiO\(_2\)) electrode by radiation with ultra-visible light.\textsuperscript{144)} TiO\(_2\)-based photocatalytic compounds\textsuperscript{145–148)} or incorporated into cementitious materials\textsuperscript{149)} are thought to decompose air pollutants, such as organic compounds. TiO\(_2\) has been developed and used as a photocatalyst for indoor and outdoor air purification and to purify water contaminated with low concentrations of toxic pollutants.\textsuperscript{150)}

**JAPANESE REGULATIONS ON FORMALDEHYDE EMISSION FROM ARCHITECTURAL MATERIALS**

In 2003, the Ministry of Land, Infrastructure and Transport of Japan amended the Building Standard Law to control indoor chemical concentrations. This regulation restricts the use of formaldehyde-emitting materials and requires the installation of mechanical ventilation to keep the air exchange rate over 0.5 times per hour. The Building Standard Law is applied to all buildings, and must be followed by architects. Simultaneously, a new standard was added to the Japanese Industrial Standard (JIS) that the method of measuring the chemical emission rate from architectural materials should be divided 4 grades.\textsuperscript{151)} The best grade is F\textsuperscript{★★★★} and the lowest is F\textsuperscript{*}. According to the Building Standard Law, F\textsuperscript{*} material cannot be used as interior material, but F\textsuperscript{★★★★} can be used freely. Recently, F\textsuperscript{*} material disappeared from the Japanese market and the infection rate of SHS in newly built residences has fallen significantly compared to before these amendments;
however, prior to the installation of new furniture in new residences, chemical substances emitted from old furniture might affect the health of residents. The regulation of chemical emission from furniture and the education of residents are required.

COMMUNICATION BETWEEN MEDICAL INSTITUTIONS AND REGIONAL HEALTH CENTERS

The Ministry of Health, Labour and Welfare in Japan disseminated knowledge about anti-SHS measure to medical institutions. The ministry has designated SHS as a disease that can be claimed under medical insurance at the request of medical institutions. When medical institutions run by prefectures or designated cities plan to build clean rooms to diagnose and consult with patients, they will receive one third of the budget from a national subsidy. The Ministry also included CS as a disease that can be claimed under medical insurance at the request of medical institutions in 2009. Most regional health centers had staff members who can assess the indoor environment, but their ability to discuss on health-related issues is limited; therefore, establishment of a hub regional health is recommended for a comprehensive consultation and referral system that can meet local needs in dealing with SHS.152)

CONCLUSION

Healthy indoor air is a fundamental right for people studying in schools, working in offices and living in residences. Indoor air quality plays an important role in the health of residents. Many factors are associated with polluted indoor air and cause health problems, including SHS, SBS, or MCS; however, these problems are not understood well in our society. The task of the authors is to encourage not only the public, but also the medical specialist, such as medical doctors, nurses, and architectural engineers, to acknowledge these problems. The review addresses health issue due to inferior indoor air quality from the viewpoint of environmental hygiene, but it is not sufficient. Continuous efforts should be made to improve the health of both of the individuals and the public.

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