Subjective Evaluation for Perceived Air Pollution Caused by Human Bioeffluents

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ABSTRACT

The concentration of carbon dioxide is used as an important index of indoor air quality representative of body odor or bioeffluents in Japan. In the construction field of Japan, there is a CO_2 concentration standard of a thousand ppm or less. However, property of occupants (such as sex, age and nationality) has non-nogligiblw effect on the room odor environment. Thus the standard of ventilation air volume should be decided suiting up for building use and occupants. In this research, we made the exposure experiments of human bioeffluents caused by occupants and considered the difference between the subjectively reports. Five conditions were set. The first one is "under twenty-five years old under uncontrolled condition" made up of people in the age of twenty-five and without restrictions on clothes and the use of cosmetics etc. The second one is "over thirty-five years old condition" made up of people in the age of thirty-five and the third one is "non-Japanese condition" made up of people with mainly Asian nationality except Japan. The fourth one is "minimum emission condition" made up of people in the age of twenty-five and with restrictions on clothes and the use of cosmetics to limit the body odor derived from pure human body. And the last one is "sweating condition" whose occupants do step up&down aerobics activity to sweat before the experiment. We made panel evaluate using three evaluation scales. Odor intensity, hedonic scale and acceptability. We called into account the influence of olfactory adaptation, so we prepared six occupant panel and six visitor panel separately. As an experimental procedure, we let the occupant panel enter a chamber and the CO_2 concentration becomes five thousand ppm by controlling the ventilation rate. Panel evaluate multiple times during the ascent process of body odor and CO_2. And in order to identify the components contained in the indoor air, we obtained samples at CO_2 concentration of five thousand ppm and did quantitative analyses. And to increase the number of data, the evaluations were conducted three times with almost three minutes intervals. But the statistical reliability is unknown for the multiple evaluation by a small number like this time, so we needed to make a study about that. In particular, we developed a probabilistic prediction method based on normal distribution. As a result of experiments, we confirmed the influence of property of occupants on the subjective evaluation and the difference between evaluations of occupants and visitors. For example, in odor intensity, evaluation of occupants is almost flat throughout the experiment. On the other hand, visitors gained higher evaluation at CO_2 concentration increased. And evaluation of occupants is more sensitive on "non-Japanese people condition" than other conditions. It seems that the occupants responded more sensitively to each other's body odor because people with different nationalities existed in the same place.

KEYWORDS

Odor, Subjective Evaluation, Odor Ingredient, the Statistical Inference Model

1 INTRODUCTION

The concentration has been used as an index of perceived air pollution caused by human bioeffluents provided by the Act on Maintenance of Sanitation in Buildings in Japan and 1000 ppm is target value to maintain comfortable indoor environment. However, discomfort odor is different depending on building use (e.g. *[1] S, Okada, 1992*), so the standard of ventilation rate is required to be set in view of building use and users not across the board.

The atmospheric CO_2 concentration has been gradually increasing, and now it is approximately 400 ppm. Thus, the target value of 1000 ppm regulated in the legislation needs to be re-considered. A level of 5000 ppm of CO_2 is used as an occupational exposure limit in factory environment, so if the exposure to CO_2 at this level lasts longer than 8 h, it might cause toxic effects. In non-industrial indoor environment, the major source of CO_2 is human metabolism. The levels of indoor CO_2 concentration thus depends predominantly on human occupancy and on the rate of ventilation. It is generally known that the olfactory adaptation occurs in the panel, and they could lose their sense of smell. So far, the ventilation design method taking the olfactory adaptation into account has not been established, which is worth making sufficient study. If we can save unnecessary ventilation rate considering such an adaptation, there could be further contribution to energy-saving.

In this research, the authors conducted the exposure experiment of occupants' human bioeffluents, and the main purpose of this study to figure out the influence of characteristics of occupants on subjective odor environment. This paper shows the results of the subjective reports of the exposure experiment and the measurement of quantitative analysis to identify the component in indoor air. In addition, the statistical reliability of data in the experiments is also studied because multiple evaluations were performed by a small number of panels. Moreover, we proposed the statistical model to predict the percentage of dissatisfied based on the ISO scale of acceptability.

2 METHODS

2.1 Approach

6 subjects were adopted as 'occupant panel(panel means subject here)' who were assumed to be source of body odor and assessed indoor air. Other 6 subjects were adopted as 'visitor panel' to assess indoor air immediately after entering the room. After occupant panel entered the chamber, the CO_2 concentration was increased by controlling ventilation rate, and panel rated their levels of odor intensity, assessed their comfort, and reported whether they could accept the air quality. The visitor panel were blind to experimental conditions. CO_2 concentration, temperature and humidity were monitored continuously. Air in the chamber was sampled and analysed to identify the components at CO_2 level of 5000 ppm.

2.2 Facilities

The experiment was carried out in two adjacent 5.8×2.2×2.2 m stainless steel laboratories (**Fig. 1**) located at Osaka University in Japan, one with a test chamber (the volume is 7.65m^3) , and the other as a waiting room for visitor panel. The chamber has a ventilation system with a duct through which the air is exhausted. The air temperature was controlled at the range from 18°C to 25□ by a room air conditioner so that panel didn't sweat.

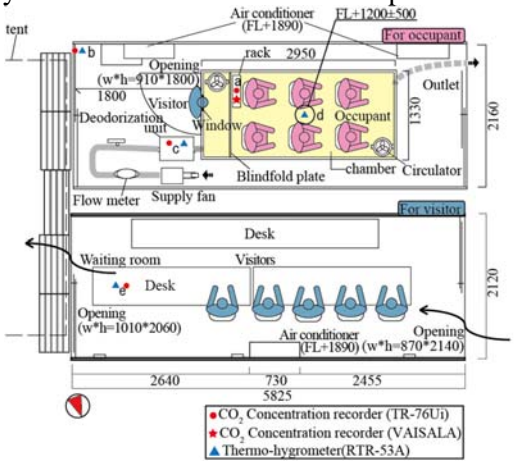

Fig. 1 Plane of the laboratories

2.3 Subjects

Three male and three female college-age subjects (mean ± SD age: 23.0 ± 1.2 years), five males and one female over 35 years old (mean ± SD age: 48.0 ± 8.0 years) and three male and three female college-age subjects with non-Japanese nationality (mean ± SD age: 23.8 ±1.6 years, nationality: Myanmar, Russia, Indonesia, India, Malaysia) were recruited for the experiments as 'occupant panel' who were assumed to be of body odor source and assessed indoor air as well. The occupant panel with non-Japanese nationality were good at English but not good at Japanese. Other eleven male and ten female college-age subjects (mean ± SD age: 22.1 ± 2.0 years) were recruited, and six people at one time as 'visitor panel' to assess indoor air immediately after putting their head into the chamber. For all subjects T&T olfactometer consisting of six standard odors to test human's olfactory was carried out to check if they had normal sense of smell before the experiments. They were all non-smokers and did not take any medication during the experiments. This information was obtained from a questionnaire completed by the subjects upon recruitment and was not verified by examining medical records. The subjects received financial compensation for participating in the experiments.

2.4 Experimental conditions

Five exposure conditions were prepared.

In three exposures, the occupants in the chamber were fixed with the six Japanese college-age panel as mentioned in Secton **2.3**. They participated in the experiment with no restrictions on clothes and the use of cosmetics, which is hereinafter referred to as "under twenty-five years old uncontrolled condition". In another condition named "minimum emission condition", they had a limitation such as bathing the day prior to the experiment day with non-fragrance bath detergents that were supplied, without using cosmetics or hair conditioner on the day, wearing clean clothes made of hemp during the experiment. In "sweating condition", in addition to the limitation of "minimum emission condition", they stayed for ten minutes in a climate chamber with the air temperature of 35□ and humidity of 70% assuming summer condition, and did step up&down aerobics activity for five minutes to get sweat before the experiment.

In two further exposure conditions, occupant conditions were the same as "uncontrolled condition" assuming usual clothes as mentioned above. In "over thirty-five years old condition", the occupants were made up with six Japanese over 35 years old, and in "non-Japanese condition", the occupants were made up of people with six non-Japanese nationalities as mentioned above.

"Minimum emission condition" was conducted three times to confirm the reproducibility of the experiment.

2.5 Measurements

Air temperature, relative humidity and CO2 concentration were continuously measured and recorded by thermos-hygrometer (RTR-53A, T&D Corp.) and CO2 concentration recorder (TR-76Ui, T&D Corp., and, GM70, VAISALA Ltd.) at measurement points shown in **Fig. 1**.

Pen-and-paper questionnaires were used to collect subjective votes, which included questions such as odor intensity, hedonic scale and acceptability of the air quality. The responses of subjects were obtained using visual analog scales shown in **Fig. 2**. The odor intensity was measured using the 6-point category scale and the hedonic scale was measured using the 9-point category scale used by Matsuo and Yamanaka et al. [2]. Perceived air quality was recorded using a continuous scale describing the acceptability of air quality; the scale is divided at the middle to force subjects to rate the air as either acceptable or not acceptable [3]. The subjects evaluated acceptability assuming two stay situations for short time (about five minutes) and long time (about eight hours). All scales were presented to Japanese subjects in Japanese and to non-Japanese subjects in English.

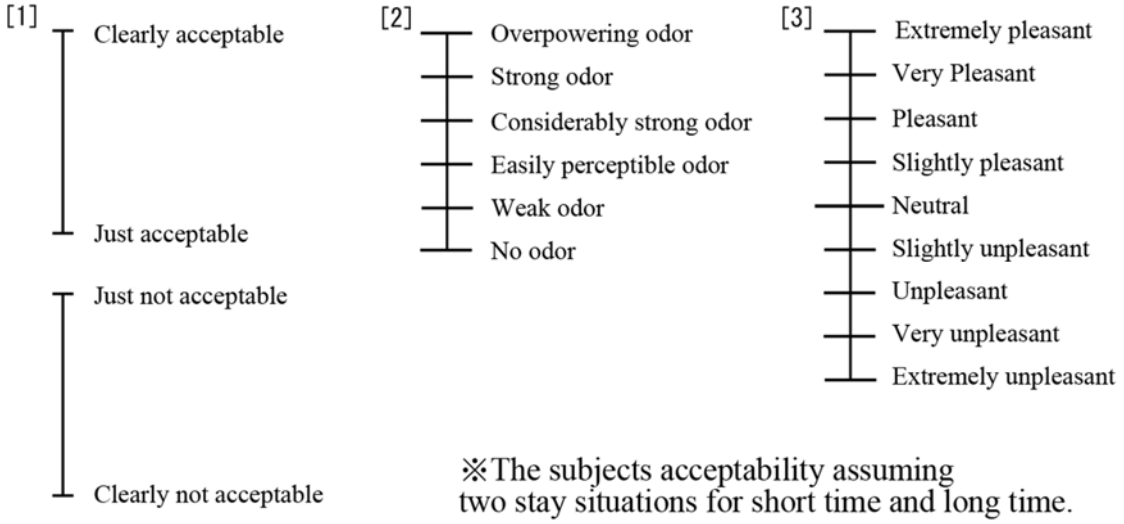

Fig. 2 Evaluation scales

2.6 Experimental procedure

The experiment was conducted from October 2016 to January 2017.

(1) Creating odor After occupants entering the chamber, CO_2 concentration in chamber was controlled to be steady state by regulating hand valve when CO_2 concentration at measurement point a in **Fig. 1** reached predetermined concentration.

(2) Instruction The visitors moved the next room that had the chamber one by one, smelled odor in the chamber through a window and evaluated air quality. They were given instructions on the odor method, such as putting all the face in the window and making two natural breaths at this time. It was announced that the smell was of air in the room where several healthy men and women stayed. This was to prevent the evaluation from being affected by noticing that it was a smell of people during the experiment. Both occupants and visitors were instructed on how to evaluate, timing and so on.

(3) Air Quality Evaluation by occupants in the process of increasing CO_2 concentration The occupants evaluated air quality in the chamber at 1080, 1270, 1800, 2170, 3260, 4030 ppm in the process of increasing CO_2 concentration.

(4) Air Quality Evaluation in CO_2 concentration steady state The occupants and visitors evaluated air quality in the chamber at 1500, 2650, 5000 ppm steadied by operating the ventilation fan. The visitors breathed deeply several times with outside air during the movement between the rooms. After that, they placed the face in the chamber through the window to smell the odor as shown in **Fig. 3** and then evaluated immediately. They evaluated three times at each concentration (eighteen times in total) per person (outside of the first day of the minimum condition).

A schematic of the time schedule illustrated was shown in **Fig. 4**.

The subjects were asked to avoid spicy food and the consumption of alcohol on the day prior to the experimental day or on the day itself. They were asked not to wear strong perfumes nor to use strongly perfumed hygienic products on any experimental day. The study was conducted under the approval of the ethical committee of Osaka University and written informed consent was obtained from each subject prior to participation in the experiments.

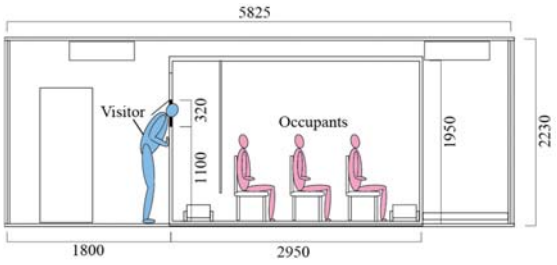

Fig. 3 The image of smelling odor

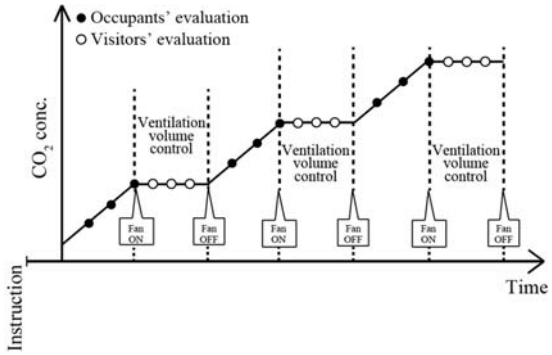

Fig. 4 Time schedule image

2.7 Statistical analysis

In this experiment, the visitors evaluated three times at the same conditions and concentrations (outside of the first day of the minimum condition), and it is possible to obtain percentage of dissatisfied from the evaluation data of acceptability. However, the standards of AIJ (Architectural Institute of Japan) [4] requires that sixty people evaluate acceptability once in order to calculate it. The statistical reliability is unknown on the date of this study. Considering that the acceptability scale combined at the middle part, rotated by 90°, and the horizontal axis was set by connecting the line (**Fig. 5**), and the evaluation value assumed as a normal distribution was divided into an inter-individual error σ^2 and an intra-individual error ${\sigma_p}^2$. The probability density distribution of samples ${\sigma_s}^2$ should include inter-individual error and intra-individual error as shown in **Fig. 6**, and the following equation **(1)** holds.

$$ {\sigma_s}^2 = \sigma^2 + {\sigma_p}^2 \tag{1} $$

When n subjects repeatedly evaluated m times, the variance of the average value is calculated by the following equation **(2)**. The index a indicates the variance of the average value.

$$ {\sigma_a}^2 = \frac{n(m\sigma)^2 + nm{\sigma_p}^2}{(nm)^2} \tag{2} $$

Since the minimum condition was conducted three times, it is possible to calculate variance for occupants.

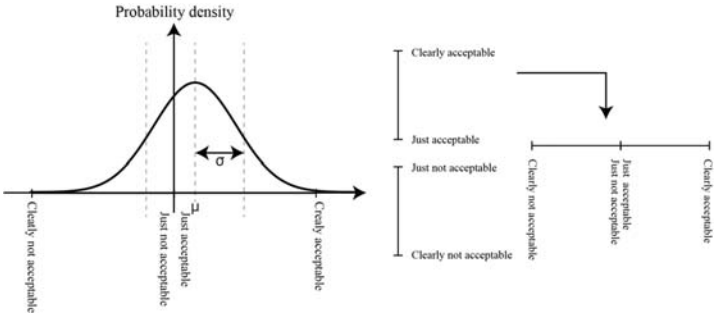

Fig. 5 The image of probability density distribution

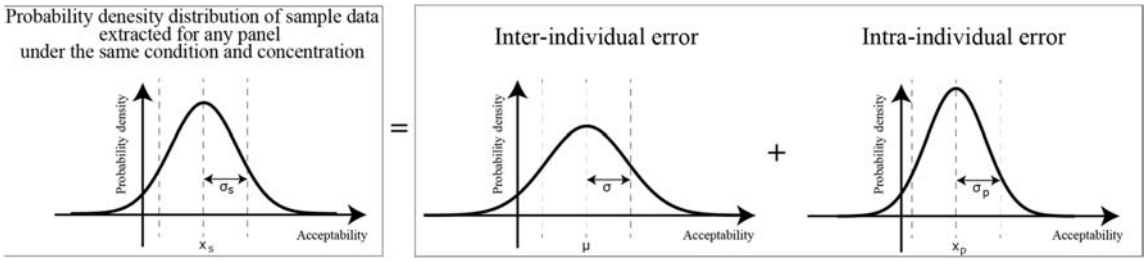

Fig. 6 The concept of probability density of one sample by one panel

3 RESULTS & DISCUSSION

(1) Odor intensity

Fig. 7 shows the results of odor intensity for each condition. The values shown in all figures are the average of panel. By using the variance of average of three times of evaluations for six panel and the variance of average of six panel, it is possible to test the difference between the average of occupants' once evaluation and the average of visitors' three time evaluations. Here "normal distribution" was used instead of "t-distribution". (The same is true for hedonic scale and acceptability.) Occupants evaluated almost flat through the environment and it can be considered to be influence of adaptation. The positive correlation between odor intensity of visitors and CO_2 concentration can be seen in each condition. In "non-Japanese condition", occupants evaluated more intense than other conditions under the concentration over 1800 ppm. Since occupants with various nationalities were in the same space, they might feel strangeness to body odor of occupants from different countries.

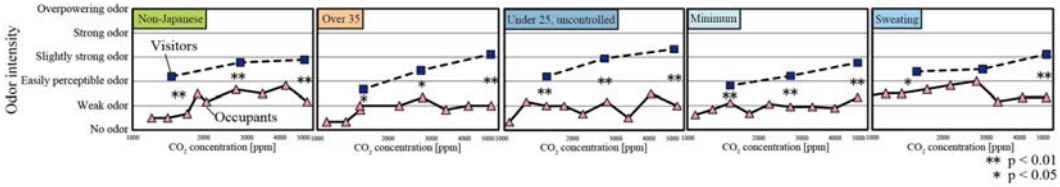

Fig. 7 The results for odor intensity

(2) Hedonic scale

Fig. 8 shows the results of hedonic scale for each condition. The difference of evaluation between occupants and visitors is smaller than that for odor intensity in all conditions. The visitors tended to perceive the air as less acceptable with increasing CO2 concentration, and occupants evaluated almost flat through the environment.

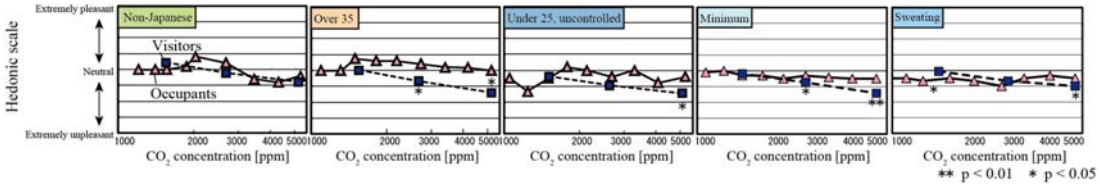

Fig. 8 The results for hedonic scale

(3) Acceptability

Fig. 9 shows the results of acceptability for each condition. The visitors evaluated less acceptable than occupants in all conditions. Comparing short-time and long-time assumptions, the visitors evaluated less acceptable at long-time assumption, while evaluations of occupants were not largely different. Comparing each condition, occupants evaluated less acceptable in "sweating condition" and "non-Japanese condition" than other conditions, and it was correlated with odor intensity.

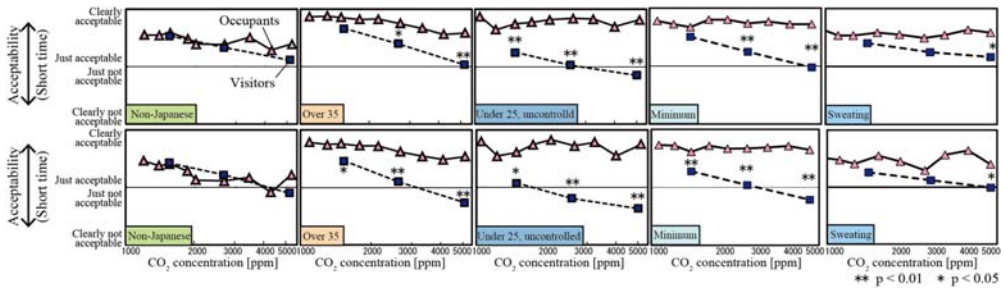

Fig. 9 The results for acceptability

(4) Quantitative analysis of the air in chamber

To quantify ingredients involved in body odor, a quantitative analysis was performed for the air in the chamber of which CO_2 concentration was 5000 ppm in each condition. **Table 1** shows the results of the analyses. "ND" in the table indicates lower limit of determination, "*" indicates that the quantitative value was calculated by extrapolating the calibration line because it exceeded the calibration line range, and "No Data" indicates that it was not possible to confirm the odor threshold in literatures etc. Nonanal and Decanal that were identified as body odor ingredients by Iwashita et al. [7] were also detected in all conditions in this experiment. 3-Metyle-2-Hexenoic acid that was reported as a major body odor ingredient wasn't detected in any conditions. P-Dichlorobenzene was detected more from occupants over 35 years old than other occupants. It was brought in clothes because it was mainly involved in repellent and five of six occupants over 35 years old wore own suits in the day of the experiment. Nonenal is an ingredient of old people's body odor, but it was not detected particularly from occupants over 35 years old. This may be because Nonenal is an ingredients of not only old people's body odor but also stress odor. Comparing "minimum condition" and "sweating condition", Folmaldehyde increased in "sweating". Ingredients that were as perfume such as Hexanal, Octanal, Decanal, 6-Metyl-5-Hepten-2-one were detected more in "non-Japanese condition" than others. Decanal that was acknowledged as fruit odor and involved in perfume and spice, in particular, exceeded calibration range. Non-Japanese people who participated in this experiment tended to use things with strong fragrance than Japanese. Acetaldehyde and Decanal were detected in all conditions, and especially the detected amount of Decanal greatly exceeded the threshold. It is considered that these ingredients may be identified as odor ingredients that we ordinarily perceive as body odor, but body odor ingredients have individual differences greatly. Therefore, further research using more subjects seems to be required.

Table 1 Quantitative analysis of indoor air in the chamber

($\mu g/m^3$)

Detection ingredient	Blank (No ventilation)	Blank (With ventilation)	Non-Japanese	Over 35	Under 25, uncontrolled	Minimum	Sweating	Odor Threshold
Folmaldehyde	4.6	2.6	14	15	17	9.9	12	670[5]
Acetaldehyde	1.6	1.5	3.5	4.9	5.7	26	4.1	2.9[5]
Toluene	4.0	ND(<0.8)	0.95	ND(<0.9)	0.93	5.1	ND(<0.9)	1356[5]
Xylene	0.92	ND(<0.8)	ND(<0.5)	ND(<0.9)	0.85	1.9	ND(<0.9)	348[6]
Ethylbenzene	0.82	ND(<0.8)	0.56	ND(<0.9)	ND(<0.8)	2.5	ND(<0.9)	806[5]
Styrene	ND(<0.8)	ND(<0.8)	0.66	ND(<0.9)	0.95	2.7	ND(<0.9)	163[5]
p-Dichlorobenzene	ND(<0.8)	ND(<0.8)	4	33	2.5	1.5	ND(<0.9)	No Data
Nonanal	3.9	4.5	16	12	20	10	6.8	2.2[5]
n-Tetradecane	1.5	1.7	4.8	ND(<0.9)	2.7	1.1	1.2	No Data
DBP	0.86	0.92	0.6	ND(<0.9)	1.3	ND(<0.8)	ND(<0.9)	No Data
DEHP	ND(<1.4)	2.4	1.3	1.8	2.8	ND(<1.4)	1.8	No Data
TVOC	18	31	460*	140*	170*	220*	150*	No Data
Butanol	1.7	ND(<1.0)	ND(<0.6)	ND(<1.1)	ND(<1.0)	ND(<1.0)	ND(<1.1)	No Data
Hexanal	ND(<1.0)	ND(<1.0)	5.3	1.6	3.2	1.2	ND(<1.1)	No Data
α-Pinene	ND(<1.0)	ND(<1.0)	ND(<0.6)	ND(<1.1)	ND(<1.0)	ND(<1.0)	ND(<1.1)	103[5]
Octanal	ND(<1.9)	ND(<1.9)	9.3	3	5.7	ND(<1.0)	ND(<2.1)	0.057[5]
Limonene	ND(<1.0)	ND(<1.0)	ND(<0.6)	ND(<1.1)	2.1	ND(<1.0)	12	231[5]
Decanal	3.2	4.1	47*	15	22	9.3	5.7	2.8[5]
Levomenthol	ND(<1.0)	ND(<1.0)	2.0	ND(<1.1)	3.6	1.3	6.6	No Data
Nonenal	ND(<1.0)	ND(<1.0)	5.3	2.0	2.0	3.2	2.8	5[5]
Isovaleric acid	ND(<1.9)	ND(<1.9)	ND(<1.2)	ND(<2.1)	ND(<1.9)	2.5	1.9	0.4[5]
n-Butyric acid	ND(<1.9)	ND(<1.9)	1.9	ND(<2.1)	ND(<1.9)	3.6	ND(<2.1)	0.7[5]
6-Methyl-5-Hepten-2-one	ND(<1.0)	1.6	19	5	7.3	4.6	ND(<2.1)	No Data
3-Methyl-2-Hexenoic acid	ND(<0.8)	ND(<0.8)	ND(<0.5)	ND(<1.1)	ND(<0.8)	ND(<0.8)	ND(<1.1)	No Data

※ Analysis by Kaneka Techno Research Corporation

(5) Standard deviation of acceptability

Table 2 shows values of standard deviation of acceptability and 95% confidence interval calculated using the method mentioned in section **2.7**. Since no correlation was observed between calculated σ_s and CO2 concentration, averaging was taken for each condition. When

we set “Clearly acceptable” as +1, “Just acceptable” and “Just not acceptable” as ±0 and “Clearly not acceptable” as -1, 95% confidence interval is equal $\pm 1.96\sigma_s$. Intra-individual error is larger than inter-individual error in each condition. 95% confidence interval narrowed when six people repeatedly evaluated three times compared to when six people evaluated once. However, it’s important in conducting subjective evaluation experiment to identify statistical confidence interval at each number of panel and evaluation times.

Table 2 Calculation results of standard deviation and 95% confidence interval

								once /six people		three times /six people		once /sixty people	
			σs	Average of σs	σp	Average of σp	σ	σ61a	95% confidence interval	σ63a	95% confidence interval	σ601a	95% confidence interval
Minimum Occupants	Short time	1080	0.25	0.23	0.15	0.15	0.17	0.09	±0.18	0.07	±0.14	0.03	±0.06
		1270	0.28		0.15								
		1500	0.29		0.19								
		1800	0.16		0.10								
		2170	0.14		0.09								
		2650	0.22		0.18								
		3260	0.19		0.16								
		4030	0.27		0.17								
		5000	0.24		0.19								
	Long time	1080	0.25	0.29	0.18	0.23	0.18	0.12	±0.23	0.10	±0.2	0.04	±0.07
		1270	0.26		0.15								
		1500	0.36		0.26								
		1800	0.23		0.22								
		2170	0.27		0.24								
		2650	0.28		0.26								
		3260	0.30		0.25								
		4030	0.31		0.25								
		5000	0.35		0.25								
Minimum Visitors	Short time	1500	0.41	0.33	0.15	0.20	0.26	0.13	±0.26	0.10	±0.2	0.04	±0.08
		2650	0.29		0.21								
		5000	0.28		0.24								
	Long time	1500	0.49	0.40	0.21	0.18	0.36	0.16	±0.32	0.11	±0.22	0.05	±0.10
		2650	0.34		0.17								
		5000	0.38		0.15								
Sweating Visitors	Short time	1500	0.33	0.38	0.19	0.13	0.36	0.16	±0.31	0.10	±0.2	0.05	±0.10
		2650	0.40		0.11								
		5000	0.42		0.10								
	Long time	1500	0.41	0.45	0.19	0.13	0.43	0.18	0.36	0.11	±0.22	0.06	±0.11
		2650	0.44		0.08								
		5000	0.49		0.11								
Under 25, uncontrolled Visitors	Short time	1500	0.43	0.40	0.14	0.15	0.37	0.16	±0.32	0.10	±0.2	0.05	±0.10
		2650	0.42		0.15								
		5000	0.35		0.15								
	Long time	1500	0.56	0.49	0.12	0.14	0.47	0.20	±0.39	0.12	±0.24	0.06	±0.12
		2650	0.46		0.16								
		5000	0.45		0.14								
Over 35 Visitors	Short time	1500	0.21	0.37	0.23	0.19	0.32	0.15	±0.3	0.11	±0.21	0.05	±0.09
		2650	0.40		0.11								
		5000	0.51		0.22								
	Long time	1500	0.37	0.45	0.28	0.26	0.37	0.18	±0.36	0.14	±0.27	0.06	±0.11
		2650	0.46		0.27								
		5000	0.51		0.22								
Non-Japanese Visitors	Short time	1500	0.33	0.46	0.09	0.09	0.45	0.19	±0.37	0.11	±0.22	0.06	±0.12
		2650	0.44		0.07								
		5000	0.60		0.10								
	Long time	1500	0.29	0.47	0.12	0.10	0.46	0.19	±0.38	0.12	±0.23	0.06	±0.12
		2650	0.46		0.06								
		5000	0.67		0.12								

(6) Proposition of true percentage of dissatisfied (PD)

By excluding the influence of variation within individuals and considering the fluctuation of the average value due to the variation among individuals, it is possible to calcurate percentage of the evaluation as of “unacceptable side” obtained by using σ in the probability density distribution of acceptability as shown in **Fig. 10**. Here, the calculated percentageis regarded as “true PD”. This method makes it possible to calculate 95% confidence interval in PD unlike the usual calculate method. **Fig. 11** shows an example of CPD (cumulative probability distribution) of acceptability (long time) in minimum condition. It is represented the average value as blue line, 95% confidence upper limit as ash line, 95% confidence lower limit as orange line and estimated “true PD” as value in the figure. **Table 3** shows the results of “true PD” calculated by this method. The PDs of occupants are almost 0%. The PDs of visitors are larger than that of occupants and a lot of values exceeding baseline of 20% are seen. The standard of AIJ [4] requires to calculate PD based on the evaluation of panel not adapted to

smell (in this case, visitor). So it can be said that we could reconfirm the importance of ventilation on indoor environment comfort through this study.

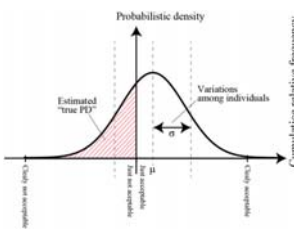

Fig. 10 Estimating method of true PD

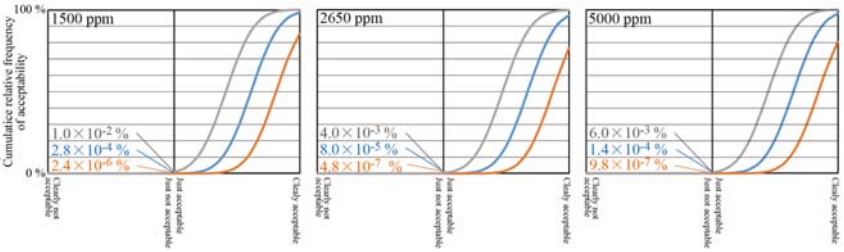

Fig. 11 An example of CPD of acceptability

Table 3 Calculation results of true PD

		ppm	1080	1270	1500	1800	2170	2650	3260	4030	5000
Minimum Occupants	Short time	Upper limit	6.7×10^{-3} %	2.4×10^{-2} %	7.6×10^{-2} %	3.8×10^{-3} %	3.8×10^{-3} %	1.8×10^{-2} %	8.7×10^{-3} %	2.4×10^{-2} %	2.4×10^{-2} %
		Average	1.6×10^{-4} %	7.5×10^{-4} %	3.0×10^{-3} %	8.2×10^{-5} %	8.2×10^{-5} %	5.2×10^{-4} %	2.2×10^{-4} %	7.6×10^{-4} %	7.6×10^{-4} %
		Lower limit	1.9×10^{-6} %	1.2×10^{-5} %	6.2×10^{-5} %	9.0×10^{-7} %	9.0×10^{-6} %	7.7×10^{-6} %	2.8×10^{-6} %	1.2×10^{-5} %	1.2×10^{-5} %
	Long time	Upper limit	0.14 %	0.18%	1.0 %	0.18 %	0.44 %	0.40 %	0.30 %	0.20 %	0.60 %
		Average	1.9×10^{-3} %	2.7×10^{-3} %	2.8×10^{-2} %	2.7×10^{-3} %	9.1×10^{-3} %	8.0×10^{-3} %	5.5×10^{-3} %	3.0×10^{-3} %	1.4×10^{-2} %
		Lower limit	8.0×10^{-6} %	1.2×10^{-5} %	2.4×10^{-4} %	1.2×10^{-5} %	5.7×10^{-5} %	4.8×10^{-5} %	3.0×10^{-5} %	1.4×10^{-5} %	9.8×10^{-5} %
Minimum Visitors	Short time	Upper limit			11%			40%			76%
		Average			2.1%			15%			47%
		Lower limit			0.25%			3.4%			19%
	Long time	Upper limit			38%			67%			85%
		Average			18%			43%			66%
		Lower limit			6.0%			22%			42%
Sweating Visitors	Short time	Upper limit			29%			45%			54%
		Average			13%			25%			32%
		Lower limit			4.7%			11%			16%
	Long time	Upper limit			46%			59%			70%
		Average			27%			39%			51%
		Lower limit			13%			21%			31%
Under 25, uncontrolled Visitors	Short time	Upper limit			49%			68%			83%
		Average			29%			47%			66%
		Lower limit			13%			27%			45%
	Long time	Upper limit			70%			81%			90%
		Average			51%			66%			78%
		Lower limit			31%			46%			60%
Over 35 Visitors	Short time	Upper limit			7.4%			28%			71%
		Average			1.8%			11%			46%
		Lower limit			0.3%			3.1%			23%
	Long time	Upper limit			30%			68%			93%
		Average			10%			40%			76%
		Lower limit			2.2%			16%			49%
Non-Japanese Visitors	Short time	Upper limit			20%			40%			59%
		Average			9.1%			23%			40%
		Lower limit			3.4%			11%			23%
	Long time	Upper limit			31%			35%			76%
		Average			16%			19%			58%
		Lower limit			6.7%			8.6%			39%

4 CONCLUSIONS

・The influence of olfactory adaptation was seen in occupants and visitors′ evaluation, which was correlated with CO2 concentration from subjective evaluation.

・For odor intensity, non-Japanese occupants evaluated stronger than other conditions′ occupants and it is suggested that people with different characteristics may be sensitive to body odor.

・For acceptability, occupants evaluated less acceptable in ″sweating condition″ and ″non-Japanese condition″ than other conditions, and it was correlated with odor intensity.

・In quantitative analysis, Acetaldehyde and Decanal were detected in all conditions, and it is considered that these ingredients may be identified as odor ingredients that we ordinarily perceive as body odor.

・We analysed statistically the reliability of data evaluated multiple times with a small number of panel and proposed a probabilistic prediction method of PD. The difference between 95% confidence interval of evaluation when six people repeatedly evaluated three times and sixty people evaluated once is much larger than when sixty people evaluated once so substitution cannot be possible by repeatedly evaluation.

5 ACKNOWLEDGEMENTS

This research was collaboration with Mitsubishi Heavy Industries, Ltd. Many thanks are due to the late Prof. Hisashi KOTANI for comments and providing direction passionately, Prof. Tomohiro Kobayashi for kind correcting the manuscript.

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