IAPOC

Indoor Air Pollution by Organic Compounds

Indoor Air Chemical Pollution Research for Healthy Living Environment

Architectural Institute of Japan

IAPOC

Symposium Appeal
(International Symposium on Current Status of Indoor Air Pollution by Organic Compounds and Countermeasures for Healthy Housing January 13, 2001)

There is a growing concern that human exposure to chemicals at levels once considered safe or presenting insignificant risk could be harmful. Exposures in utero, during infancy or over a lifetime are now suspected to have adverse biological effects on the central nervous system development affecting cognition, immune system as well as physical development. Disorders associated with chemical exposures are called by many names such as 'sick building syndrome', 'sick house syndrome', 'sick school syndrome', 'multiple-chemical sensitivity', 'chemical sensitivity', 'toxicant-induced loss of tolerance (TILT)' and 'chronic fatigue syndrome.' This indicates that we know there are many suffering from these disorders not only in developed countries but also in less developed countries, but we do not know the specific biological mechanisms involved. The lack of clear biomarkers and the time lag between initiating exposures and ultimate symptoms make it technically, and increasingly politically, difficult to develop an extensive body of evidence needed to regulate many chemicals and industrial processes or to compensate the chemically injured. The emerging science associated with low-level chemical exposures requires that we examine both the way we think about chemicals and health, and the solutions we devise to prevent chemically-caused injury.

We, as scientists and citizens assembled in this International Symposium on Current Status of Indoor Air Pollution by Organic Compounds and Countermeasures for Healthy Housing, appeal to everyone living in the 21st Century to address these serious problems by applying the principles stated in The Right to Healthy Indoor Air (WHO, 2000). Integrated approach to this multi-disciplinary issue is essentially needed to live in a healthy house.

The Right to Healthy Indoor Air (WHO, 2000):

P1 Under the principle of the human right to health, everyone has the right to breathe healthy indoor air

P2 Under the principle of respect for autonomy ("self-determination"), everyone has the right to adequate information about potentially harmful exposures, and to be provided with effective means for controlling at least part of their indoor exposures.

P3 Under the principle of non-maleficence ("doing no harm"), no agent at a concentration that exposes any occupant to an unnecessary health risk should be introduced into indoor air.

P4 Under the principle of beneficence ("doing good"), all individuals, groups and organizations associated with a building, whether private, public, or governmental, bear responsibility to advocate or work for acceptable air quality for the occupants.

P5 Under the principle of social justice, the socio-economic status of occupants should have no bearing on their access to healthy indoor air, but health status may determine special needs for some groups.

P6 Under the principle of accountability, all relevant organizations should establish explicit criteria for evaluating and assessing building air quality and its impacts on the health of the population and on the environment.

P7 Under the precautionary principle, where there is a risk of harmful indoor air exposure, the presence of uncertainty shall not be used as a reason for postponing cost-effective measures to prevent such exposure.

P8 Under the "polluter pays" principle, the polluter is accountable for any harm to health and/or welfare resulting from unhealthy indoor air exposure(s), and is responsible and accountable for correcting the condition.

P9 Under the principle of sustainability, health and environmental concerns cannot be separated, and the provision of healthy indoor air should not compromise global or local ecological integrity, or the rights of future generations.

Signer : William Rea, Satoshi Ishikawa, C.Y. Shaw, Lars Moelhave, Jan Sundell, Claudia S. Miller, Shuzo Murakami, Koichi Ikeda, Yukio Yanagisawa, John Spengler, Peder Wolkoff, Kazuaki Bogaki, Akira Eboshida,Shinichi Tanabe,Shinsuke Kato, Hal Levin, Hiroshi Yoshino

Indoor Air Chemical Pollution Research for Healthy Living Environment

It would be almost impossible at present to construct any building, including a house, within the extent of normal construction costs and construction period without the use of artificially synthesized chemical substances. The use of chemical substances has brought great progress in building quality and wide improvement of the living environment, as well as the economical effect accompanying reduced construction costs and shortened construction periods. Chemical substances have some beneficial effect, but they will cause contamination problems when carelessly discharged into the environment, even if in a small amount.

There are strong demands for energy saving at present from the global environment point of view. In response to this demand, high air-tightness and insulation of buildings have seen rapid improvement. One-sided high air-tightness that does not duly consider room air quality and the control of room air pollution, however, has often brought about large reductions in the amount of ventilation. This has in turn resulted in greatly accelerating room air pollution due to chemical compounds such as volatile organic compounds (VOCs) generated from the building materials in which those chemical substances are used. People in the present age spend about 90% of their time in rooms. They are therefore subject to increased chances for hours of exposure to higher concentrations of pollutants than in the past. Even if the pollutant is in a lower concentration than a value showing acute toxicity, the number of people whose health has obviously been affected by long-time exposure has increased. This effect on health resulting from room air pollution is also referred to as "sick building syndrome", and constitutes a big social problem.

Under such a situation, the present interdisciplinary study was carried out for three years by researchers in the architecture, chemistry, medical science and social science fields in Japan cooperating to rapidly settle the problem of room air pollution and develop technology needed to construct healthy and sanitary buildings. The former Science and Technology Agency (present Ministry of Education, Culture, Sports, Science and Technology) provided aid with the science and technology promotion and coordination fund. In the study, the actual living conditions were investigated and the effect chemical substances had on the human body was medically examined. The means to measure and evaluate the amount of chemical substances generated from construction materials, a model for predicting pollution with the use of data on emission rate, ventilation methods to lower the concentration of chemical pollutants to healthy and sanitary ranges and methods to remove and decompose chemical substances were developed, among others. Manuals for examining and evaluating room environments and for avoiding the effect on health were also prepared for the inhabitants as a result.

In conclusion, I would like to again express my gratitude to the persons concerned, as well as to the Ministry of Education, Culture, Sports, Science and Technology and Architectural Institute of Japan, for their efforts toward the smooth advance of this study.

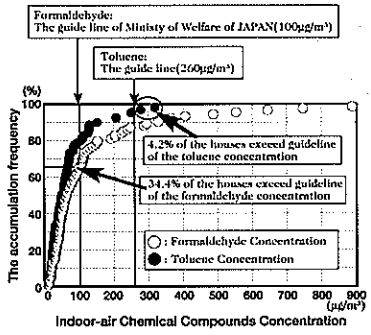
Shuzo Murakami, Study Representative
(Professor, Faculty of Science and Technology, Keio University)

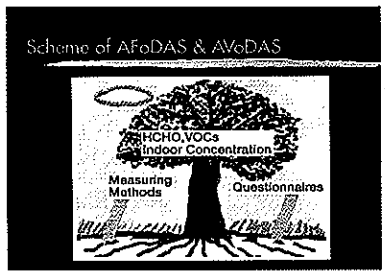
Indoor Monitoring and Medical Investigation

①Field Survey on the Awareness of the Occupants and Residential Environment

Niigata University : Akabayashi, National Institute of Public Health : Ikeda

For this study, the houses with any kind of a lifestyle and type of ventilation system were sampled. The air quality, indoor thermal environment, air-tightness, thermal insulation of the houses, and the awareness of the occupants were investigated. As the results of the questionnaire survey of IAQ, the question is "Do you feel that indoor air is bad in your house?" As for the answer of this question, "yes" answers are 38.9% of all houses, and "no" is 61.1%. The worst smell is from cigarette smoke. Other bad smells are from heater, cooking, pet and newly built house's smell and so on. As the results of the accumulation frequency of chemical compound concentration using passive gas monitor that were exposed 1week in the living room, the formaldehyde concentration in about 34% of all houses exceeds 0.08ppm which is the guideline of the Ministry of Health, Labour and Welfare, Japan. The toluene concentration in about 4% of all houses exceeds 0.07ppm the guideline of the Ministry of Health, Labour and Welfare, Japan. As a airtightness improves, formaldehyde concentration increases in the houses in which ventilation system was installed only at the rest room and the kitchen. The result that could get it by this investigation is put together, and a data base is built, and design foundation materials are provided widely in the internet homepage.





②Elucidation on Pollution Load to Human Body and Medical Effect from Chemical Pollution

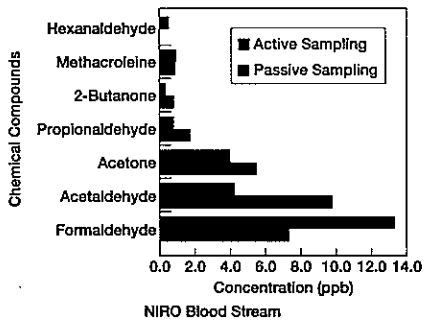
University of Tokyo : Yanagisawa, Kitasato Inshtute Hospital : Ishikawa

MCS (Multi-Chemical Sensitivity) patients suffer from variety of symptoms, such as sinus pain, hoarseness, cough, sore throat, burning eyes, fatigue, difficulty of concentrating, headache, aching muscles, joint pain and more. Since they are subjective symptoms, a question arises whether these symptoms emerge from physiological reactions due to exposures to certain chemical compounds or psychological ones. To answer this question, we aimed to develop methods to measure and accumulate objective data.

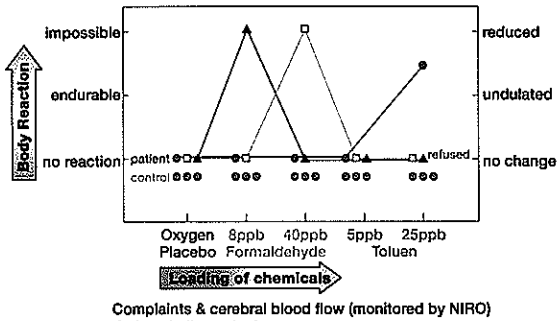
The objective medical data were obtained from nervous function tests, such as pupil response followed by light stimuli, smooth pursuit ocular movement and contrast sensitivity function, and blood stream measurements of the brain using NIRO (Near Infrared Oxygen Monitoring). Definite changes of these objective functions were detected under various exposure levels of responsible chemicals given inside of an exposure chamber.

The objective environmental data were collected to identify and quantify the responsible chemicals to induce these symptoms. Passive and active sampling methods were simultaneously applied to take personal exposure data.

According to the results of both chamber tests and environmental measurements, we found exposures to a lower level of chemicals, for example one-tenth of indoor guideline, could induce the symptoms to MCS patients. Based on these findings. We could accumulate clear objective evidences that there were very sensitive people who developed annoying symptoms when exposed to certain chemicals even at very low dosages.



NIRO Blood Stream



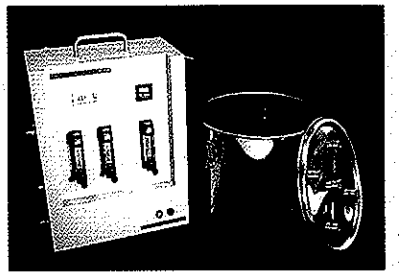
Complaints & cerebral blood flow (monitored by NIRO) during challenge test

Emission Analysis and Mitigation Measures

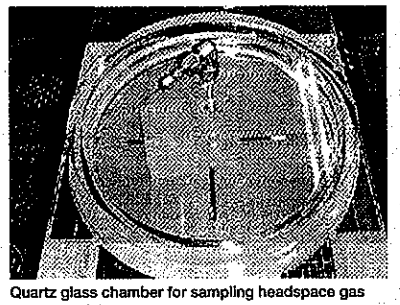
①Study on the Measurement of the Emission Rate and Evaluation

Waseda University : Tanabe, Ochanomizu University : Kubota, Kagoshima University : Iwashita

In the task of "Measurements of Aldehydes and VOCs Emission rates from building materials", the purpose of this study is to measure and evaluate Aldehydes and VOCs emission rates from building materials. To achieve good indoor air quality it is very important to decrease emission rates of chemical pollutants from building materials. A small-scale chamber ADPAC (ADvanced Pollution and Air quality Chamber) was developed for precise measurement of chemical emission rates. The performance of ADPAC was investigated to meet criteria. Several types of building materials were measured by using ADPAC. In the task of "Chemical analysis and sampling method for VOC Emitted from building materials", for the development of effective chemical analyses and sampling method, an on-line system for the concentration and induction to GC-MS analysis of headspace gas emitted from building materials was constructed using multipurpose sampling and thermal desorption system. The composition and concentration of VOC emitted from wallpapers, wooden materials and housing construction adhesives were measured effectively with good reproducibility. Various kinds of VOC were detected in the chemical building materials. The composition and amount of VOC was differed very much depend to the materials. These results showed that it is very important to check the VOC level of the indoor housing products before shipping from the producer to develop the low VOC products. This measurement system is very effective for this purpose because of its easiness and reproducibility. In the task of "research on the evaluation method for perceived air quality", the relationship between the concentrations of individual VOC and the perceived air quality voted by sensory panel was determined with five VOCs emitted from wood stain. Consecutively the relationship between the VOCs concentrations in the mixture of the five VOCs and the perceived air quality was investigated. Moreover, the experiment, which investigates the effect of air pollution on sick building syndrome and productivity, was conducted. Since sensitive subjects who complained irritation during the exposure, had less performance of proofreading task, better air quality is desired for the efficiency of intellectual work.



Small-scale chamber ADPAC



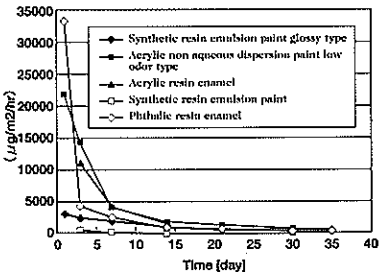
Quartz glass chamber for sampling headspace gas from materials

Subjects performing a typing task on PC

②Development on the Mitigations and Methods in Residential Environment

Building Research Institute : Bogaki, Motohashi, Chiba Institute of Technology : Komine

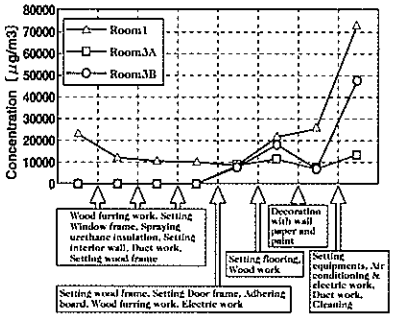
Development of the Method for Controlling Emission from Building Materials : VOCs from several coating materials, adhesives, and other materials were measured by flask method. Effects of temperature and time on VOCs emission were experimentally investigated and standardized data was accumulated. The VOCs emission reduced at short time than formaldehyde. In other words, if taking sufficiently dry time after work, it found that there were little influence of VOCs. And it found that the inorganic coating material including chemical adsorption agents showed high absorption capacity and little releasing.



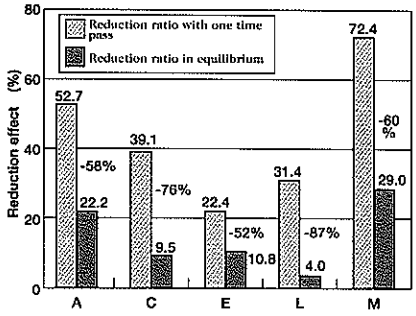
The change of the emission from the various paint

Survey on Emission's from Execution and Everyday Life and the Development of Controlling and Mitigation : It was investigated the change of the indoor air quality at some building site. As the result, it is found that the concentration of Formaldehyde and VOC's in air rose after constructing big surface area such as the wall panel. Also, the survey on emission source such as the furniture and so on which were used in the everyday life in the dwellings was conducted. From the experiments and the questionnaire investigation, it was found that the effects of furniture and smoke on indoor air quality and the emission from opened burning type fixtures.

Development of Controlling and Mitigation Method Related with Household Equipment, HVAC System and Life Articles : The primary screening test equipment for passive type removal materials which had adsorptive & solvent capacity of formaldehyde and VOCs were developed and the standard testing and evaluation method of the purify efficiency for air cleaners and removal materials were proposed. The practical reduction effect of the air cleaner or passive type removal materials those were thought to satisfy the evaluation standard on the basis of laboratory tests, were verified by a full scale experiment. As a result, some of passive type removal materials and air cleaners had effect on decreasing in concentration of formaldehyde. But no one had effect on decreasing in concentration of VOCs.



Example of the concentration change of TVOC in the construction process at the experimental house made by RC.



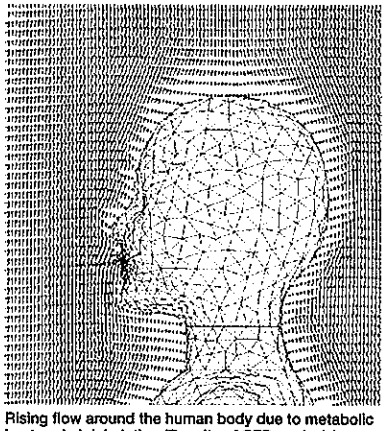
Reduction ratio with one time pass and reduction ratio in equilibrium

Development of Optimal Designing Method for Indoor Environments to Prevent Air Pollutant Exposures

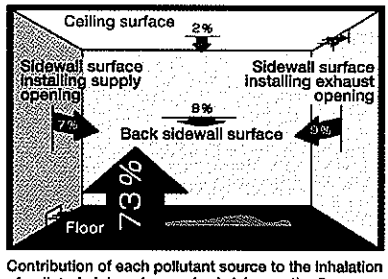
①Investigation on Emission and Diffusion of Chemical Pollutants in a Room and Development of Method to Predict the Concentration of Air to be Inhaled by Human Body

Keio University : Murakami , University of Tokyo : Kato

A mathematical model for the transportation of chemical pollutants are investigated. There included; (1) internal diffusion in building materials, (2) building material and air- interface, (3) transportation inroom air, and (4) the effects of adsorption and desorption, based on experiments and theoretical considerations. Those models are incorporated in CFD (Computational Fluid Dynamics) and the prediction method for chemical pollutants distribution in a room is developed. A experimental system has been prepared that can predict the emission, diffusion and concentration profile of a chemical pollutants in a room when the building material used and the ventilation conditions are provided. The spreading properties of pollution in a room with chemical pollutants have been evaluated using this CFD method. A method to evaluate the concentration of polluted air to be inhaled by the human body has also been developed with CFD, and a system to analyze risk for human intake of pollutants present in each part of a room has been prepared by combining both methods. As shown in the figure, the human body forms a thermal plume around its periphery due to its metabolism. Inhaled air is under the influence of the flow ascending from the neighborhood of the floor round the periphery of the human body. Consequently, the contribution of a pollutant on the floor surface to the inhalation of polluted air by the human body is extremely great in case of an approximately calm state, though depending on the ventilation property in the room. Even if the generation of pollution is at the same rate from the floor, the wall and the ceiling of a room, 50 % or more of the pollutant inhaled originates from the floor when the human body is standing, and 70% or more of the inhaled pollutant originates from the floor when lying on the floor as shown in the figure. This shows that it is important to improve the floor material against preventing inhaled air pollution.



Rising flow around the human body due to metabolic heat and air inhalation (Results of CFD analysis)

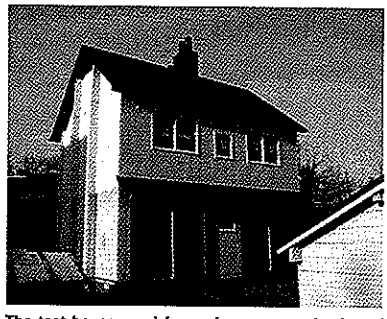


Contribution of each pollutant source to the inhalation of polluted air by a human body lying on the floor

②Development of Hybrid Energy Saving Ventilation and Air Conditioning System to Reduce Personal Pollution Exposure

Tohoku University : Yoshino

The purposes of this study are, firstly, to establish the method of performance evaluation on the ventilation system for decreasing indoor air pollution by chemical materials, secondly, to develop the hybrid ventilation system for energy saving, and thirdly, to make the design manual for an optimum ventilation system corresponding to various conditions. For these purposes, experiment and numerical analysis of the hybrid ventilation system using a test house shown in the photo were done and field measurements of the ventilation performances of occupied houses were performed. As a result, it was clarified that a mechanical supply ventilation system, one type of hybrid ventilation system that supplies the outdoor air forcibly to the second floor or another type of hybrid ventilation system that supplies the outdoor air from the crawl space, had better performance in the viewpoint of the outdoor air distribution to each room. On the other hand, the hybrid ventilation system with heat exchanger was developed and the examination of the performance has also been done.



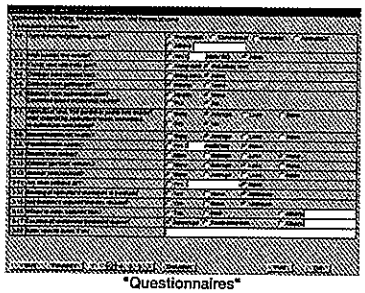
The test house used for performance evaluation of various ventilation systems

TASK 4 Mitigation to Chemical Pollution for Practical Use and Making a Manual to the Occupants

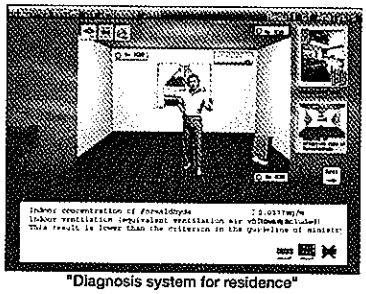
Architectural Institute of Japan : Kawata, Taisei Corporation : Morikawa

We prepared "Manual" for formaldehyde and volatile organic compounds, based on the results from studies. This "Manual" explains approximately one hundred important items in the form of questions and answers, in line with table of contents ("background", "basic knowledge for indoor air chemical pollution and compounds", "before purchase pre-occupancy ", " post occupancy ", "at the time of reform", "attention after residence", "in the case of feeling subjective symptoms", "the integrated information transmitting and evaluating system"), for not only residents who have a few professional knowledge but also designers and builders.

The integrated information transmitting and evaluating system is composed of "Questionnaires" and "Diagnosis system for residence". "Questionnaires" is composed of 4 questionnaires. (2 questionnaires for residents at pre-occupancy and post occupancy, and 2 questionnaires for designers and builders at planning/designing stage and after completion of building) The results of diagnosis by "Questionnaires" show category of improvement in an evaluation chart. "Diagnosis system for residence" included various data (such as chemical emission volume from interior materials or cigarette smoke, the effect of curtailment for chemical compounds by air cleaner, the method of ventilation and so on.) Moreover, This system can easily evaluate the concentration of indoor air pollution in houses by computer, with any combinations of selected interior materials, conditions of dwelling, conditions of ventilation and so on.



"Questionnaires"



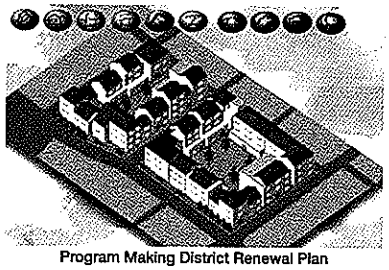
"Diagnosis system for residence"

TASK 5 Development of the Technology for Proper Ventilation

Nasu University : Kume, University of Tokyo : Asami, Hosei University : Fukui, University of Tokyo : Hatta, Tsukuba University : Ohmura

It is also needed to promote proper air circulation in cities in order to prevent indoor air pollution. For that purpose, we have developed a guiding system for the improvement of outdoor environmental condition, which promotes urban renewal projects and realizes urban sight plans with proper air circulation.

Air pollution in the districts facing trunk roads is also is a serious problem, which causes indoor air pollution by ventilation. We have developed a technology which controls directly the outdoor air pollution by charging toll for the social cost caused by the motor vehicles.



Program Making District Renewal Plan

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○The initials "IAPOC" stand for "Indoor Air Pollution by Organic Compounds". As POC represents "Port of Call", IAPOC symbolizes the destination of indoor air pollution