

A Survey of BTEX Concentrations in selected Automotive Paint Shops and their Vicinities in Thailand

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ABSTRACT

This study was to conduct a preliminary survey of the concentrations of benzene, toluene, ethylbenzene and xylene (BTEX) in ambient workplaces of 94 automotive paint shops and their surrounding communities in Bangkok, Thailand. Results showed that the average toluene concentration emitted from these shops was higher than other compounds. Although none exceeded the short time exposure limit (STEL) recommended by National Occupational Safety and Health (NIOSH), except for benzene detected in a few shops, many measured concentrations of toluene and xylene exceeded the odor threshold, which could possibly be a cause of odor nuisance. Therefore, these two compounds should be measured in this type of shops in order to be used as source tracers when odor complaint occurs.

Key words: BTEX, VOCs, Painting, Nuisance

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Introduction

Since the nuisance statistics have been initially recorded in Thailand, the most common complaint problem is objectionable odor which has occurred mostly in Bangkok¹. Part of the reasons is due to the accelerated growth of the economy in Thailand which results in population immigration from rural areas to many big cities. In addition, new technologies have been introduced without regard to environmental awareness, thus leading to many serious problems such as air pollution, untreated wastewater, and excessive noise. Also, many factories, with insufficient or no pollutant control equipment, are located in the same areas as residential zones. Automotive paint shops are frequently targeted by complaints from surrounding neighborhoods due to their emitted solvents, especially the volatile organic compounds used in the painting processes. Among these, a group of BTEX (benzene, toluene, ethylbenzene and xylene) is of particular concern for several reasons. Benzene is classified as known human carcinogen; Group A² and all four cause adverse effects to humans. Xylene causes objectionable odor even at low concentrations. Additionally, huge amounts of these VOCs are emitted from automotive paint shops. For instance, up to 2,202 tons per year of toluene and 609 tons per year of xylene released from the shops was measured in the Bangkok Metropolitan Area³.

Consequently, this study was to survey the concentration level of BTEX in automotive paint shops and their surrounding areas. The relationships of the BTEX concentrations at both places were also investigated. The results of this study are not only useful for worker and public health protection,

but also provide vital information supportive of the regulatory decision making process.

Methods

Ninety four automotive paint shops and the communities in their vicinities within 10 districts of the Bangkok Metropolitan Area, i.e., Khlong Toei, Vadhana, Bang Sue, Chatuchak, Bang Kapi, Suan Luang, Bang Khen, Bueng Kum, Lat Phrao, and Sai Mai were proposed by district officers of Bangkok Metropolitan Administration for air sampling and data collection from June to August, 2008. At each shop, the type of air pollution control equipment was recorded and two samples were collected. One sample was collected inside the shop where the pollutants were possibly being emitted to its neighborhood. The other was collected at the closest neighborhood downwind which was often located within 10 meters of the shop boundary line. The sampling duration time varied from 10 to 60 minutes, depending on the estimated concentration level in order to prevent breakthrough from the front to the back of the charcoal tube.

Before sampling, the personal pumps were calibrated by a soap bubble meter. The chemicals were collected in a 100 mg/50 mg coconut shell charcoal tube sucked by a pump with the flow rate of 0.2 l/min. A sample was extracted by CS₂ for 30 minutes and then injected into a gas chromatograph- FID to quantify the concentrations of these pollutants. Two blanks were analyzed for every 10 samples. More details about this sampling method and analysis are explained in NIOSH (National Occupational Safety and Health) method 1501⁴.

Results

1. Air cleaning device

Results showed that 78 percent of the shops were equipped with air cleaning devices

which were used to reduce the objectionable smell, such as air filters, wet scrubbers and incinerators as shown in figure 1. The most popular pollutant control equipment in these automotive paint shops is the air filter.

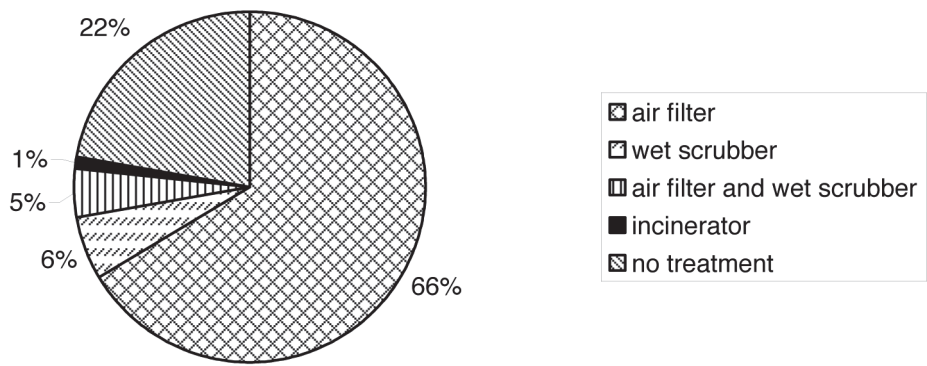


Figure 1 Odor control systems in the automotive paint shops (n = 86)

2. BTEX Concentrations in the automotive paint shops

2.1 Nuisance Aspects

Benzene, with a gasoline-like odor, is rather pleasant aromatic odor⁵. The concentrations of benzene in the surveyed shops ranged from below detection limit (less than 0.01 ppm) to 1.092 ppm which was lower than the odor threshold as shown in figure 2.

Toluene poses pungent, sweet, benzene-like odors⁵ while the xylene odor character is sweet⁶. The concentrations of toluene and xylene in the

shops were <0.01- 7.209 ppm and <0.01-3.355 ppm, respectively. Seven percent of the measured values of both compounds exceeded the odor threshold as shown in figure 3 and 4. For ethyl benzene, with a sweet and gasoline-like odor, had concentrations which ranged from <0.01- 3.494, of which only one was higher than the odor threshold as shown in figure 5.

To determine which shops could possibly be causing the odor nuisance, the authors used the equation of Chawangwongsanukul⁷ as shown below to predict the nuisance problem from toluene and xylene.

For Xylene, $I = 2.307\log C + 3.494$ (1)

For Toluene, $I = 2.053\log C + 0.574$ (2)

where I = odor intensity
C = chemical concentration (ppm)

The calculated number from the above equation can be interpreted as shown in table 1.

Table 1 Odor intensity and odor level⁷

Odor intensity	Odor level
0	no odor
1	very light (detection threshold)
2	light (recognition threshold)
3	moderate
4	strong
5	unbearable smell

In case of xylene, nineteen shops (approximately 20% of the total automotive paint shops) had an odor intensity of more than 1 which was above the detection threshold. Among these, eleven of them had values of more than 2 which were above the recognition threshold, while five of them had the values of more than 4 which were interpreted as a strong odor. Consequently, these shops have high potential to be the focus of complaints by their neighbors.

For toluene, sixteen shops (approximately 17% of the total automotive paint shops) had

odor intensity higher than the detection threshold. Among these, four of them should be monitored further because the odor intensity values were above the recognition threshold. However, none caused a strong odor.

The odor complaints could occur even with low odor intensity, depending on several factors such as frequency, duration and so on. Therefore, close monitoring and the maintenance of the pollutant control equipment employed should be done at all automobile paint shops with odor intensity over the detection threshold.

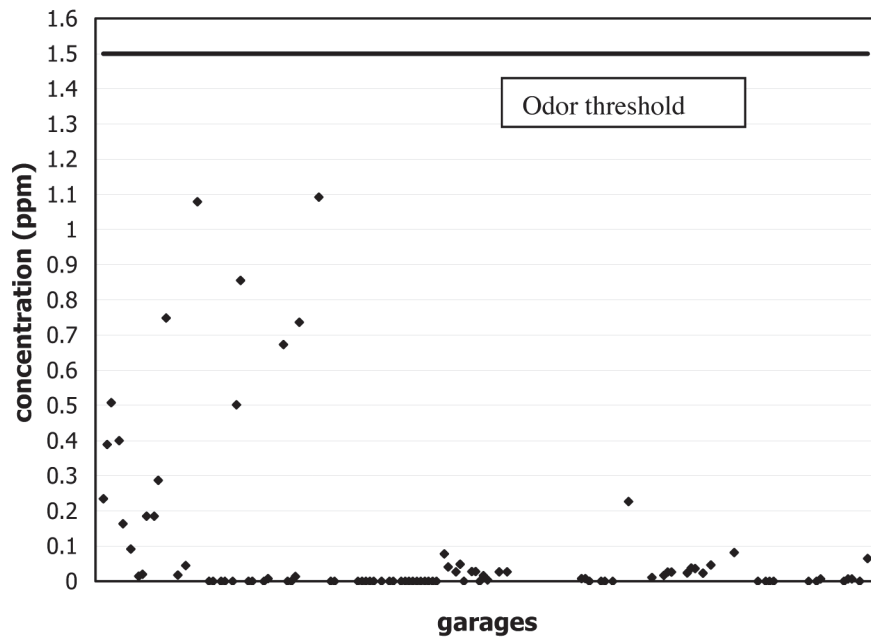


Figure 2 Benzene concentrations measured inside the automobile paint shops

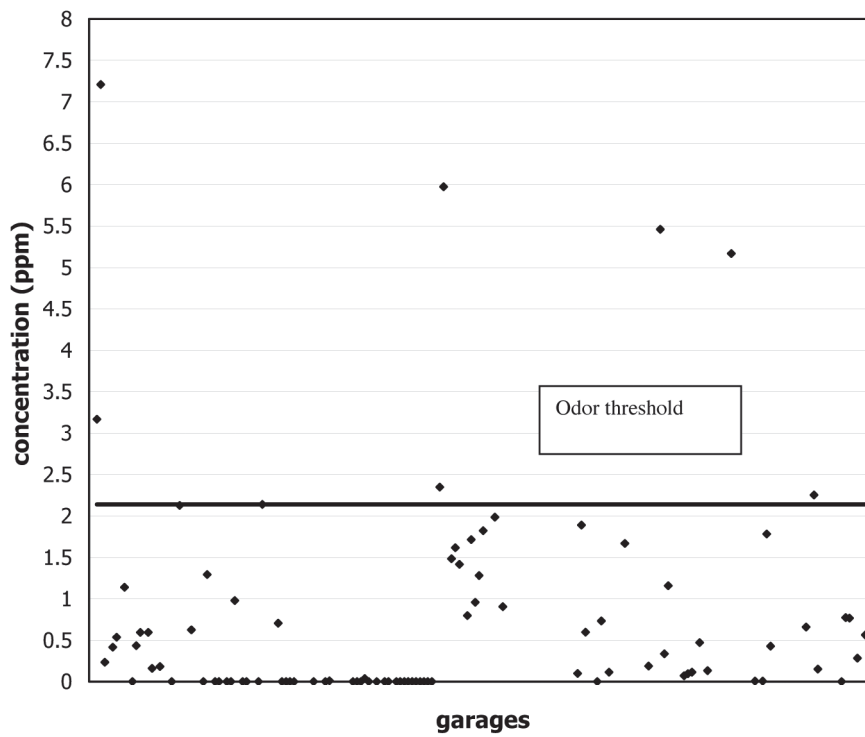


Figure 3 Toluene concentrations measured inside the automobile paint shops

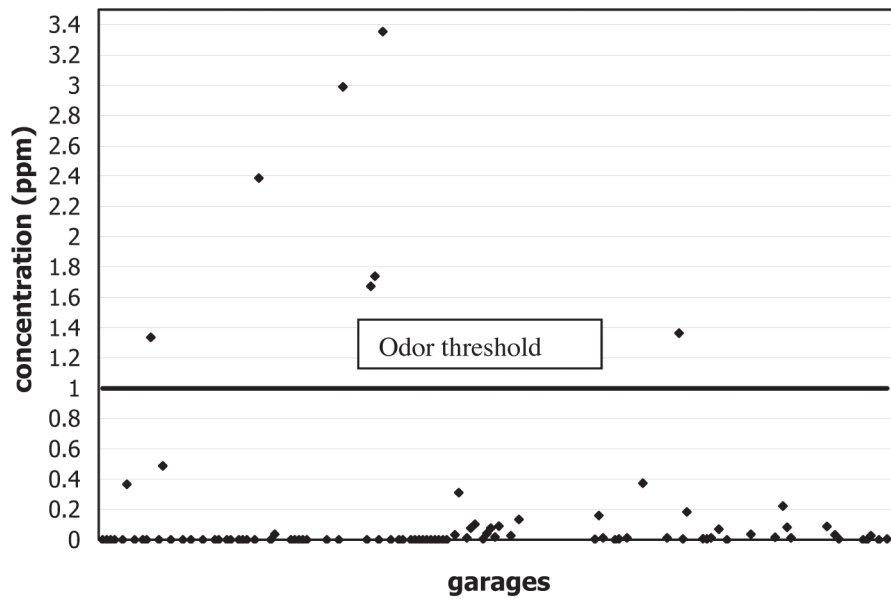


Figure 4 Xylene concentrations measured inside the automobile paint shops

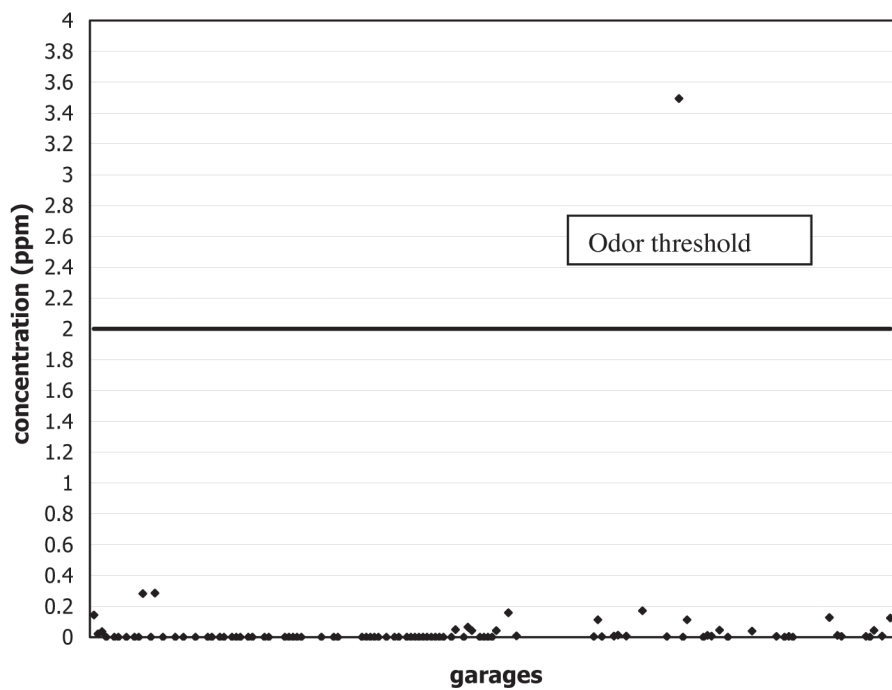


Figure 5 Ethylbenzene concentrations measured inside the automobile paint shops

2.2 Health Aspects

BTEX is a group of aromatic compounds which can possibly cause skin, sensory and respiratory irritation, as well as central nervous system depression. Additionally, these compounds will probably cause adverse health effects on kidney, liver and blood systems in case of prolonged exposure⁸. Results from several studies, indicate that benzene increases the incidence of leukemia^{2,9}. Although no measured values of benzene exceeded

the odor threshold, 2.1% of the shops posed a concentration higher than the 15 minutes short term exposure limit (STEL) recommended by NIOSH (table 2). In this study, the authors did not compare the results with time weight average (TWA) due to the short sampling period. Therefore, 8 or 10 hours sampling is recommended since the TWA of these compounds are more rigid than STEL (table 2).

Table 2 Threshold limits of BTEX

	OSHA	NIOSH		Other sources	
	TWA (ppm)	Ceiling (ppm)	STEL (ppm)	TWA (ppm)	Odor threshold (ppm)
Benzene	1	1	1	0.1	1.5 ¹⁰
Toluene	200		150	100	2.14 ¹¹
Xylene	100		150*	100**	1.0 ¹²
Ethylbenzene	100		125	100	2.0-200 ¹³

* o-xylene only
** o-xylene, m-xylene and p-xylene

3. Concentration of BTEX in the automobile paint shop’s vicinity and the relationship with the concentration inside the shops

The concentrations of benzene, toluene, xylene and ethylbenzene in the vicinities were <0.01-1.079, <0.01-1.182, <0.01-2.388, and <0.01-0.045 ppm, respectively. Most of these were undetectable. When compared the measured values inside the shops with the ones within their neighborhoods, the relationships were very low ($r^2 < 1$) (an example is shown in figure 6). This is possibly

because the measured values at the vicinity might be mixed and interpreted with the BTEX emitted from vehicles and other sources. In addition, the detected BTEX values at several shops were low, resulting in many undetectable concentrations at the communities. However, for toluene, the authors can find a slight relationship of its concentrations at several shops and their neighborhoods within certain ranges as shown in figure 7. This may partly be because the concentrations of toluene were high enough to let us see this relation.

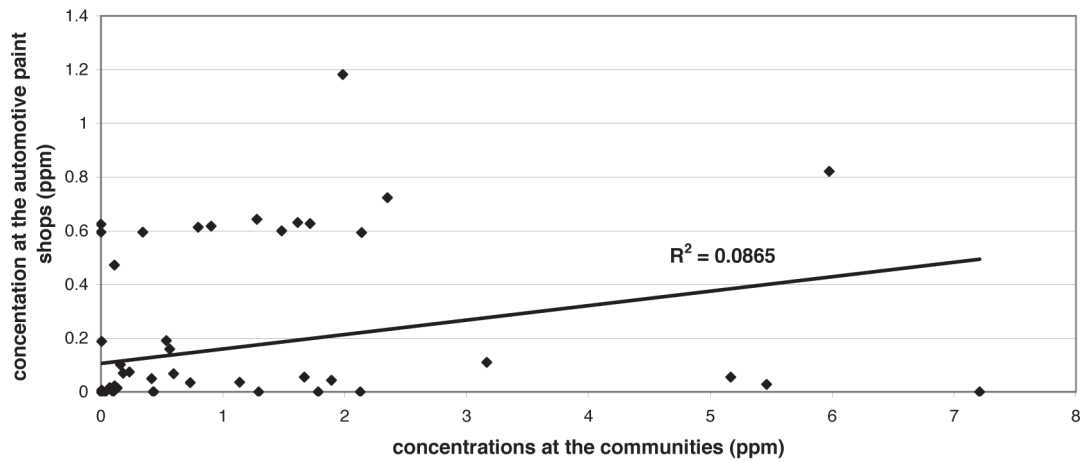


Figure 6 Relationship of toluene concentration inside and outside the shops

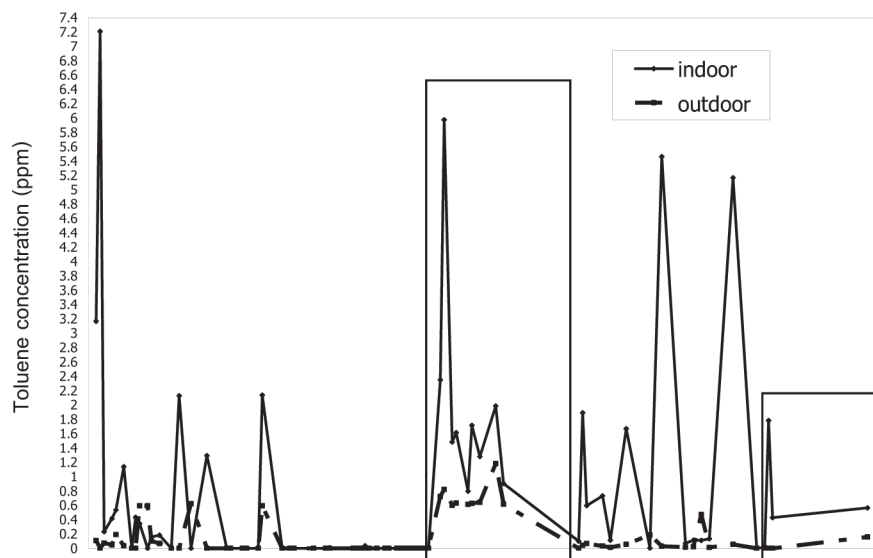


Figure 7 The comparative toluene concentrations in the shop and its neighborhood (Faint relationships are shown in the boxes).

Discussion

It can be seen that air filter is much more popular than wet scrubber in the surveyed shops. This might be due to the equipment is easy to operate and maintenance. Although wet scrubber can be used to treat the air stream, the contaminated liquid released from the system needs to be further treated.

Regarding the chemical concentrations detected in the shops, most of them did not exceed several thresholds as determined by OSHA and NIOSH. Nevertheless, they might cause odor nuisance because many detected values were above the odor threshold. Among these, the concentration of xylene and toluene are the crucial compounds which need to be monitored since xylene emits a strong smell at a lower concentration than the others (table 2) and toluene is common in the automotive paint shops. Additionally, the authors can note that the concentrations of toluene at the shops are higher than the other compounds. Therefore, they might possibly be used as a tracer to track down their sources (automotive paint shops) if one has its background value at the receptor (automotive paint shop's vicinity) and if the concentrations at source and receptor are measured at the same time. However, when there is a complaint, other investigations such as the use of questionnaires are required because smell from the shops do not result from any specific chemical but a mixture of compounds¹⁴.

Compared the chemicals detected in these automotive paint shops to house's garages, similar compounds were observed. Several studies¹⁵⁻¹⁹ confirmed that the amounts of BTEX

due to combustion of engine while being started-up or parked and evaporation of stored products such as solvent, cleaning products, oil were dominant. Consequently, even odor complaint resulting from automotive repair shops (without painting process), these two compounds are possibly used as tracers as well since work characteristics at the repair shops potentially released toluene and xylene more than those at the house's garages.

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การสำรวจระดับความเข้มข้นของสารกลุ่ม BTEX ในอุ้งพื้นสัณยภัณฑ์และชุมชนโดยรอบในประเทศไทย

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บทคัดย่อ

งานวิจัยนี้เป็นการสำรวจเบื้องต้นเพื่อศึกษาระดับความเข้มข้นของสารกลุ่ม BTEX ซึ่งประกอบด้วย เบนซีน (Benzene) โทลูอิน (Toluene) เอธิลเบนซีน (Ethylbenzene) และไซลีน (Xylene) ในอุ้งพื้นสัณยภัณฑ์และบริเวณชุมชนโดยรอบในเขตกรุงเทพมหานครจำนวน 94 แห่ง ผลการศึกษาแสดงให้เห็นว่าระดับความเข้มข้นเฉลี่ยของโทลูอินที่ถูกปล่อยออกมาจากอุ้งพื้นสัณยภัณฑ์มีความเข้มข้นสูงกว่าสารอื่นๆ ที่ทำการตรวจวัดเมื่อทำการเปรียบเทียบค่าที่วัดได้กับขีดจำกัดที่อนุญาตให้สัมผัสได้ในระยะเวลานั้นๆ (Short Time Exposure Limit; STEL) ที่กำหนดโดย National Occupational Safety and Health (NIOSH) ผลปรากฏว่าระดับความเข้มข้นของสารที่ทำการตรวจวัดที่อุ้งพื้นสัณยภัณฑ์มีค่าไม่เกินค่าที่กำหนดยกเว้นสารเบนซีนที่ตรวจวัดในสถานประกอบการบางแห่ง นอกจากนี้ผลการศึกษาแสดงให้เห็นว่าค่าความเข้มข้นของโทลูอินและไซลีนที่ตรวจวัดภายในหลายสถานประกอบการมีค่าสูงกว่าขีดจำกัดในเรื่องกลิ่นที่ตรวจวัดได้จากการดม (odor threshold) ซึ่งอาจจะส่งผลให้เกิดเหตุรำคาญในบริเวณใกล้เคียงได้ ดังนั้นเมื่อมีการร้องเรียนเหตุรำคาญจากกลิ่น สารเคมีดังกล่าวควรจะถูกตรวจวัดในอุ้งพื้นสัณยภัณฑ์ที่ก่อให้เกิดเหตุรำคาญเพื่อใช้ระบุถึงแหล่งที่มาของกลิ่น

คำสำคัญ: BTEX, สารอินทรีย์ระเหย, การปนเปื้อน, เหตุรำคาญ