ABSTRACT
There are materials and instruments which can be various pollution sources of indoor air quality in a room. Recently, volatile organic compounds are paid attention as one of main air pollution sources. There are a lot of pollutants in a room else VOCs, therefore it is important to make a comprehensive assessment of indoor air. We prepared to measure multi-component of indoor air quality. In this report, we described measured results that we measured the Multi-Components of indoor air quality at main public facilities in Sapporo and Nagoya cities. We suggested an evaluation method by radar chart and categorized of characteristics of indoor air pollutants of each public.

KEYWORD
Indoor Air Pollutant, VOCs, Behavior Pattern, Risk-Assessment, Rader Chart

INTRODUCTION
Since 1970 the problems concerning the indoor air quality have been observed. In one of the background, high airtight of building which the energy saving requests caused too small ventilation. This induced higher concentration of the indoor contaminants. As for another background, the time when the people worked and spent indoor became increase. Indoor air quality influences human health. The role of indoor air quality to human health was increasing.

Recently, volatile organic compounds are paid attention as one of main air pollution sources. There are a lot of pollutants in a room else VOCs, therefore it is important to make a comprehensive assessment of indoor air.

We prepared to measure a variety of indoor air quality including VOCs and natural radioactive substances. In this report, we described measured results of multi-components of indoor air quality at main public facilities in Sapporo and Nagoya, with the cooperation of the Nagoya University. This purpose of this research is to clarify the difference of indoor air quality between temperate area and frigid area. We suggested an evaluation method by radar chart and categorized of characteristics of indoor air pollutants of each public.

METHODS
We measured multi-components of indoor air quality at main seven public facilities in Sapporo and Nagoya with the cooperation of the Nagoya University. Seven places consist of the laboratory, the lecture room, the library, the museum, the closed room of the University, the underground public facilities and outdoor. The measurement was performed in the middle of October in Nagoya and in the beginning of November in Sapporo.

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VOCs were measured and analyzed as follows. Absorbance by absorptiometer. Reagent (AHMT) was added to the liquid. When its liquid color turns bruise blue, we measured the -5-mercapto-1,2,4-triazole) method. Sampling air was absorbed into Caustic soda. Secondly coloring of colonies.

Formaldehyde was measured by Silset (Shimazu Co.) by using AHMT (4-amino-3-hydrazine -5-mercaptop-1,2,4-triazole) method. Sampling air was absorbed into Caustic soda. Secondly coloring of colonies.

The method of preparation used in measurement of natural radioactive substances was the filter. Almost radon short-lived decay products form radioactive aerosol in living space. The principal of this method is that such aerosol are caught by paper filter by using the method we can obtain instantaneous concentration value and its sampling time was 5 min. The measurement concrete procedures were as follows.

By using small air pump (Iwaki Pumps), we collected radon short-lived decay products through phloro-pore filter (Sumitomo Electric, AT07P-47mm φ; WP-500-50-47mm φ) which had high collection efficiency. Secondly by using the scintillation detector and scintillation counter we measured the number of times of alpha particles, which generate on the filter. Finally we calculated the concentration of radon short-lived decay products.

Volatile Organic Compounds were measured and analyzed as follows. We measured 3 times each point. We used the average of the result in this report.

Table-1 shows measured substances and instruments. The number of measured items was 14. The number of analyzed component in VOCs items was 52.

1) Air temperature, humidity, carbon dioxide and carbon monoxide were measured with IAQ monitor (KANOMAX). Ammonia, sulfur dioxide and sulfur hexafluoride were measured with multi-gas-monitor (Velta). We measured the above items every 2 minutes for one hour.

2) Airborne bacteria and fungi were measured with RCS air sampler. Sampling air volume was 40[L/min]. We incubated airborne bacteria and airborne fungi in the temperature-controlled bath. The former was 48 hours at 37 degrees and the latter was 72 hours at 25 degrees, and counted the number of colonies.

3) We measured suspended particulate matter (SPM) with the scattered light method. The sampling air was sent to capillary column. Finally they were determined by gas chromatography and mass spectrometer (GC/MS).

4) Ozone was measured with Handy Ozone Leak Checker (Ebara Jitsugyo Co.,Ltd). This instrument senses ozone by thin film type semiconductor.

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We collected the sampling air including measuring substance (VOCs) through the tube filling adsorbent. The tube was set desorption apparatus (TCT CP-40 20-Chrompack), and its desorption substances was sent to capillary column. Finally they were determined by gas chromatography and mass spectrometer (GC/MS).

Table-2  Identified VOC components

<table>
<thead>
<tr>
<th>Component</th>
<th>Acetone</th>
<th>Ethanol</th>
<th>Ethylbenzene</th>
<th>Methylcyclohexane</th>
<th>Toluene</th>
<th>1,2-Dichloroethane</th>
<th>Trichloroethylene</th>
<th>p-Xylene</th>
<th>Bromodichloromethane</th>
<th>DMF</th>
<th>1,2,4-Trimethylbenzene</th>
<th>1,1,1-Trichloroethane</th>
<th>1,2-Dichloroethane</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ppm]</td>
<td>0.05</td>
<td>0.1</td>
<td>0.5</td>
<td>1.0</td>
<td>2.0</td>
<td>0.0</td>
<td>2.0</td>
<td>0.1</td>
<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Table-3  Standard value

<table>
<thead>
<tr>
<th>Component</th>
<th>Reference value</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>TVOC</td>
<td>400 [ppm]</td>
<td>Taget value given by MHLW</td>
</tr>
</tbody>
</table>
RESULTS AND DISCUSSION

SO₂, NH₃, SF₆ and O₃ is less than minimum limit of detection value in the present measurement. We focused on the other ten items undergone a huge change. We made radar chart and used it for an evaluation tool. By using ten items, we categorized ten items into natural origin, microbe, manmade, chemical material group. We used TVOC as a represented index of VOCs in this research.

Regarding the present radar chart, we set up the parameter deliberate, air temperature was foreside, humidity was downside, and the other items were side. Therefore the good air quality corresponded a slimline forms and the poor air quality did a fat forms in our radar chart.

The value of closure line of the present radar chart except for air temperature and humidity represents the reference value and the target value in the standards for indoor air quality. Regarding the value of closure line of air temperature and humidity, we set 30℃ and 50%.

We summarized the measuring results in Figure-1 to Figure-7. In these seven figures, black line and dot-line represents the measured result of Nagoya and Sapporo, respectively.

1) Underground public facility
   Figure-1 shows the measured result of underground public facilities in Sapporo and Nagoya cities. The shapes of radar chart of both cities were slimline forms. The results showed that contaminant levels in both underground public facilities were very low. We considered the reason why mechanical ventilation systems were active.

2) Laboratory
   Figure-2 shows the measured results of laboratory in both universities. These chart forms were favor right side at the expense of the other, because several kind of natural origin, ex. Radon, Airborne fungi, Suspended particulate matter, were extremely low levels. Although the area of this chart was larger than Figure-1, risk level was considered the same level of underground public facilities in Figure-1.

3) Lecture room
   Figure-3 represents the measured results of lecture rooms in both universities. The measured value of formaldehyde in Nagoya reached 80ppb, the standard limit level. It was considered the reason why this room was reconstructed and equipped with newer facilities especially desks and chairs. It was well known that the emission rate of formaldehyde was very high in the newest equipments. The levels of the other measured items were no matter as well as laboratory. And the shape of this chart appears to be similar to those of Figure-2.

4) Library
   Figure-4 shows the measured results of library in both universities. There was no cause for concern except for the higher level of airborne bacteria in Sapporo. The shape of this chart was favor right side similar to the laboratory, the lecture room. This shape was considered to relate typical composition of indoor air comparing with outdoor air described below.

5) Outdoor
   Figure-5 shows the measured results of outdoor in both cities. Compared with charts of the foregoing, the shape of this chart had left-leaning tendency. It was considered that relatively high levels of air humidity, SPM and airborne fungi were caused by the weather effects.

6) Museum
   Figure-6 shows the measured results of museum in both universities. Compared with Figure-5, this chart is right-leaning in contrast. Formaldehyde and TVOC were high concentration. TVOC in Nagoya was above 400[μg/m³]. We considered it was caused by the location of new interior materials and articles on display which were known to be sources of VOCs at outmoded building without inadequacy ventilation systems. It was pointed out that the museum should be taken measures against high concentration.

7) Closed room
   Figure-7 shows the measured results of closed room without window in both universities. Several measured items ran out of the closure line. Compared with Figure-1, the composition of this chart suggested serious bad condition of indoor air quality. Especially Radon, SPM, TVOC and humidity were high level. Radon concentration in both cities was above reference value 300[Bq/m³]. TVOC in Nagoya was above 400[μg/m³]. It was considered that urgent countermeasures were required. Because there were the living rooms near the present closed rooms.

The levels of contaminants in Nagoya were higher than those in Sapporo in this research. This presently radar chart system enabled to distinguish the locale-specific feature of indoor air quality. This system had usability to find out characteristics of each place. The present measured results suggested that indoor air quality might be affect on the condition of interior side than the regional difference.
Discussion on VOCs
We got the chromatogram of each measurement places like Figure-9 by using gas chromatography and mass spectrometer (Figure-8), and calculated the concentration of VOCs. Figure–10 shows the result of calculation of concentration of VOCs. It shows high concentration of ethanol and the total amount of the other components causes high concentration of TVOC at museum in Nagoya University. We speculated the location of new interior material and article on display which emitted high VOCs, especially ethanol was high concentration because it is in wide use for fluxing material, agent of organic synthesis and antiseptic. The measured value at closed room in Nagoya University was above 400 μg/m³. It was caused by the high concentration of trichloroethylene. Figure-10 also shows a relatively high toluene level in whole. We could measure toluene in the outdoor. It was considered that the present measured places should be introduced some security measures like a chemical purification for toluene.

We sampled 100[ml/min] during the half-hour after the ventilation machine stopped. We used two trapping tubes. One is filling TenexTA, another is filling TenaxTA and Carboxen1000. Table-2 shows identified 52 kinds of VOC components.

CONCLUSIONS
We measured the multi-components of indoor air quality including VOC and natural radioactive substances at main public facilities in Sapporo and Nagoya cities. In this report, we suggested an evaluation method by radar chart that we considered origins of air pollutant and feature of air quality and discussed characteristic of indoor air pollutants of each public facilities. Moreover, we considered a characteristic and measures for safety of each facility about each ingredient of VOC.

We discussed about the result of natural radioactive substances in part 2.
ACKNOWLEDGEMENTS

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REFERENCES