Monitoring the Total Volatile Organic Compounds (TVOCs) and Benzene Emitted at Different Locations in Malaysia

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Abstract: *This study measured the amount of benzene and total volatile organic compounds (TVOCs) at three locations in Malaysia with contaminant emissions from different sources. The chosen locations included an evening market, a site on a roadside and an indoor environment at the Universiti Sains Malaysia (USM). Our results showed that the mean concentration of benzene during a painting project in the School of Civil Engineering at USM was 2.05 ppm, and the maximum benzene concentration at the evening market was 0.6 ppm. The mean concentration of TVOCs at the roadside location was 1.21 ppm. There are currently no health-related guidelines that set an exposure limit for benzene in Malaysia; hence, the U.S. Occupational Safety and Health Administration (OSHA) permissible exposure limit of 0.5 parts per million (ppm) of benzene in the workplace during an 8 hours work-day and a 40 hours work-week was used as an interim guideline value. Our results showed that the current concentrations of TVOCs and benzene were higher than the permissible limits set by OSHA.*

Keywords: benzene, emissions, OSHA, permissible limit, TVOC

1. INTRODUCTION

Benzene, toluene, ethylbenzene and xylene (BTEX) are members of an important group of aromatic volatile organic compounds (VOCs) emitted from a variety of sources. These BTEX chemicals play a vital role in tropospheric chemistry and can pose considerable risks to human health.[1] Benzene, in particular, is known to be carcinogenic and is emitted mainly from petrol-fuelled cars. It can thus be found in all urban areas.[2]

By examining the relative contributions of light-duty vehicles (LDV) and heavy duty vehicles (HDV), it can be determined that aldehydes, BTEX compounds and alkanes are mainly produced by LDVs, while the emissions of CO, NO_x, SO_2, and PM_{10} (Particulate Matter) are dominantly caused by HDV.[3]

This study monitored the total VOCs (TVOCs) and the benzene emitted from various sources at different locations. The chosen locations are: an evening market, a spot by a roadside and an indoor environment at the Universiti Sains Malaysia (USM). There are currently no health-related guidelines that set an exposure limit for benzene in Malaysia; hence, the U.S. Occupational Safety and Health Administration (OSHA) permissible exposure limit of 0.5 parts per million (ppm) of benzene in the workplace during an 8 hours work-day and a 40 hours work-week was used as an interim guideline value. The OSHA short-term exposure limit (STEL) for airborne benzene is 5 ppm for 15 minutes.[4]

2. RESEARCH BACKGROUND

Air pollution is defined as the presence of one or more contaminants in the outdoor atmosphere, the indoor atmosphere or combinations thereof in such quantities and of such duration as may be or may tend to be injurious to humans, plants or animal life.[5]

The Malaysian economy has grown rapidly in the past 27 years, largely due to the development of industrial estates, free trade zones, power plants and the petroleum industry. If due care is not taken, this rapid growth could result in the deterioration of the Malaysian environment. The most severe environmental problems associated with air-quality degradation may result from vehicle emissions and industrial sources. Particulate matters can originate from stacks and exhaust, and dust can originate from quarrying activities, construction projects and open burning.[6]

In several large cities, the amount of air pollutants is increasing with time and at times exceeds the levels prescribed by national ambient air-quality guidelines. There are currently three major sources of air pollution in the Malaysian environment, namely mobile, stationary and open burning sources. Figure 1 illustrates the percentage contribution of each source in Malaysia.[7] The recorded concentration of benzene (as a BTEX) at several different cities in the world is shown in Figure 2.

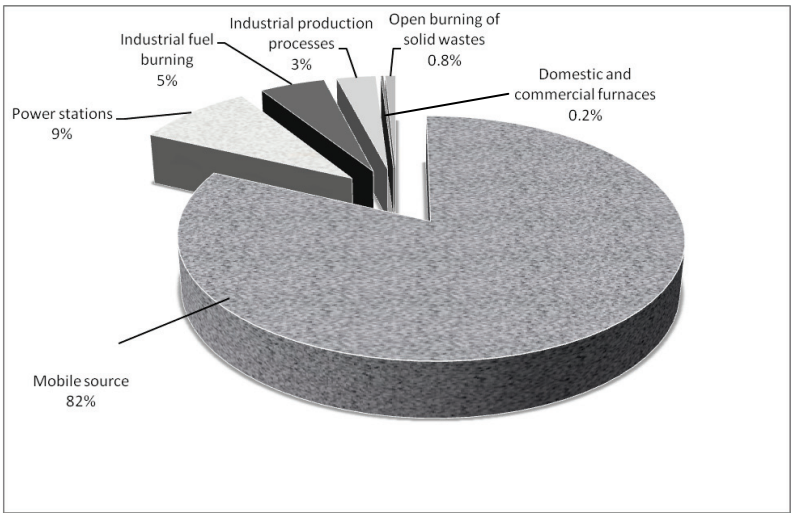

Figure 1: Sources of air pollution in Malaysia.[7]

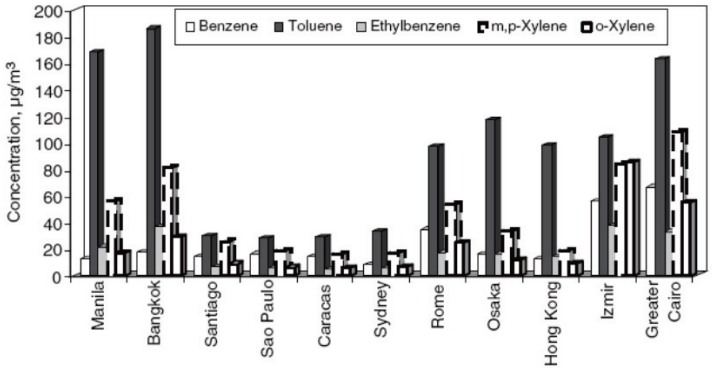

Figure 2: Comparison of BTEX concentrations for different cities worldwide.[14]

There has been a marked increase in the ownership of motor-powered vehicles in Malaysia. In 2006, there were 6.91 million registered cars on the road[8] with an annual growth of approximately 8%. Lead content reduction was regulated beginning in July 1985 that saw the initial content of 0.84 grams/litre reduced to 0.5 grams/litre, and later reduced further to 0.15 grams/litre in January 1990. Benzene is currently used as a replacement for lead as anti-knocking agent. The benzene level was initially limited to 5% by volume (Euro 2) in 2004 and should have been further reduced to 1% (Euro 4) in 2009.[10] However, due to many unexpected economic factors, Malaysia still use the Euro 2M standards, which were adopted from Euro 2 specifications.

The EPA Complex Model indicates that benzene emissions account for nearly 70% of the total toxic emissions from vehicles using conventional

gasoline, and that exhaust benzene accounts for nearly 90% of the total benzene.[9] The emission of benzene is expected to be reduced with improvements in fuel quality.

The estimated worldwide average emissions of VOCs were approximately 1347 million tons per year (Mt/year) from biogenic sources and 462 Mt/year from anthropogenic sources. Ambient total concentrations of airborne VOCs (155 compounds) in urban and suburban areas have been reported to be in the range of 16.2–1033 $\mu g/m^3$. Some VOCs have toxic health effects even at low concentrations, and exposure to BTEX compounds at high levels can cause respiratory, neurological, genetic and excretory system damage.[11]

Statistics on transport-related pollution deaths for Penang and Malaysia is yet to be made available for reference. In London, the residents collectively lose approximately 34,000 years of life from transport-related pollution. This high figure is largely related to the slow moving traffic in central London (16 km/h) and the ever-worsening congestion in the city, which emit more pollutants. In addition, soot from diesel pollution also leads to 27,000 non-fatal heart attacks and more than 400,000 emergency room visits in the U.S. annually.[12]

Chronic exposure to benzene is known to result in bone marrow failure and increase the risk of acute myelogenous leukaemia (AML). There have been previous descriptions of AML associated with occupational exposure to pesticides or solvents that have contained benzene that suggest a pattern of disease, although direct evidence linking benzene to AML is lacking.[13]

Low benzene concentrations in ambient air are likely to be dangerous, and studies have also found a correlation between traffic density and the incidence of leukaemia in children.[15] This study will investigate the concentration of benzene at two ambient and one indoor locations, and the levels of benzene to which the public are exposed will be grossly determined.

3. EXPERIMENTAL

The monitoring of TVOC and benzene was carried out using a direct air-quality (AQ) meter and a Photo Ionisation Detector (PID). The instrument is capable of measuring TVOC, CO, CO_2, temperature and relative humidity, simultaneously. The meter can also be used as an "early warning" indicator when the air quality worsens.[16]

4. RESULTS AND DISCUSSION

Several studies were carried out to measure the benzene concentrations at different sites using a PID monitor. The first measurements were taken close to a car's petrol tank, a car's exhaust outlet and a motorbike's exhaust outlet. The results show high concentrations of TVOC and benzene, as shown in Figure 3.

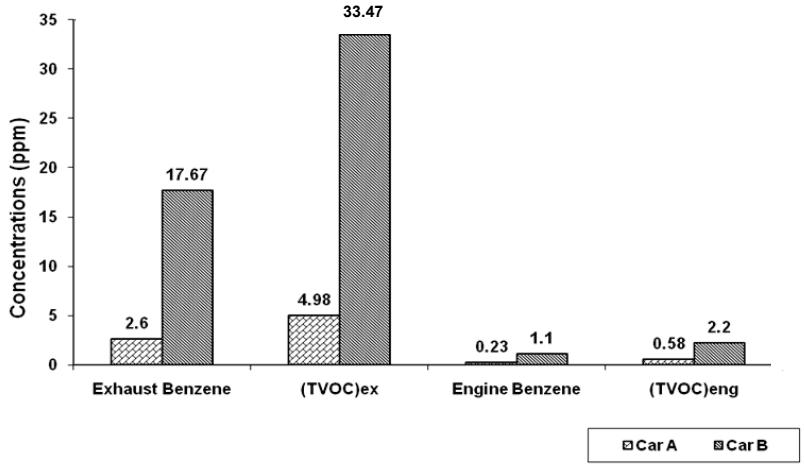

Figure 3: Benzene concentration emitted from different sources.

The results show that there is a high concentration of TVOC and benzene (33.47 and 17.67 ppm, respectively) emitted from car exhaust, but the exact amount depends on the car engine's condition.

The second measurement was done at an evening market in Parit Buntar, which is a popular place for Malaysians to spend their time enjoying food and shopping. Benzene that originates from frying activities in the market was measured, and the results are shown in Figure 4. These data show that there are high concentrations of benzene (0.6 ppm) emitted during frying activities.

Figure 4: Concentration of benzene during an evening market in Parit Buntar.

The third measurement was performed in the School of Civil Engineering at the Universiti Sains Malaysia (USM). In this location, the paints being used to paint the wall and ceilings in the school were the main sources of TVOC and benzene emissions.

As shown in Figure 5, the TVOC and benzene concentrations in the middle of the school near the staircase were 2 ppm. Being an enclosed area had most likely contributed to this high reading.

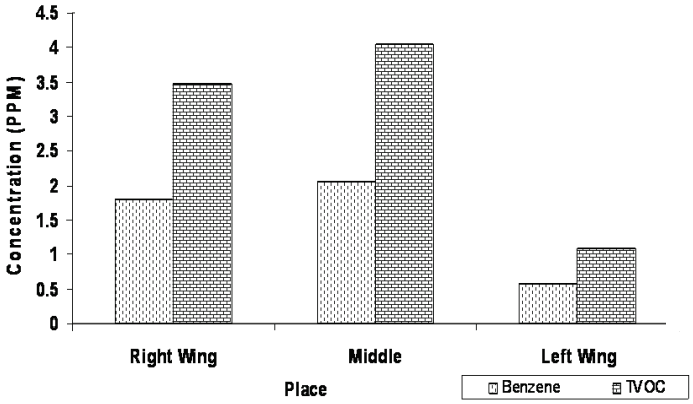

Figure 5: Mean concentration of benzene during school painting.

In the fourth and final measurement, the concentration of benzene was measured by a roadside at the main gate of USM Engineering Campus. The inline traffic flow was analysed during the morning rush hour, as shown in Figure 6.

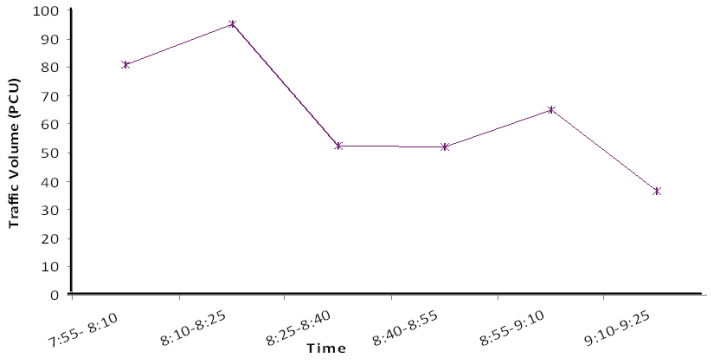

Figure 6: Traffic flow at USM main gate (Engineering Campus).

The results of the traffic count show that the traffic peak occurs from 7:55 am to 8:25 am. When comparing the traffic flow with the benzene concentrations, a strong positive correlation was discovered, and it is clearly visible in Figure 7. This result is in accordance with previous literature reports that stated that vehicles are the main source of benzene contamination in the air.

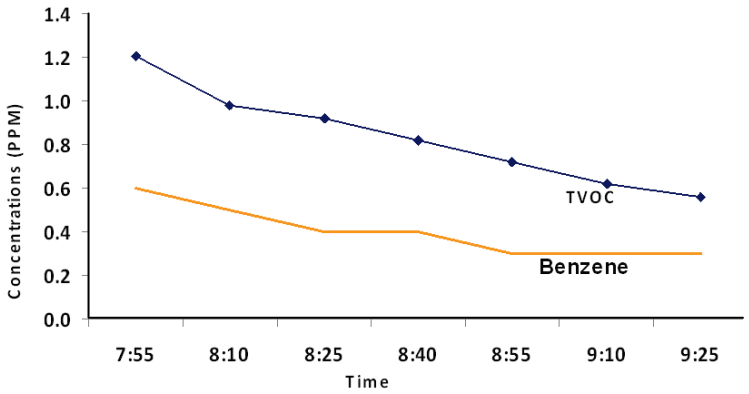

Figure 7: Benzene and TVOC concentrations at the main gate of USM Engineering Campus.

5. CONCLUSION

Preventive measures should be taken to protect human health from the high concentration of benzene (17.67 ppm emitted from car exhaust) that was measured in these studies. This study was a preliminary attempt to examine the TVOC and benzene concentrations originating from different sources. A more comprehensive study should be carried out to determine the reaching effects of these pollutants.

6. ACKNOWLEDGEMENTS

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