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Characterization of BTEX in Malaysian petrol

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Abstract

Current Malaysian legislation comply to EURO 2 grade with maximum of 5% benzene content by volume in petrol and no limit to the aromatic hydrocarbons content that includes toluene, xylene and ethyl benzene until 2027. Benzene, Toluene, Xylene and Ethylbenzene (BTEX) which present in petrol is simultaneously released to the environment in the form of liquid spills or vapor losses. High concentration of BTEX in petrol leads to high exposure of this chemical to human and environment. BTEX is associated with major chronic diseases and cancer which its application is monitored. Petrol fuel from five brands available in Malaysia was bought and undergoes GC-FID for Benzene, Toluene, Xylene and Ethylbenzene concentration analysis. In Euro 5, TEX is categorize under aromatic group which has maximum permissible level of 42% by volume. Petrol brand 1 has the highest average benzene concentration at 32842.87 mg/L. Petrol brand 5 on the other hand has the highest average TEX concentration with 21685.68 mg/L Toluene, 13310.39 mg/L Xylene, and 17799.77 mg/L Ethylbenzene. More than 73% reduction of BTEX is required for the current petrol to comply with EURO 5 regulation and a short-term mitigation need to be applied to reduce the BTEX from being released during this changeover period.

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1. Introduction

Increase in population has contributed to the increase in demand of petrol consumption on the improvement of social welfare specifically in transportation. Petrol is a mixture of chemical containing benzene, toluene, ethylbenzene and xylene (BTEX) [1]. BTEX can be lifted up into the environment by emissions from burning coal and oil, petrochemical waste and storage operations, motor vehicle exhaust, and evaporation from petrol service stations [2]. Petrol stations are one of the major contributors to the release of BTEX unburned fuel in the form of liquid spills or vapor losses. The concentrations of BTEX known to amplify during fueling because the levels of benzene in air and the daily volume of petrol sold are closely related. BTEX could potentially diffuse into water and soil from industrial discharge, disposal of products containing benzene, gasoline leaks from underground storage tanks and spillage during delivering, storage, and purchasing of fuel on the petrol stations. It can be categorized as the monoaromatic volatile organic compound that has high vapor pressure. Due to high volatility and vapor pressure, monoaromatic hydrocarbon in BTEX can easily transform into vapor even at room temperature [3]. Several volatile organic compounds in petrol including BTEX have been known to contribute to ozone depletion that enhances the global greenhouse effects [2]. Other adverse effects associated with these air pollutants are global warming, acid rain, and photochemical smog [3].

BTEX is being classified as toxic and Class 1 carcinogenic compounds [4]. Human animals can be infected by BTEX through skin contact, ingestion and inhalation [2]. Short-term effects of exposure to BTEX are fatigue, headache, dizziness, drowsiness, confusion, tremors, loss of consciousness [2, 4]. Adverse effects of BTEX exposure are known to include myeloid leukaemia, myeloma, reduction in the production of red and white blood cells from bone marrow, decline in immune system, damage to central nervous system, slow reflexes, liver and kidney failure and cancer [4]. Studies also revealed that benzene poisoning can cause damage to genetic code [5]. Foo [6] stated that a worker might have 155 times higher risk of death from leukemia if exposed at 10 ppm of benzene for 40 years of cumulative working period than normal people and 1.7 times higher if exposed at 1 ppm. Guo [7] reported a death case because of toluene sniffing in Taiwan. Rajan and Malathi [8] stated that acute effects like nausea, headache and throat irritation can occur at 100 ppm xylene exposure. Xylene could potentially interrupt the action of proteins essential for neuron function. High concentration with prolonged exposure of xylene can cause severe damage to lung, kidney, liver and memory impairment [9].

BTEX is highly regulated in its applications because of its hazardous properties and proven to cause significant effects to human health and environment. Concentration of BTEX in petrol is governed by the European Union Law which has set the maximum composition according to grade known as EURO grade [10]. Benzene is set at a maximum 5% by volume in EURO 1 and 2 while 1% by volume for EURO 3 and above. Toluene and Xylene are not specified in the regulation but are summed up in total aromatic categories in EURO 3 and above. Total aromatic has a 42% by volume maximum limit in EURO 3 and 35% by volume in EURO 4 onwards. The benzene concentration allowed in petrol for each EURO grade is based on the permissible benzene content by volume. EURO 1 and EURO 2 are allowed up to 43800 milligrams of benzene in every liter of petrol while EURO 3, EURO 4 and EURO 5 allowed 8760 milligrams benzene in every liter of petrol. By implementing EURO 5 in 2027, Malaysian Petrol Company is required to reduce the benzene concentration in its product up to 79.98% in order to achieve new permissible concentration set in the new regulation.

BTEX in petrol varies by countries as different countries comply with different EURO grades. All European Union members are required to comply with EURO 6 grade while other countries adopted several other EURO grades [11]. Malaysian government had adopted the EURO 2 grade in EQA 1974 Environmental Quality (Control of Petrol and Diesel Properties) regulation 2007 until 2027. New amendment was made under the same regulation in 2015 to change the grade from EURO 2 to EURO 5 while the changing period was given until 2027 [12].

The objectives in this work were: (1) to measure BTEX concentrations in the petrol available in Malaysia; (2) to compare the concentrations measured with the values with the current regulation and legislation applied in Malaysia and the world; (3) to evaluate the current standpoint of fuel composition in Malaysia until the new legislation fully functioning on 2027.

2. Materials and Methods

Unleaded Gasoline of 95 Relative Octane Number (RON) from 5 brands available for purchase in Malaysia petrol stations are used in this study. The sample are bought from the petrol stations in an air tight glass container under room temperature. The sample then undergoes GC-FID to determine the concentration of BTEX. GC-FID are set up using gas chromatograph with Capillary column DB-WAXETR (30 m x 0.32 mm x 1.00 μ m). The GC oven temperature are program at 70°C to 150°C for 2 min, followed to 250 °C, with a split 10: 1. Hydrogen was used as the gas carrier with 22.0 PSIG flow rate setting.

3. Results and Discussions

Petrol from five brands available in Malaysia was bought at the petrol stations and undergoes GC-FID for benzene, toluene, xylene and ethylbenzene concentration analysis. Petrol sample analysis shown that petrol brand 1 has the highest average benzene concentration at 32842.87 mg/L while the lowest average concentration is petrol brand 5 at 19498.50 mg/L. Concentration of benzene in Europe petrol had been known to varies from 0.3 to 8.6 % in volume (2628 mg/L to 75336 mg/L) shown in Fig.3. Hoekman [13] had similar benzene range in w/w % of 0.5 (4380 mg/L) to 2.5 (21900 mg/L) in United State (USA) petrol. Concentration of benzene in all petrol brands does not exceed 5% volume (43800 mg/L) limit set in EURO 2. More than 60% reduction of benzene concentration is required to comply with 1% volume (8760 mg/L) limit set in EURO 5 by 2027 [12].

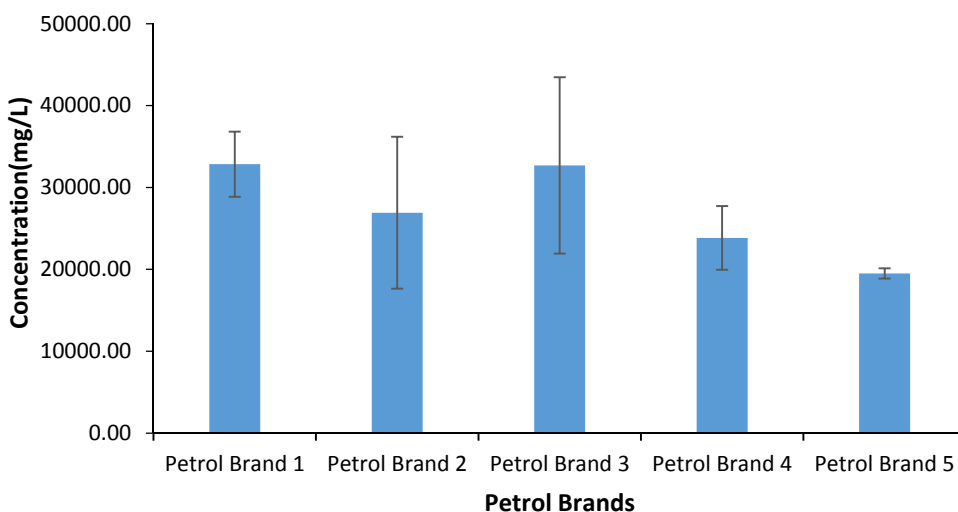


Fig. 1. Benzene concentration in petrol sample.

Fig. 2 presents the TEX concentrations in Petrol. Petrol brand 5 has the highest average TEX concentration with 21685.68 mg/L Toluene, 13310.39 mg/L Xylene, and 17799.77 mg/L Ethylbenzene. Petrol brand 3 on the other hand has the lowest average TEX Concentration at 12163.89 mg/L Toluene, 7653.86 mg/L Xylene, and 10755.58 mg/L Ethylbenzene. Faruq (2012) finds similar trend in toluene and xylene concentration in petrol around the world to be at 18.78 – 22.99 w/w% (135159.66 mg/L – 165459.03 mg/L) and 9.75 -29.42 w/w% (211735 mg/L). USA Petrol had been recorded to contain 7.174 w/w% (51631.28 mg/L) toluene and 9.688 w/w % (69724.54 mg/L) xylene. There is no specific permissible limit value for Toluene, Xylene and Ethylbenzene (TEX) stated in the regulation for EURO 2 (MFGG, 2007). It has been reported that TEX is group together with several other components under aromatic with a limit of 42 % by volume [12].

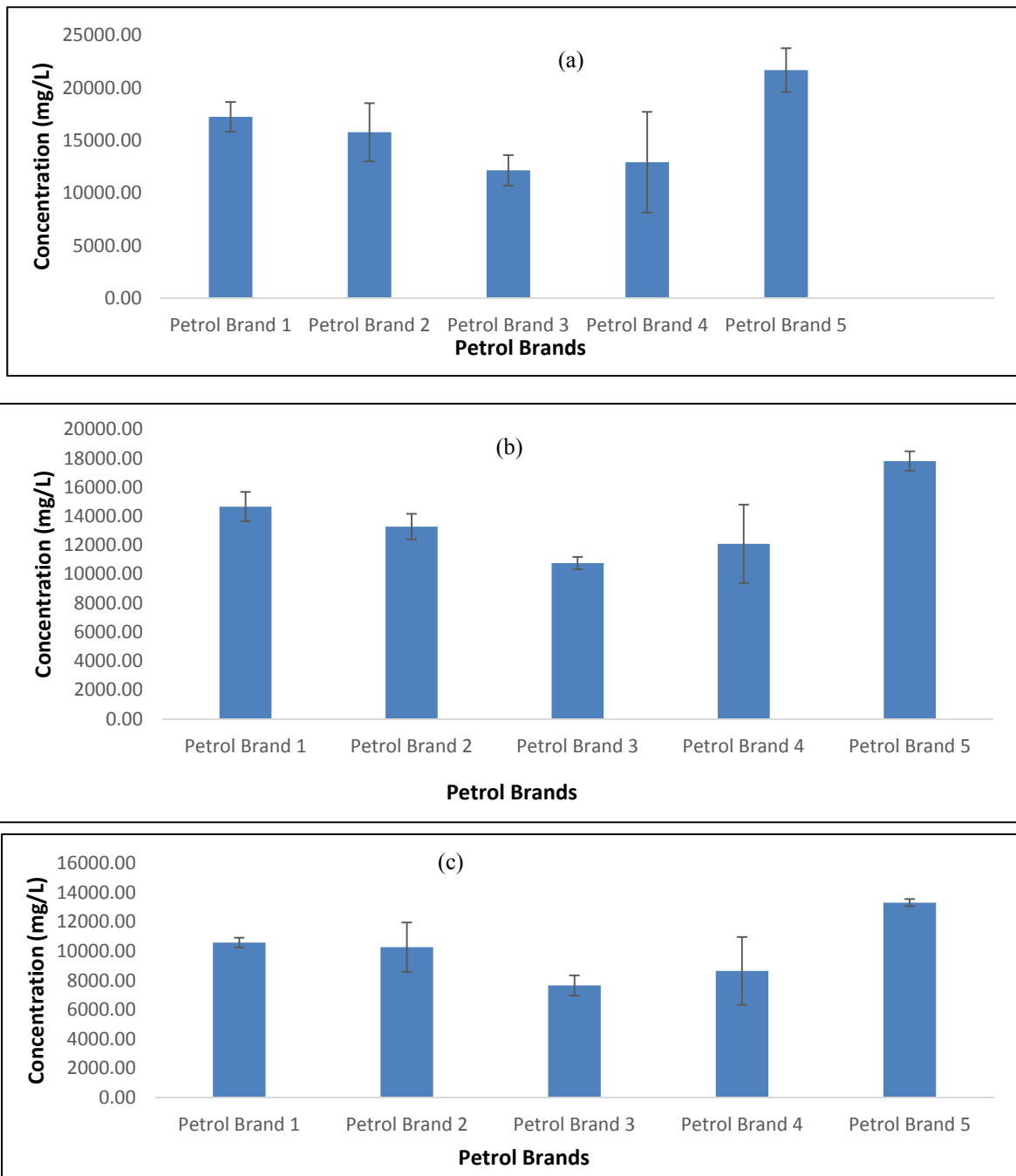


Fig. 2. TEX concentration in petrol (a) toluene; (b) xylene; (c) ethylbenzene.

Fig.3 shows the BTEX Comparison by Brand. Each petrol brand has their own formulas in developing its fuel product to achieve the best quality for their performance, efficiency and optimum combustion which explain the differences in composition of BTEX and leads to high exposure of this chemical to human and environment. High demand of petrol will kept increasing every years based on the increasing trend on the Malaysian petrol consumption and the exposure to BTEX will also increase exponentially. Progressive action has been made by the Malaysian government for the Environmental Quality (Control of Petrol and Diesel Properties) (Amendment)

Regulation 2015 [12]. The changes are taken place decades from now and a quick short-term action are to be initiated to control the current exposure of BTEX as the usage of petrol service station are unavoidable.

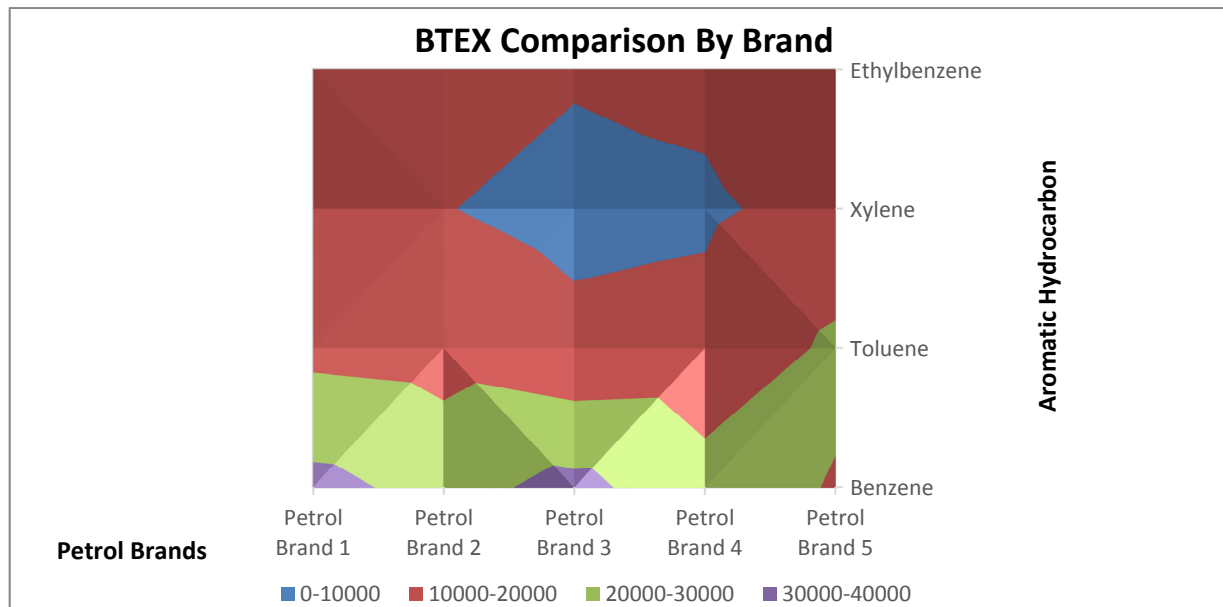


Fig.3 BTEX comparison by brand

4. Conclusion

Due to highly hazardous and high adverse impact to the environment, BTEX is highly monitored in its applications. Concentration of benzene in petrol are governs by the European Union Law which has set the maximum composition per grade. The chemical constituent of petrol are gazette in Malaysian legislation under Environmental Quality Act 1974 (ACT 127) in the "Environmental Quality (Control of Petrol and Diesel Properties) Regulation 2007"(MFGG, 2011). Current Malaysian legislation comply to EURO 2 grade with maximum of 5% benzene content by volume in petrol and no limit to the aromatic hydrocarbons content that includes toluene, xylene and ethyl benzene until 2027 (MFGG, 2014).

The composition of BTEX in petrol is varies depending on brands. All brand does not exceed the permissible limit set in EURO 2 regulation implemented in Environmental Quality Act 1974. The commitment of the Malaysian government on managing the environmental issues with the concern for public health are materialize by the new amendment of Environmental Quality (Control of Petrol and Diesel Properties) on 2015. The current BTEX composition does not meet with EURO 5 regulation and a lot of reduction is required especially on benzene concentration. Innovative approach need to be taken for this 10 years transition period in order to control the benzene exposure from petrol.

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