Measurement of Volatile Organic Compounds in Indoor Air of Museums by Serially Connected Passive Samplers

M. Butsugan [1] and Y. Sekine [2]
[1]Hitachi Chemical Co. Ltd
[2]School of Science, Tokai University

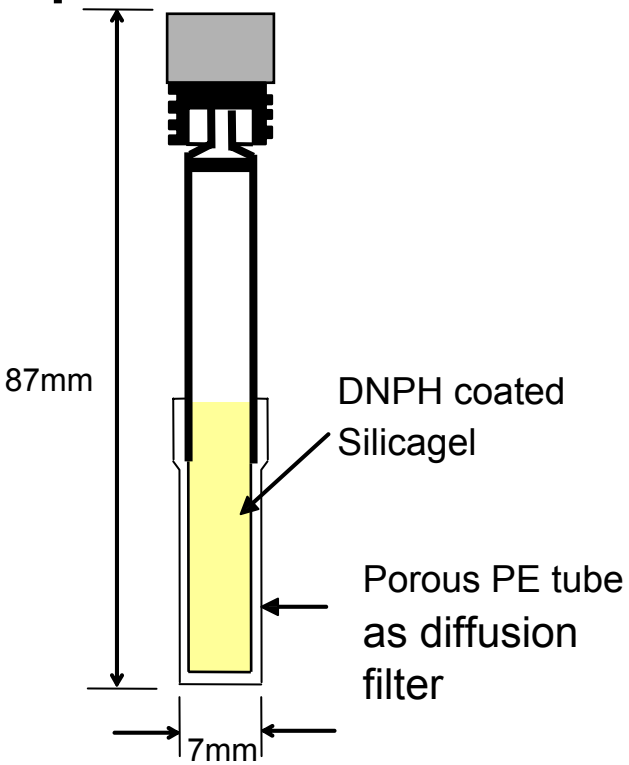
Passive samplers

- Simple device suitable for assessing indoor air quality and personal exposure

- Previous passive samplers;
  DSD-DNPH
    for aldehydes and ketones
  VOC-SD
    for VOCs

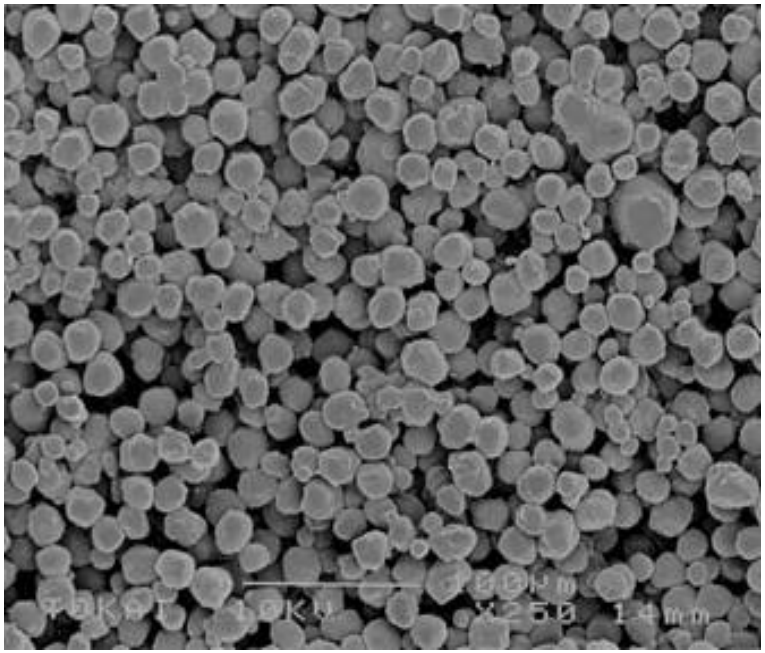
(available from SIGMA-ALDRICH, Japan)

DSD-DNPH



Schematic view of the sampler

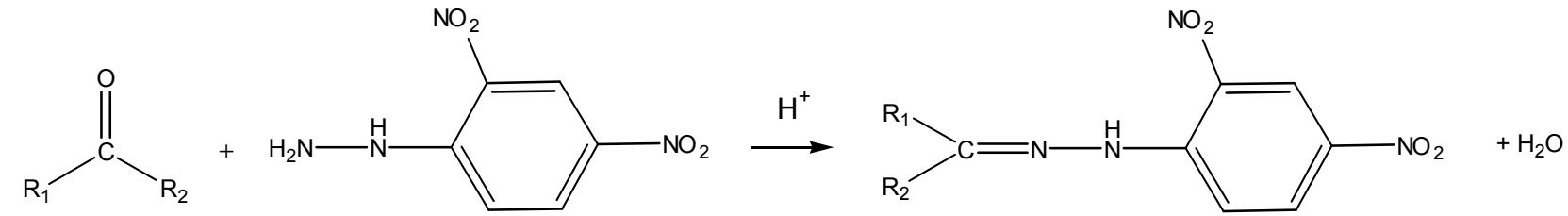
DNPH: 2,4-dinitrophenylhydrazine



SEM image of the diffusion filter

Porosity: 34.5%
Air cavities: ~20μm

Determination by HPLC

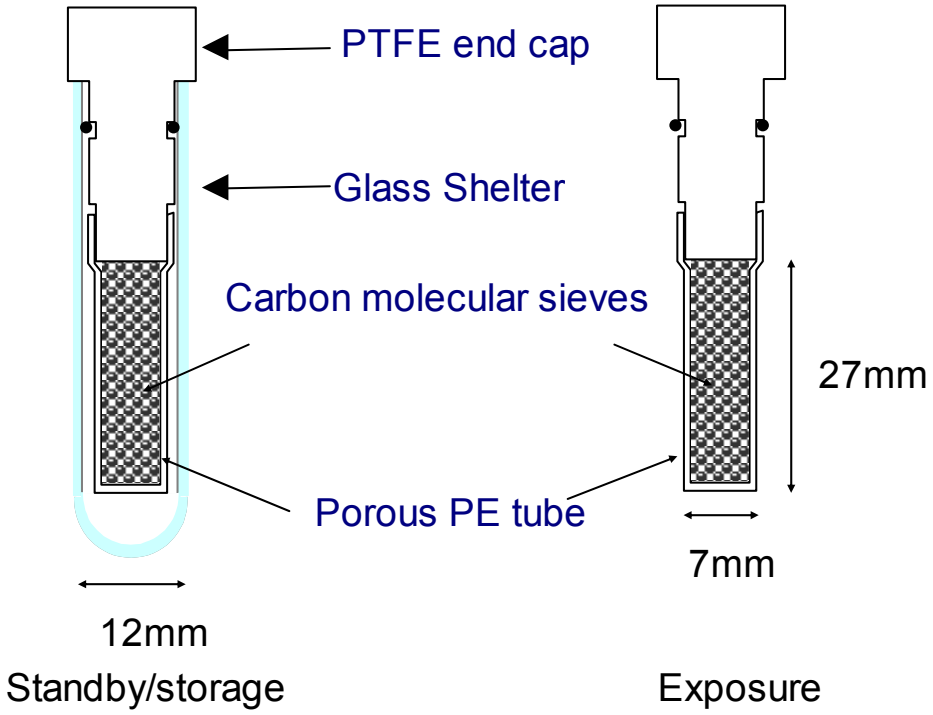


carbonyl compounds **DNPH** **DNPH derivative (hydrazone)**

Reaction of carbonyl compounds with DNPH

DNPH derivatives are extracted by 10ml of acetonitrile and subsequently determined by reverse-phase HPLC with UV-Vis detector at 315nm.

VOC-SD



Schematic view of the sampler

Trapped VOCs are extracted by 2ml of carbon disulfide and subsequently determined by GC/FID or GC/MS.

Sampling rates

- Sampling rates of both passive samplers were practically determined by small chamber experiments comparing with active samplings

Sampler	Analyte	Sampling rate, α(ml/min)	ref.
DSD-DNPH	formaldehyde	71.9	(1)
	acetaldehyde	59.4	(1)
	acetone	51.7	(1)
	glutaraldehyde	40	(2)
VOC-SD	benzene	47	(3)
	toluene	42	(3)
	ethylebenzene	32	(3)
	m-,p- xylene	35	(3)
	styrene	37	(3)
	o- xylene	32	(3)

(1) Uchiyama et al., *Atmos.Environ* .,38,6319(2004) (2) Sekine et al.,J. Health Sci.,51,629(2005)
(3)Butsugan et al., *Proc.of Indoor Air 2005* ,2289(2005)

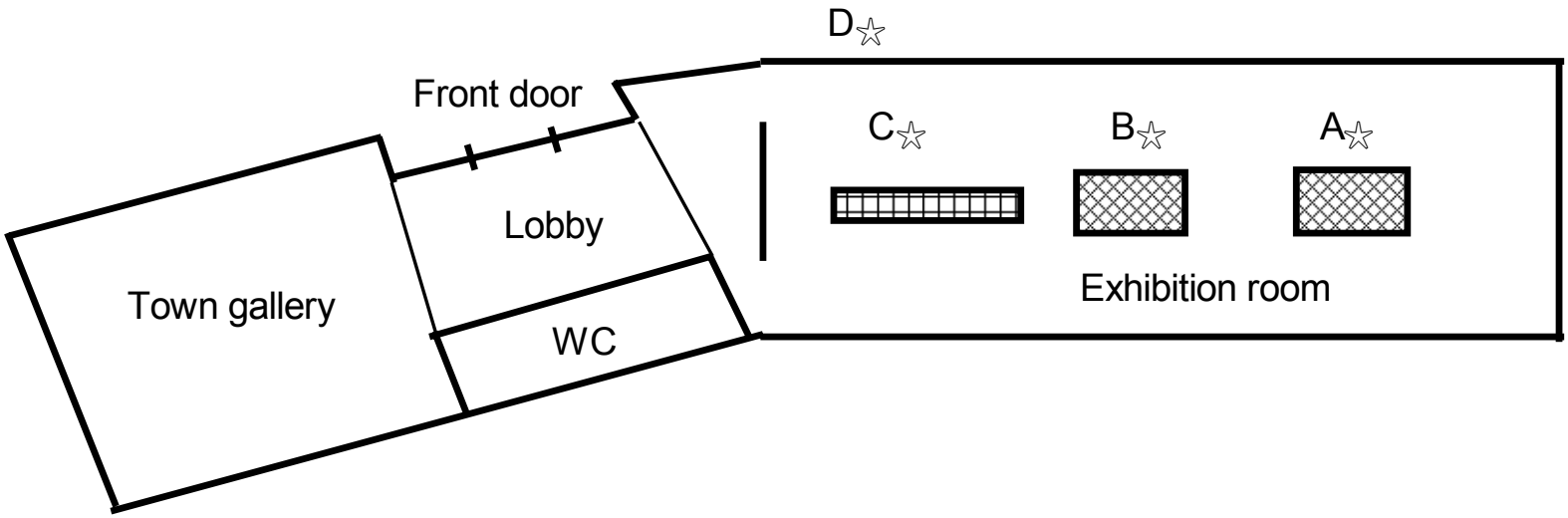
Serially connected sampler

- The sampling portions of DSD-DNPH and VOC-SD are connected in series to give a single tube (DSD-Serial) for samplings of multiple indoor air pollutants.
- The new sampler was applied to field measurements of indoor air pollutants in a museum and validated the sampling performance.

Field tests in museum

- Takehiko Miyanga Memorial Museum, Hadano, Kanagawa, Japan
- Major displays: Oil paintings
- Floor area : 192m^2
  (exhibition room)
- 24hrs-air ventilation system
  Air exchange rate:>0.7 ACH
- Sampling period: July 9 –11, 2006 (Museum was closed.)
- Sampling duration: 38.5h
- Temp: 24.5℃, R.H.70%

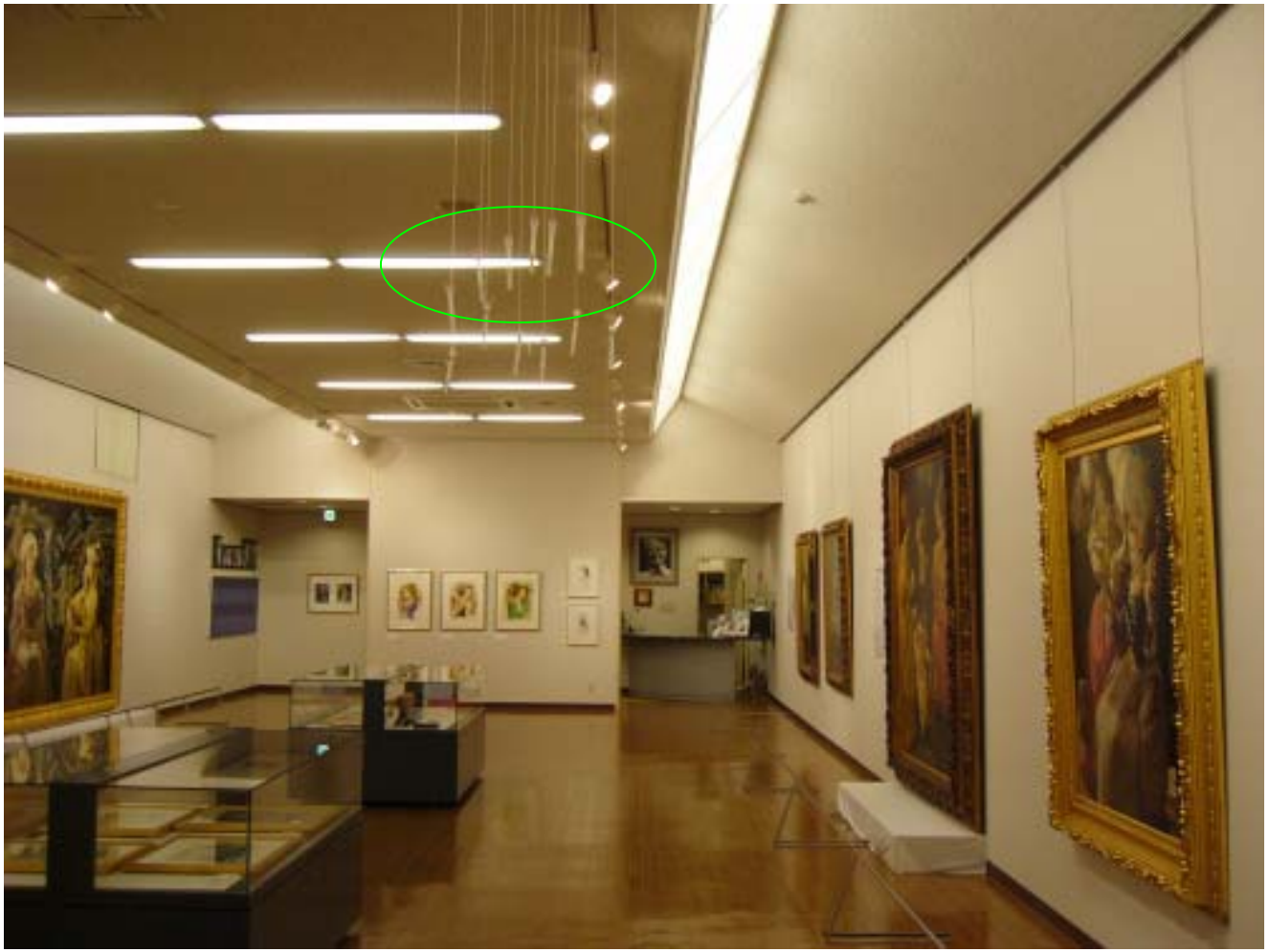
Sampling sites



Number of samplers deployed at each sampling site

Sampler	A	B	C	D	travel blank
DSD-Serial	6	2	2	2	3
DSD-DNPH	6	-	-	-	3

Deployment of the DSD-Serial



Deployed at the height of 2 m from the floor

Analytical procedure

<Aldehydes & ketones>

DNPH coated silica gel

↓

Transfer to vial

↓ ← 3ml of acetonitrile

Extraction with mild shaking

↓

Centrifugation (3000rpm,5min)

↓

HPLC analysis
(Hitachi Elite System)

<VOCs>

Carbon molecular sieves

↓

Transfer to vial

↓ ← 2ml of carbon disulfide

Extraction at 5℃ for 2hrs

↓

Centrifugation (3000rpm,5min)

↓

GC/MS analysis
(Shimadzu QP-5000 System)

Comparison of collection amount of aldehydes and ketones

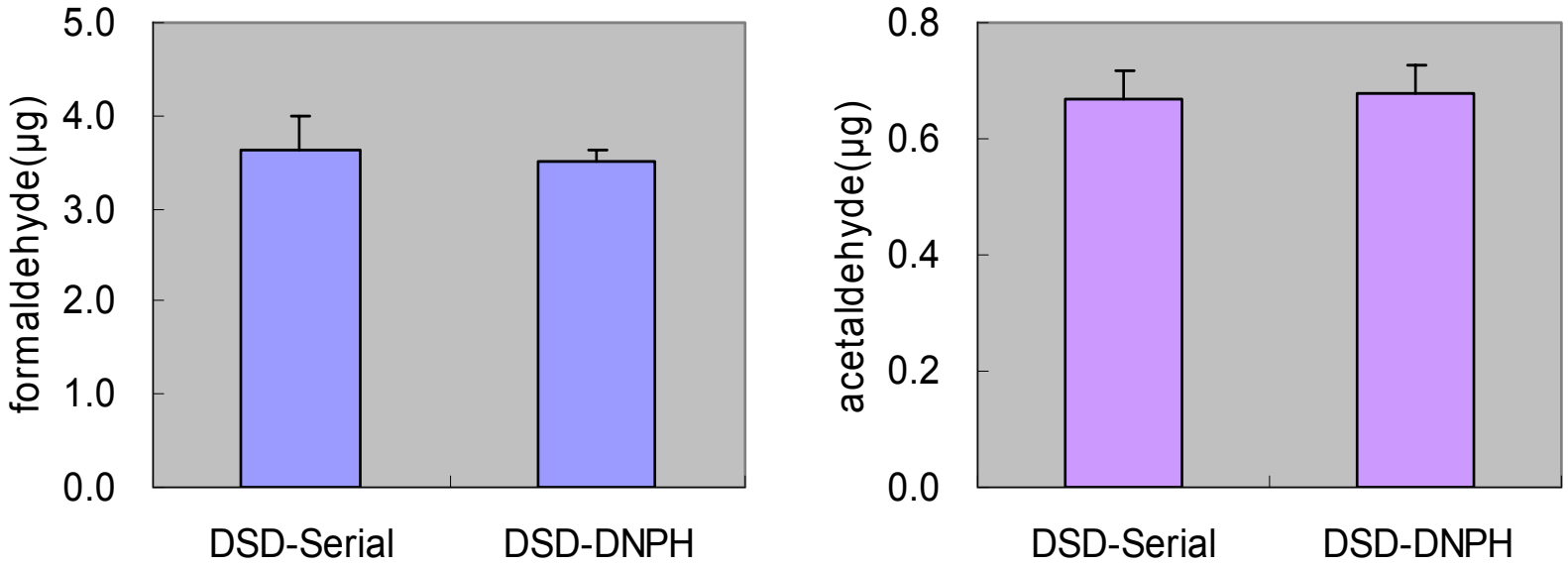


Figure. Comparison of collection amount of formaldehyde and acetone by co-located two kinds of samplers at site A (n=6).

No significant difference was found (*t*-test, $p<0.05$)

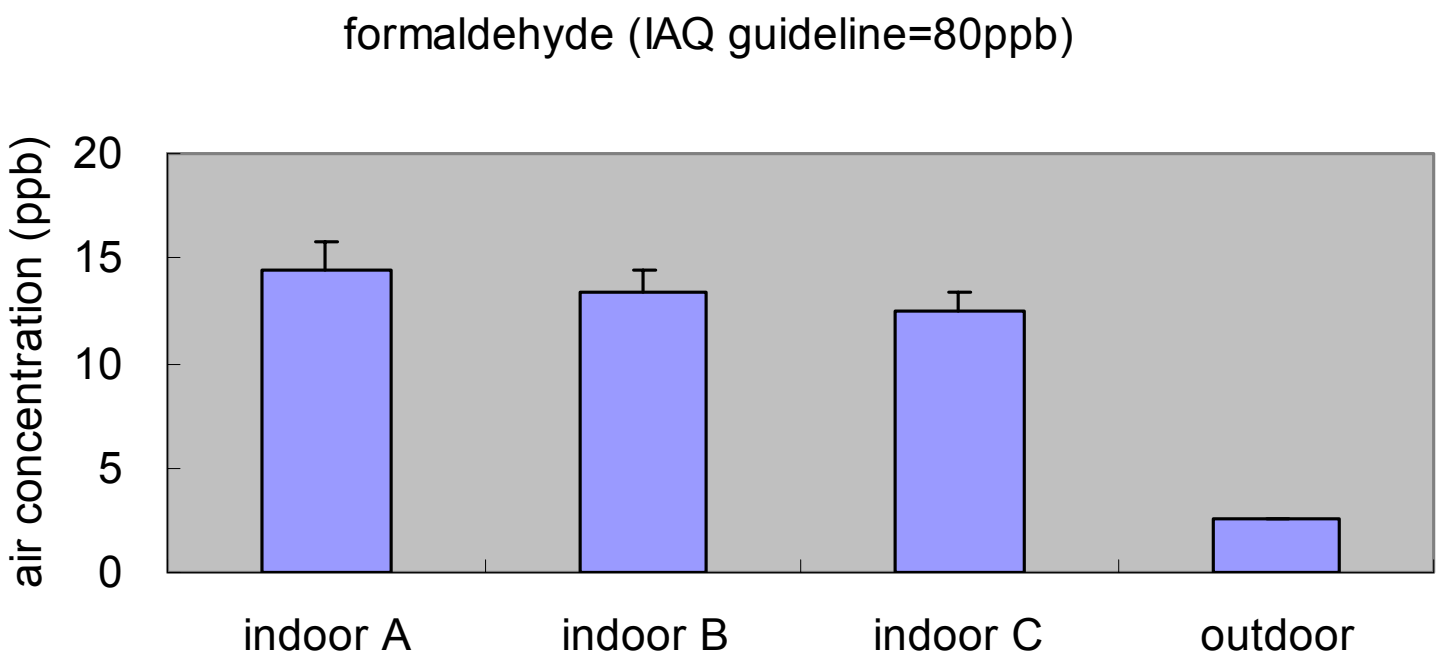
Travel blanks and LOQ

Analyte	Travel blank (μg)	LOQ(ppb)
formaldehyde	0.072 ± 0.004	0.14 *
acetaldehyde	0.063 ± 0.006	0.20 *
acetone	0.17 ± 0.006	0.17 *
benzene	not detcted	0.69 **
toluene	0.13 ± 0.05831	1.6 *
m-,*p*- xylene	0.062 ± 0.01301	0.37 *
ethylebenzene	not detcted	0.71 **
styrene	not detcted	0.66 **
o- xylene	not detcted	0.57 **
p- dichlorobenzene	not detcted	0.42 **

LOQ was defined as, * : 10σ, ** : S/N=10

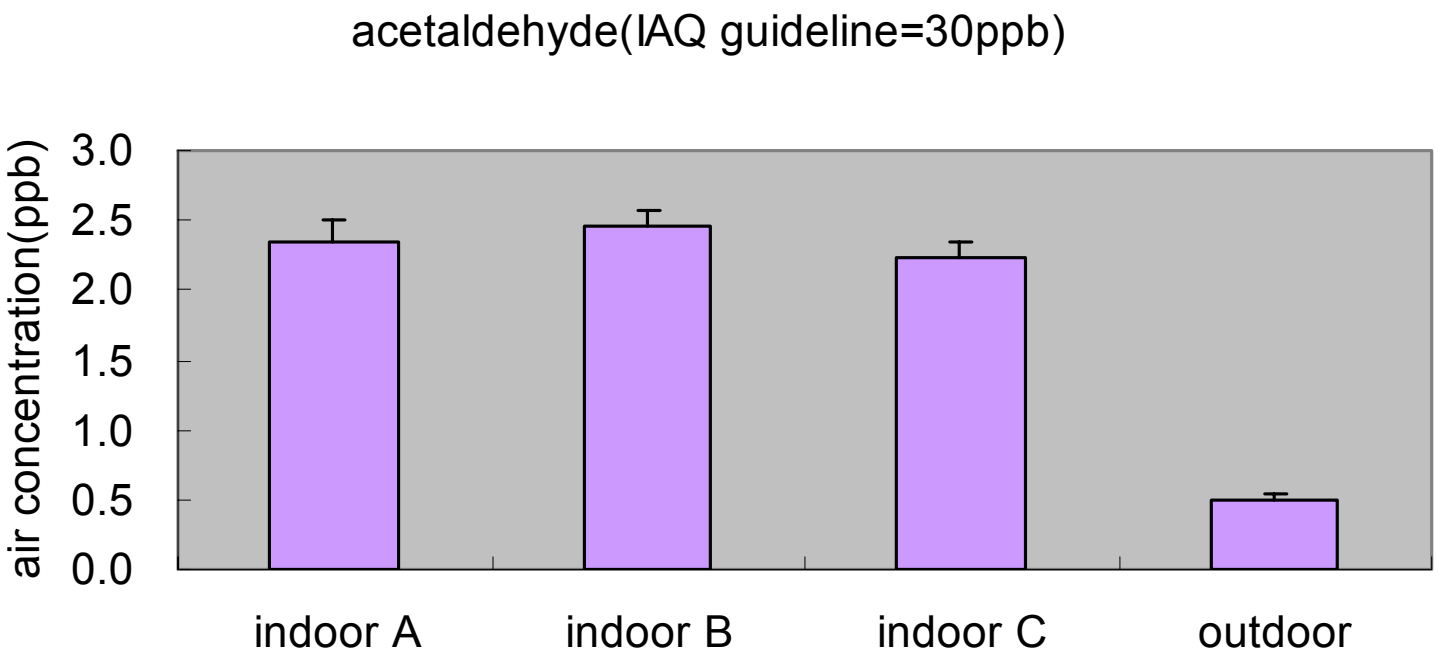
Sampling duration: 38.5h

Formaldehyde in the museum



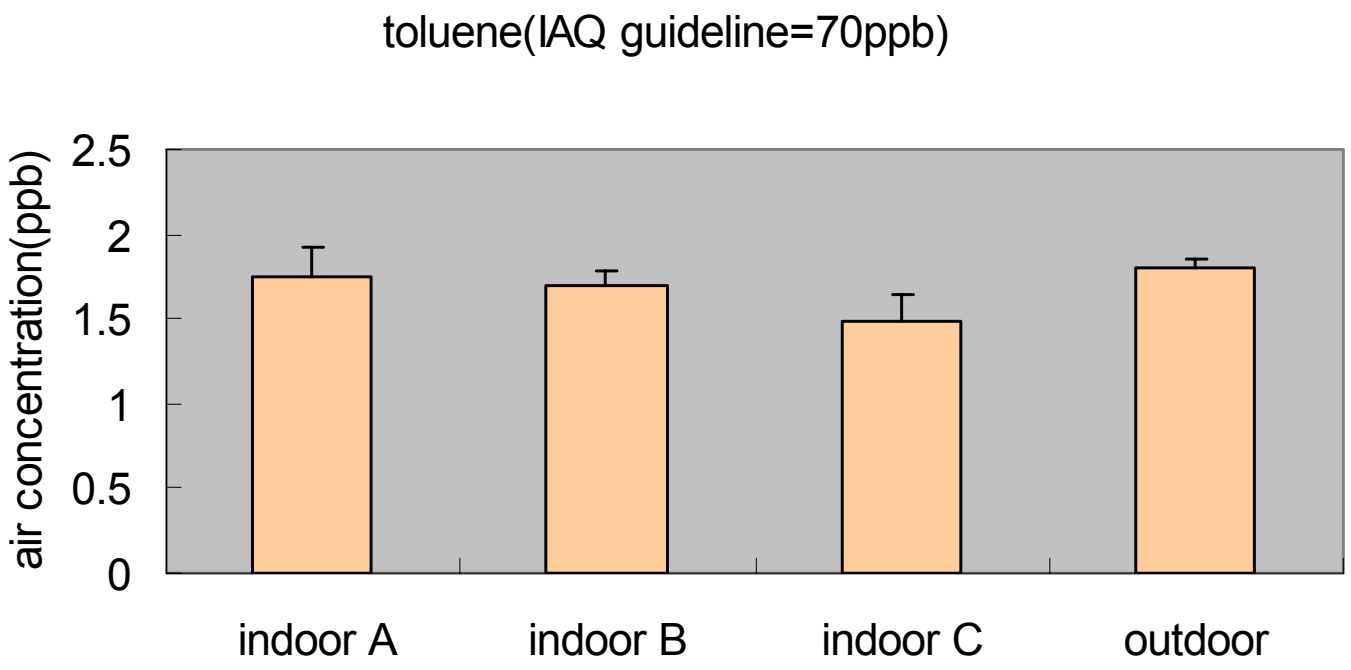
Possible emission source: wooden materials for flooring etc.

Acetaldehyde in the museum



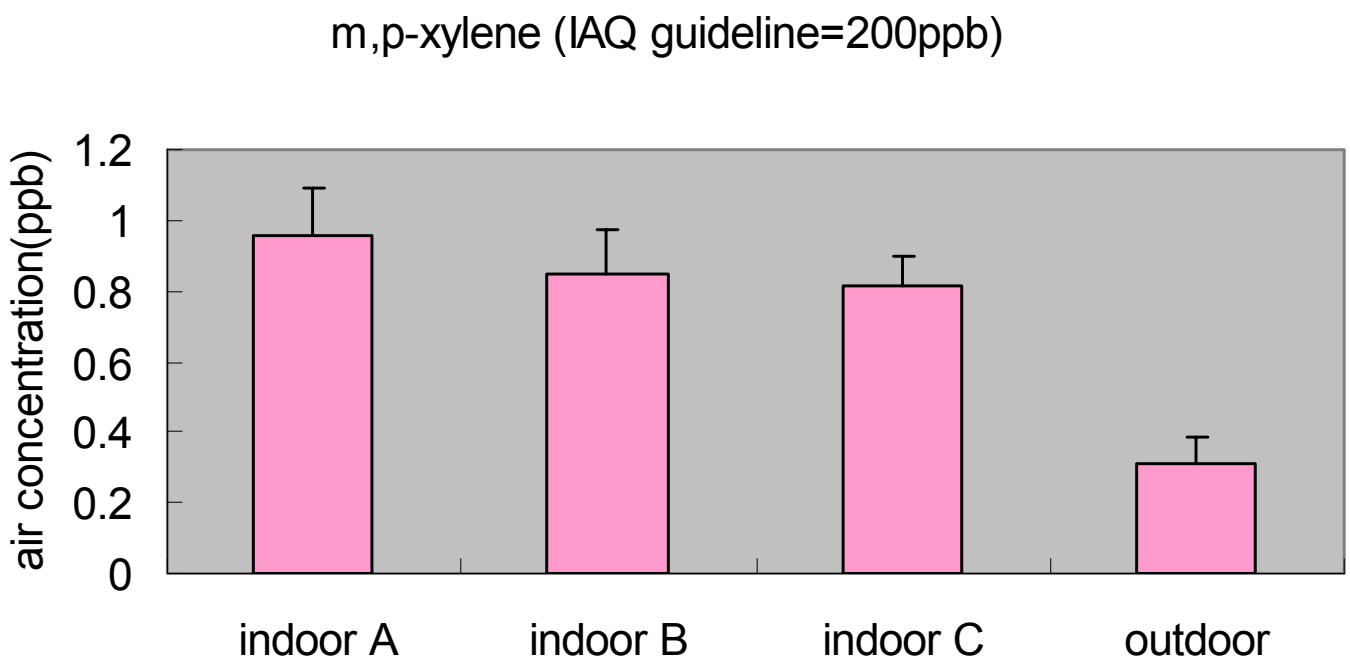
Possible emission source: wooden materials for flooring etc.

Toluene in the museum



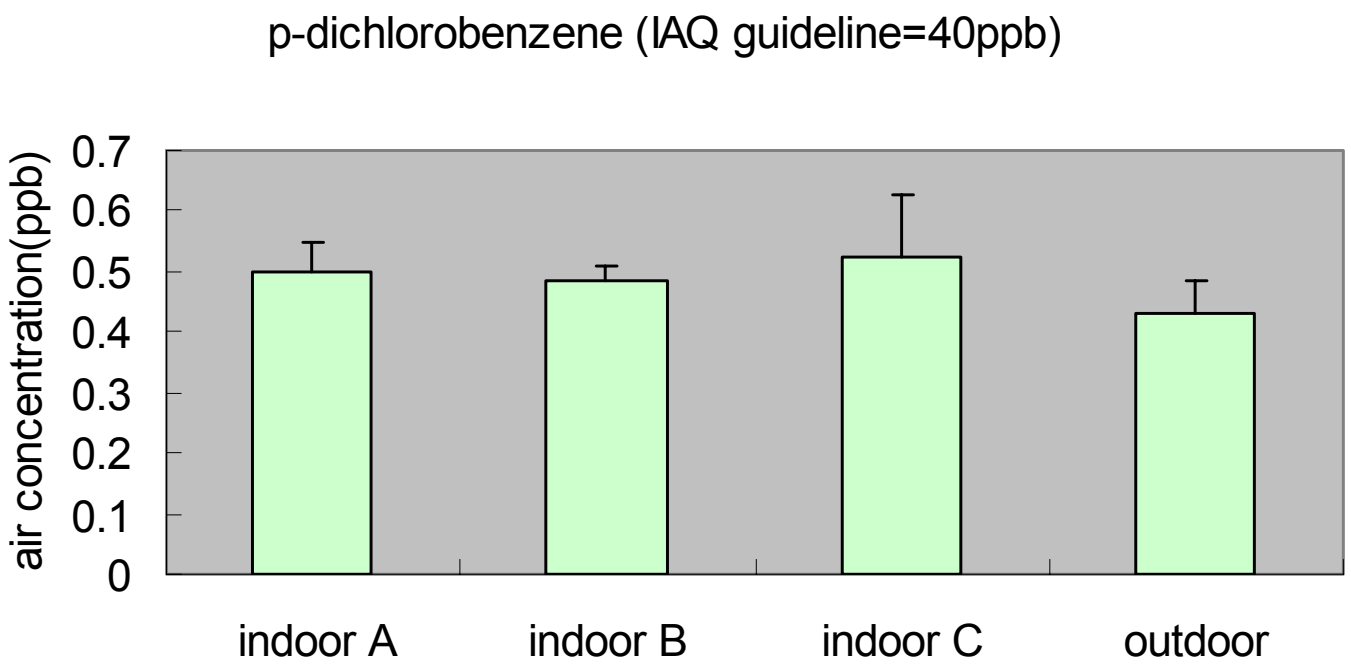
Possible emission source: background outdoor air

m,p-xylene in the museum



Possible emission source: oil paintings

p-dichlorobenzene in the museum



Possible emission source: background outdoor air

Conclusion

We have developed a serially connected passive sampler (DSD-Serial) and applied to field measurements of indoor air pollutants in the museum and lead the conclusions as follows.

- Sampling rates of previous passive samplers (DSD-DNPH & VOC-SD) can be used for the DSD-Serial, because no significant difference was found in the collection amounts of analytes.
- DSD-Serial showed a high sensitivity enough to assess indoor air quality of a museum.
- Indoor air quality of the Takehiko Miyanaga Memorial Museum was well controlled by mechanical ventilations.

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