Lanwatsu passive samplers for indoor, outdoor air sampling and personal-exposure

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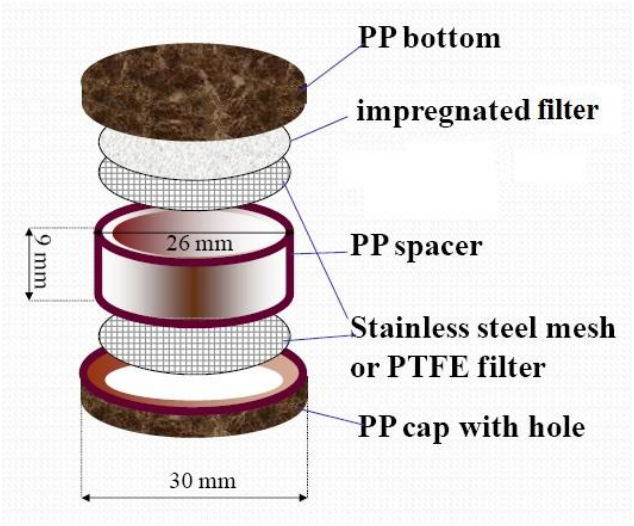
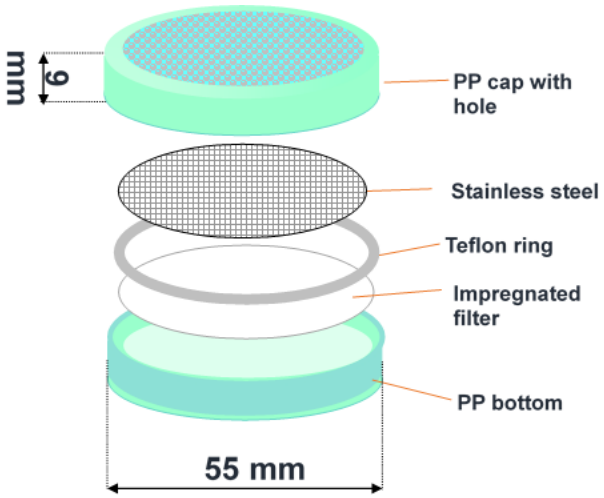
Diffusive sampler is a device which is capable of taking samples of gases or vapors from the atmosphere at a rate controlled by a physical process such as gaseous diffusion through a static air layer or a porous material and/or permeation through a membrane, but which does not involve active movement of air through the device

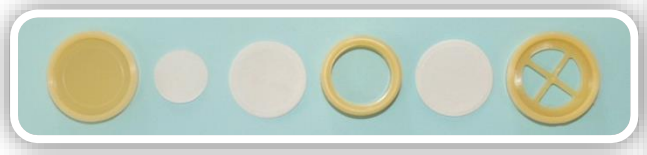
The basic principles of passive sampling

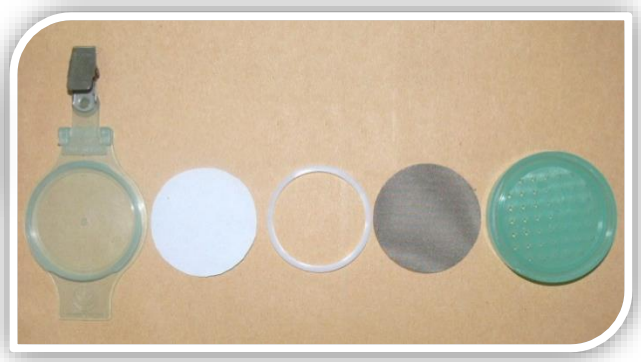
The sampling technique is based on the property of molecular diffusion of gases, hence the term passive (also referred to as diffusive) sampling. The gas molecules diffuse into the sampler where they are quantitatively collected on an impregnated filter or an absorbent material. Thus they achieve a time-integrated (or average) concentration. No electricity, pumps or other supporting equipment are needed.

Inorganic gases are absorbed by chemical reaction on a filter, impregnated with a solution specific to each pollutant measured. The reaction product, which is washed out of the filter prior to analysis, is specific to the particular gas in question. When species do not react sufficiently fast with other chemicals (e.g., organics) they are instead trapped on an absorbent material. Such gases are then desorbed from the adsorbent during analysis.



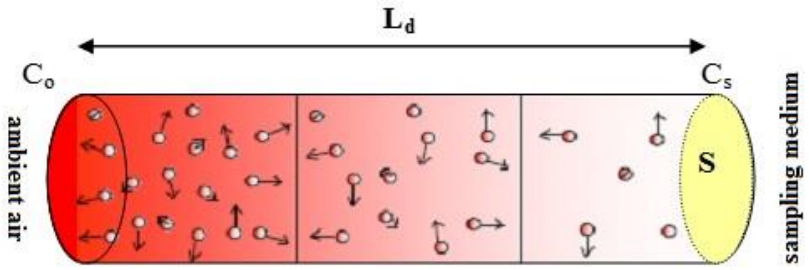






Schematic Diagram of diffusive passive samplers (a) and Lanwatsu passive samplers for SO_2, NO_2, NH_3, O_3 (b) and for HNO_3, HCl and carboxylic acids (c).

The small-size (1cm x Φ3 cm) and wide-size (1cm x Φ6 cm) LanWatsu passive samplers are shown in the above Figure. The cap, the bottom and the spacer are made of polypropylene. Stainless steel meshes (or Teflon filters) together with the spacer make a barrier – a static air layer, in which molecules of air pollutants diffuse and trapped on impregnated filter or absorbent (sampling medium) located on the bottom by chemical reactions or absorption. The rates of reaction or absorption are very high, hence the concentration of pollutant on the surface of sampling medium is almost zero.



Working principle of passive samplers.

According to the First Fick Law, an amount of pollutant diffused and collected on sampling medium is proportional to diffusion coefficient of a gas, duration of sampling (min) and concentration gradient, and can be expressed by the following expression

$$m_a = D_a \frac{C_o - C_s}{L_d} \times S \times t = D_a \frac{C_o}{L_d} \times S \times t \qquad (1)$$

Or

$$C_o(ppb) = K \frac{m_a}{t} \times 60 \qquad (2)$$

K is conversion factor which depends on geometry of a passive samplers and a nature of pollutants. K is determined experimentally, and is often expressed by ppb.h/μg.

The concentration of air pollutants (μg/m^3) can be evaluated via an uptake rate of pollutant of interest (v_a -ml/min) and duration of sampling (min) as follows

$$C_o(\mu g/m^3) = \frac{m_a}{v_a t} \times 10^6 \qquad (3)$$

Advantages and shortcomings of passive sampling

Passive sampling have some advantages over active sampling and continuous monitoring that make passive samplers very attractive for use in regional-scale relative air quality measurements as well as water quality monitoring.

- Passive samplers are relatively simple, portable and inexpensive to deploy in the field.
- Passive samplers do not require electrical power to operate; therefore they can be used in areas where electrical power is inaccessible.
- Passive samplers do not require calibration and maintenance.
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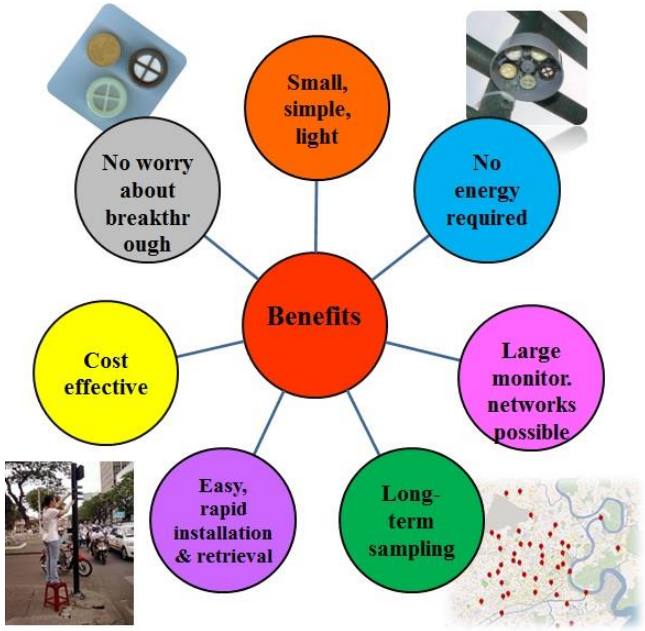
- Passive samplers do not require well-trained technical personals.
- Passive samplers make possible a wide monitoring networks with many sampling sites at the same time.
- Passive samplers is the unique tool that provides possibility to measure long-time average concentration of pollutants at low cost.
- Passive samplers allow to collect large volume of air without worry of breakthrough volume.
- Passive samplers are tool of sampling together with an enrichment.



However with passive sampling short-time average and instantaneous concentration.

Usage

Reusable Lanwatsu passive samplers are applied for indoor and outdoor monitoring as well as personal exposure measurement. Sampling duration is from one week to 2 months for SO_2, NO_2, NH_3, HNO_3, O_3, HCl and carboxylic acids in the ambient air, and from 8 to 24 hours for benzene, toluene, ethylebenzene and xylenes. In environment with high pollutant level such as working environment and road-side air, sampling duration can be shorten considerably. The protective shelters and carry cases were designed especially for indoor, outdoor sampling and personal exposure measurement.

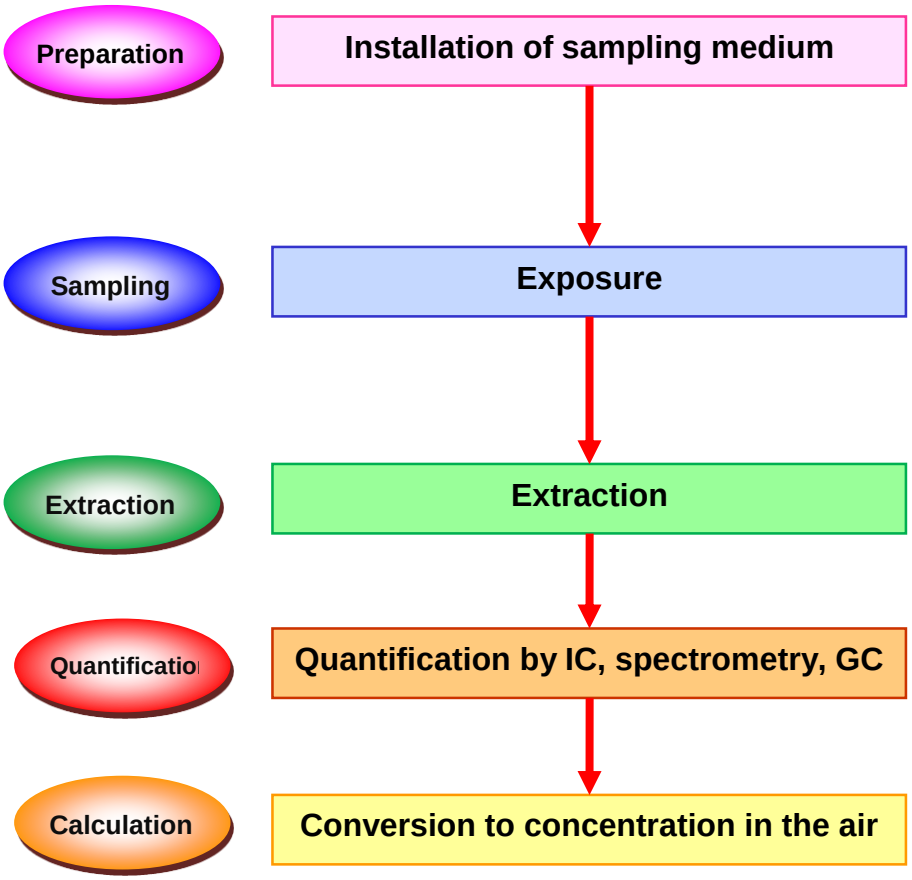
Lanwatsu passive samplers were utilized for air pollution management in many international projects

- The project "Acid deposition in East Asia" supported by the Japan Society for the Promotion of Science.
- The project "Atmospheric acidification and Conservation of cultural issues in East Asia" supported by the Japan Society for the Promotion of Science.
- The project "Benzene pollution caused by exhaust from motorcycles" supported by Vietnam National Foundation for Science and Technology Development.
- The project "Development of Environment- and Climate – friendly City in Danang" carried out by German International Cooperation.

Outdoor sampling: Passive samplers are mounted by stainless steel clips in a protective shelter that is fixed on trees, lamppost, frames… by cable ties or screws.

Indoor and personal exposure sampling: Passive samplers are attached on cases hanged on walls, glasses, breath pocket, wires…

Monitoring procedures



Preparation

Lanwatsu passive samplers are supplied as 1) ready for use; 2) emty, an user should intall sampling media before use.

Sampling media is supplied in air-tight vials or sealed glass tubes kept in aluminum zipper envelops.

Installation of sampling media should be done in clean air, as faster as possible to avoid contamination.

Ready-for-use passive samplers and sampling media shouldbe stored in a refrigerator.

Sampling

Take a passive sampler out of a container and mount it on a carry case or a protective shelter. Commonly sampling duration is 8 hours for working environment, 1 week or 1 month for ambient air to match requirements of air-quality standards. Store exposed samplers in well-sealed zippered aluminum envelops at low temperature in clean environment. Do not forget to record a time and a date of the beginning and the end of exposure.

Passive samplers are supplied with clean vials or tubes for the extraction. Transfer of sampling media into vials/tubes should be done in clean air.

A great care should be paid while working with passive samplers. Wear gloves and use forceps to avoid contamination.

Quantification and calculation

Analyses should be carried out not later than 2 weeks after the exposure.

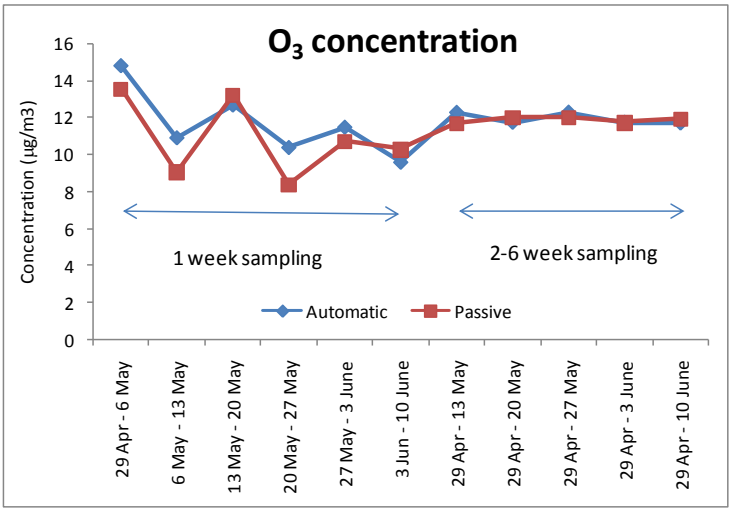
Transfer of sampling media into extraction vials or tubes and extract with appropriate solvent. The extracts are analyzed by spectrometric (SP), ion-exchange (IC) or gas-chromatographic (GC) methods.

Concentration of air pollutants in the air is evaluated by using the expression (2) or (3).

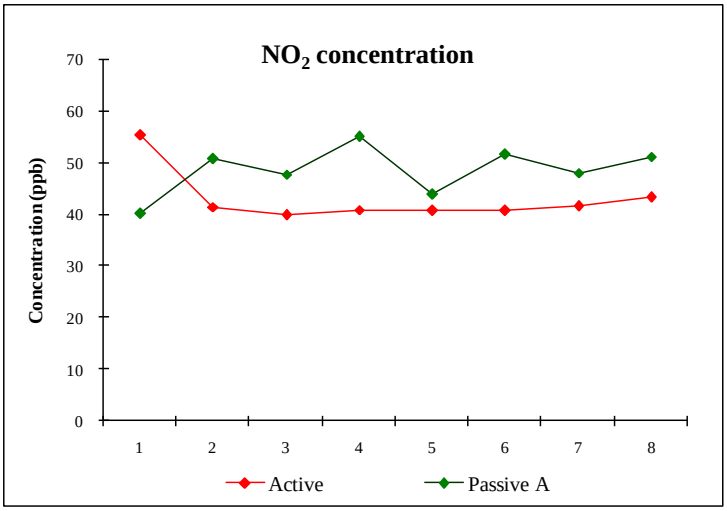
	Solvent	Volume/ml	Method	Analyte
NO_2	Saltzman reagent	5	SP, IC	NO_2^-
NO_x	Saltzman reagent	5	SP, IC	NO_2^-
SO_2	H_2O_2 0,03 %	5	IC	SO_4^{2-}
O_3	Water	5	IC	NO_3^-
NH_3	Water	5	SP, IC	NH_4^+
HCl, HNO_3	Water	5	IC	NO_3^-
carboxylic Acids	Water	5	IC	$HCOO^-$, CH_3COO^-, $C_2H_5COO^-$
BTEX	CS_2	1	GC	BTEX

Comparison of passive, active and continuous monitoring

Ozone concentration in the exposure campaing 29/4/2010 – 10/6/2013 measured by using automatic ozone analyzer (Data provided by HCMC EPA) and Lanwatsu Passive samplers.



Concentration of NO_2 in road-side air measured by Saltzman active sampling and by passiving sampling using Lanwatsu passive samplers. Sampling duration was 1 - 8 hours.

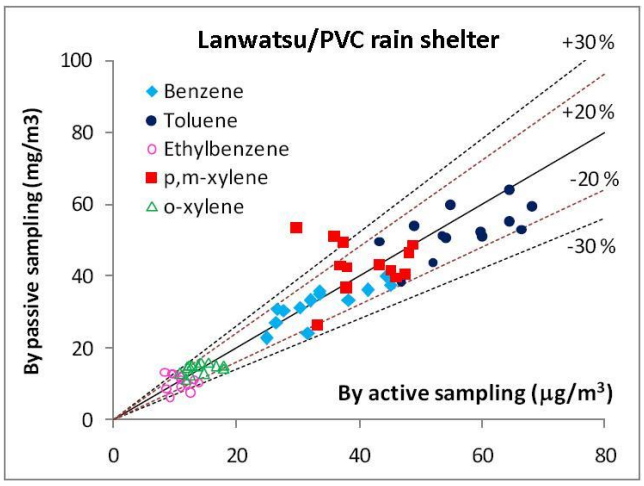


Passive sampling allows the measurement of integrated total or average pollutant concentrations over a sampling duration of several hours, one to several days or weeks. The data showed that at sampling duration of 1 week or above, the maximum variation between ozone concentrations obtained by using automatic ozone analyzer and Lanwatsu Passive samplers was 15 %, and the average one was 3,9 % (number of data: 11).

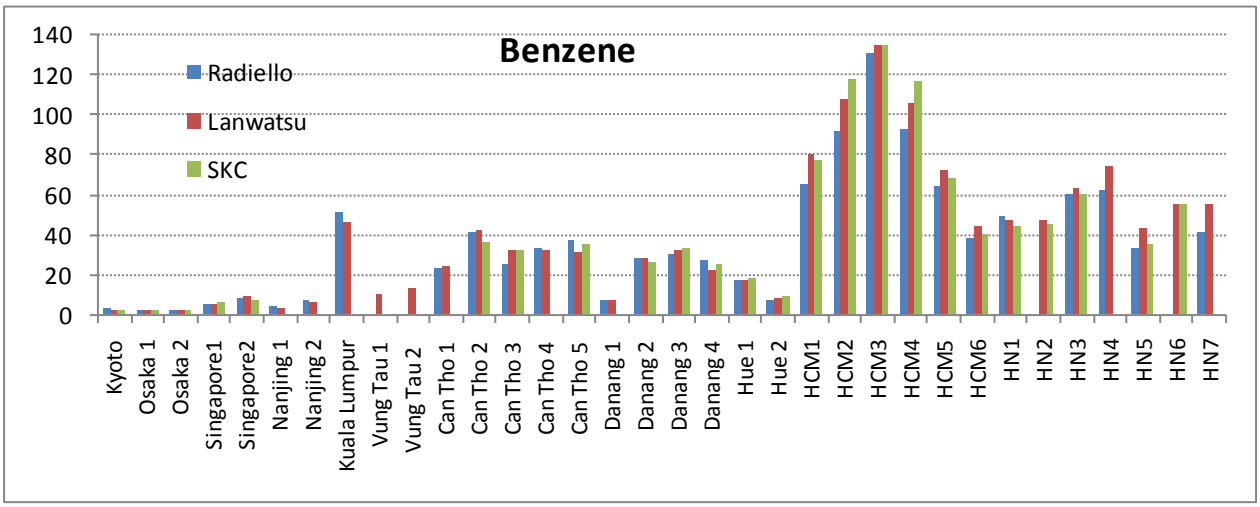
NO_2 level in road-side air at crowded roads in HoChiMinh City is very high due to a huge number of motorcycles. This makes possible utilization of passive samplers for hour measurement. For sampling duration of 2 – 8 hours, the average variation between data obtained by active and passive sampling was below 20 % (number of data: 120). However the variation was very large, up to 50% for one-hour sampling, hence special consideration shoud be paid when using passive samplers for short-time monitoring of pollutant in the ambient air.

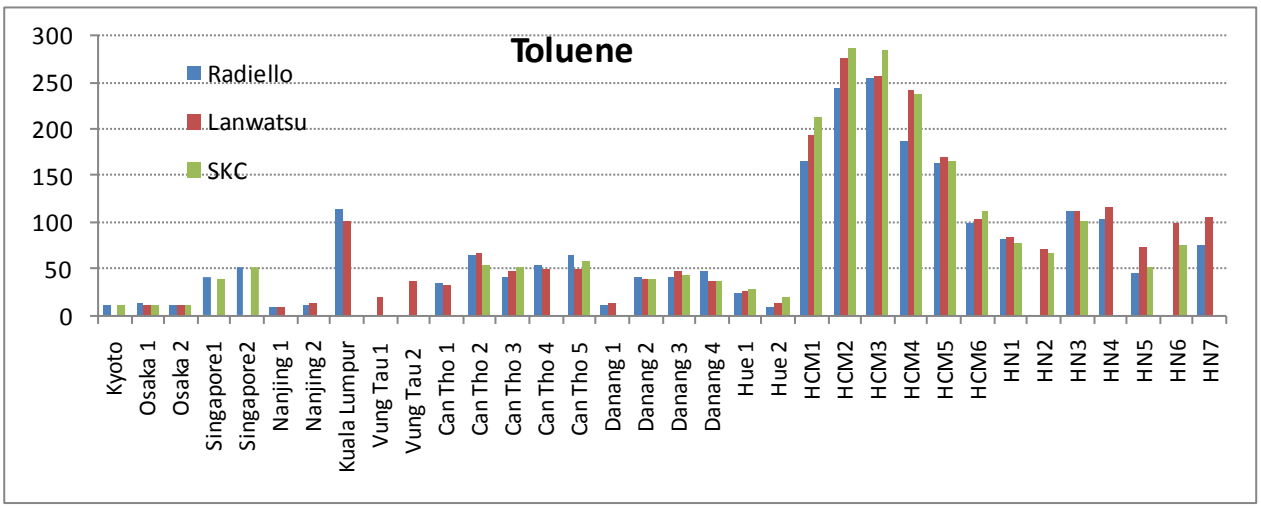
The data obtained for SO_2, NO_2, NO_x, O_3, NH_3, HCl, HNO_3, C1-C3 faty carbocylic acids at sampling duration of 1 week and above showed that concentrations obtained by using automatic analyzers or active sampling and Lanwatsu Passive samplers were almost the same with variation below 20 %.

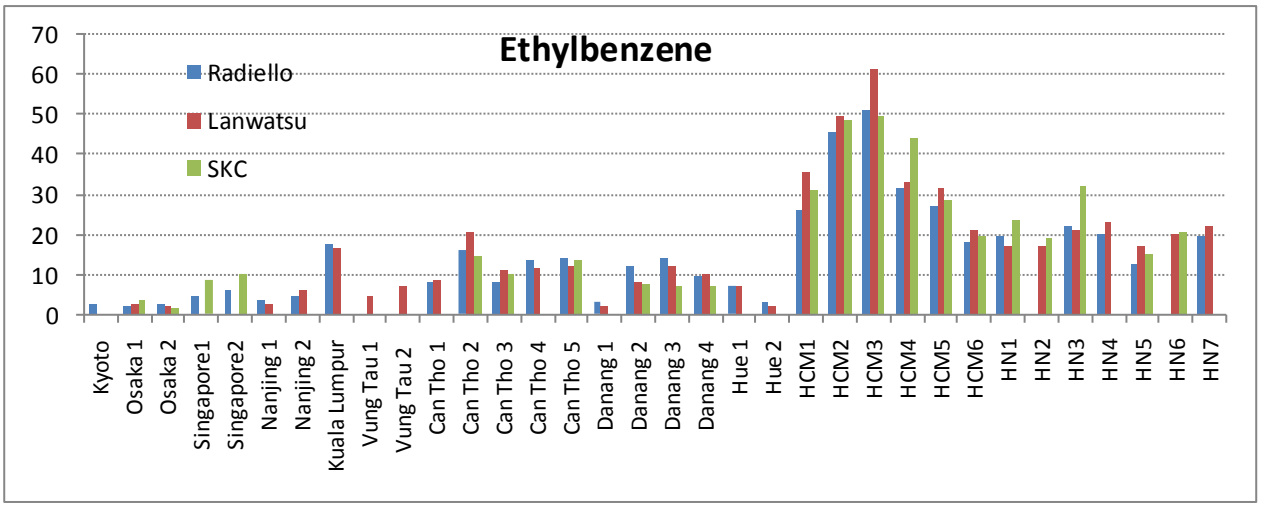
The daily BTEX concentration in road-side air in front of Depatment of Science and Technology oh HCMC were measured by using NIOSH 1501 active sampling and passive sampling with Lanwatsu, Radiello (Italy), SKC (USA) passive samplers. The variation of benzene and toluene concentrations obtained by active and passive sampling using Lanwatsu passive samplers were lower 20 % for all samples in two set of 13 samples/set (Figure in the right). Only 23% of xylene samples and 15% of ethylbenzene samples gained variation above 20% with the maximum variation below 40 %. Those variations were in the same range of the variations reported for the commerciallized Radiello and SKC passive samplers. Daily BTEX concentration BTEX concentration in East Asia measured by passive sampling using Lanwatsu, Radiello and SKC passive samplers were similar. All the above mentioned confirm that passive sampling is good alternative of active sampling; besides Lanwatsu passive samplers are good choice for passive sampling of BTEX species.

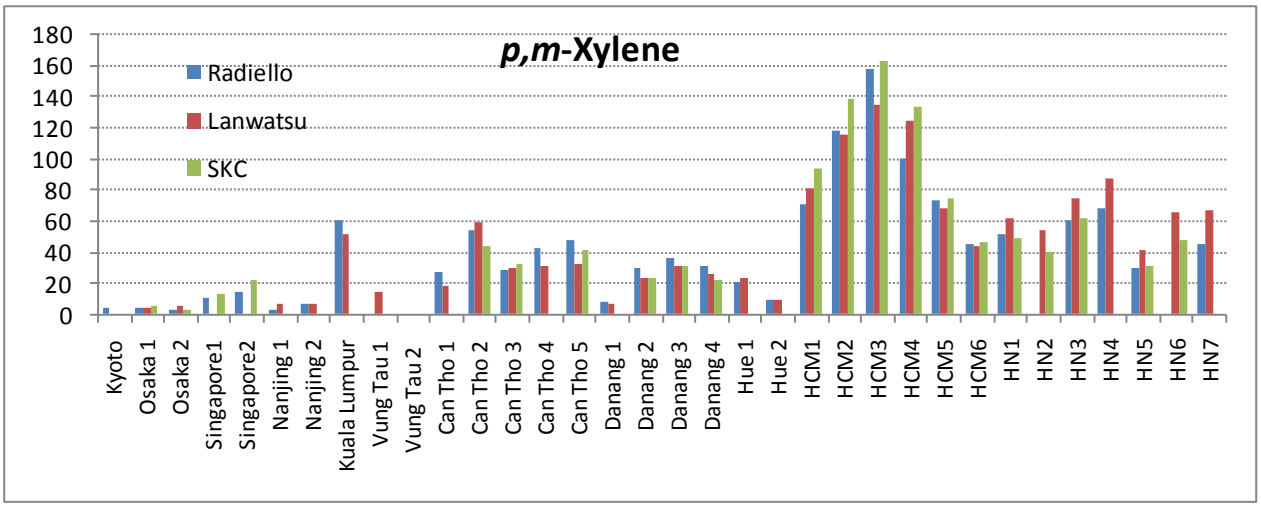


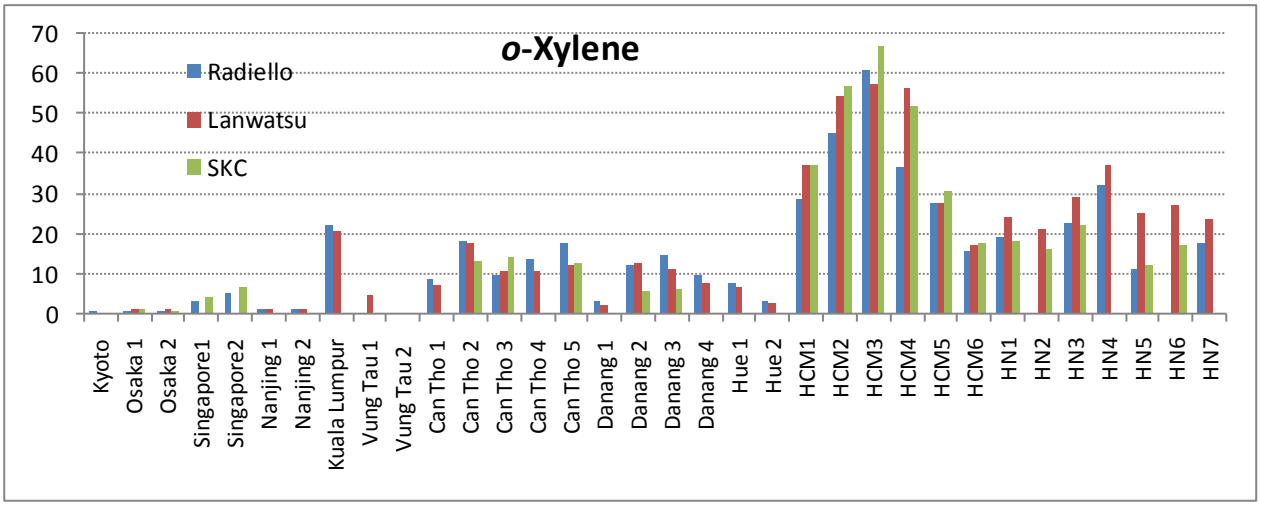
Daily BTEX concentration in road-side air in measured by using NIOSH 1501 active sampling and passive sampling with Lanwatsu passive samplers.











Daily BTEX concentration BTEX concentration in East Asia measured by passive sampling using Lanwatsu, Radiello and SKC passive samplers.

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