Original Article

Risk Assessment of Ambient Air Pollutants and Health Impact around Fuel Stations in Urban Cities of KSA

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Abstract

Background: In Saudi Arabia, fuel dispensing facilities commonly present around the residential places, educational institutions, and various health care facilities. Fuel pollutants such as benzene, toluene, and xylenes (BTX) and its alkyl derivatives are harmful to human health because of their toxic, mutagenic, or carcinogenic properties. The aim of this study was to determine the BTX concentration levels of common pollutants in and around fuel stations and their harmful health effects in the urban cites of KSA. **Methods:** Forty fuel dispensing facilities were randomly selected on the basis of three different areas: residential, traffic intersection, and petrol pump locations (refueling stations). Portable ambient analyzer was used for measuring BTX concentration. *t*-test was applied to determine the difference between these different areas. **Results:** All mean concentration values of pollutants such as BTX around residential, traffic intersection, and fuel stations are exceeding the limits of air quality standards values ($P < 0.01$). The mean levels of benzene are 10.3 and 11.07 ppm in Dammam and Khobar, respectively, and they exceed the reference level of 0.5 ppm. Hazard quotient was more than >1, which shows that carcinogenic probability has increased those who were living and working near fuel stations. **Conclusions:** The results found that the high concentration of pollutants (BTX) is in the environment around fuel stations. The environmental contamination associated with BTX in petrol fuel stations impulses the necessity of preventive programs to reduce the further air quality deterioration and reduce the harmful health effects.

Keywords: *Air, benzene, fuel, pollution, toluene, xylenes*

Introduction

Fuel dispensing facilities are surrounded by houses, schools, and hospitals, particularly in urban areas.[1] Majority of fuel stations were constructed under the old regulations and standards and did not follow the international standard of environmental regulations.[1]

There are two common sources of emission of benzene, toluene, xylene (BTX) compounds: first, emission from vehicles on the roads and second in fuel stations. Among BTX, xylene is the most dangerous to human health.[2-4] Fuel and gas products have high concentration of BTX, which emitted in the form of vapor in the environment. These volatile organic compounds (VOCs) are common sources for gasoline vapor emission and motor vehicle exhaust.[5]

BTX also plays an important role in the atmospheric chemistry. It has been recognized as an important photochemical precursor for tropospheric ozone and second organic aerosol.[6]

There are different studies that found concentration of benzene was 89.09%, xylene was 252%, and toluene was 239% in the fuel compare to the normal threshold level.[7] Benzene and ethyl benzene are well-known carcinogens to human body.[8] Population which are living near the petrol pump stations and working in fuel stations are directly exposed to BTX. These toxic products are VOCs, which are commonly called as BTX.[9] These toxic compounds are classified as group 1 and 2b carcinogens.[10-13]

There are various health disorders due to the exposure of these toxic organic compounds.[14] Such disorders as neurological, cancers, and teratogenic effects. The main route of entry is inhalation or ingestion. The most common health impact is leukemia, which is estimated to affect around 1 million people around the world. and four times likely associated with leukemia in thier lifetime risk on exposure

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to benzene concentration 1 mg/m^3[15] In occupational setting, the health impacts of BTX are well known in the oil industry. There is an association found between cancers and BTX in different study results.[16,17] The present study aimed to assess the air quality concentration of BTX around residential, traffic intersection, and fuel stations and their health outcome.

Methods

Study Settings and study design

This is the cross-sectional study and 40 petroleum fuel stations were randomly selected, 20 samples each from the two cities of KSA. Hazard quotient (HQ) was calculated to determine the carcinogenic effects of BTX on human being who are living nearby fuel stations.

Sampling and measurements

The stratified random sampling was used for the selection of fuel stations. BTX concentration levels were measured using a standard calibrated instrument. MIRAN SapphIRe portable ambient analyzer was used for measuring BTX.[18]

Data analysis was done on SPSS software. Results were presented in frequency tables. Descriptive statics, independent comparison *t*-test, correlation, and graphical presentation were used for data presentation. A HQ was calculated, which is the indicator of health hazard to the community. A value of HQ ≥1 indicates the risk of carcinogenic probability, and value <1 indicates the safe level.[19]

Results

The concentration of BTX was found in city 1 as following: benzene concentration was 10.3 (benzene TLV 0.5 ppm) p-0.791, toluene 4.09 (toluene TLV 20 ppm) p-0.001, and xylene 2.47 (Xylene TLV 100 ppm) p-0.006, respectively. The means values of measured BTX in fuel petrol stations in City 2 were found as following: benzene concentration was 11.07 (1.9 ppm) and xylene 3.97 (1.1 ppm), respectively. Both toluene and xylene were within the normal TLV, but benzene found excessive allowed TLV in both cities; significant differences were found between the levels of toluene and xylene among the fuel petrol stations in city 1 comparison with city 2 fuel stations. However, there are no significant differences in the levels of benzene in both cities [Table 1].

Table 2 shows the mean levels of BTX concentration from petrol stations located at the residential area (8.0 ppm), side streets (12.2 ppm), and direct street (11.5 ppm) in city 1. Benzene concentrations in all sites were found to be exceeding the TLV (0.5 ppm), while mean concentrations of toluene and xylene were within the TLV (20 and 100 ppm, respectively) in all selected sites.

Table 3 shows the mean level of the BTX concentration from the petrol stations located at the residential areas, side streets, and direct streets in city 2. Benzene concentrations in all sites were found to be exceeding the TLV (0.5 ppm), while the mean concentrations of toluene and xylene were within the TLV (20 and 100 ppm, respectively) in all the selected sites.

Table 4 shows the mean difference of the BTX concentration among different sites, and *P* value shows that difference was statistically significant.

Table 5 shows the HQ for BTX among different sites; HQ values show that there is a risk of carcinogenic effect to the nearby communities who are living near to fuel stations.

Discussion

The results of the present study show that the BTX concentrations in both cities were at high levels in air at petroleum stations. All mean values of the measured BTX in fuel petroleum stations in both cities are shown that benzene exceeds the limits of air quality criteria. Although both toluene and xylene were within the normal limits

Table 1: The concentration of common pollutants in fuel stations

Concentration	**TLV	City 1		City 2		*P**
		Mean	Range (Min.-Max.)	Mean	Range (Min.-Max.)	
Benzene (ppm)	0.5 ppm	10.3	0.25-21.63	11.0	0.83-25.05	0.791
Toluene (ppm)	20 ppm	04.0	0.48-19.20	01.7	0.26-04.6	0.001*
Xylene (ppm)	100 ppm	02.4	0.61-06.88	03.9	0.50-11.83	0.006*

**(Threshold Limit Value) independent sample *t*-test; *P<0.01

Table 2: The concentration of common pollutants in different sites adjacent to fuel stations in city 1

Sites near to fuel station	Benzene TLV ppm 0.5 ppm			Toluene TLV ppm 20 ppm			Xylene TLV ppm 100 ppm		
	Mean ppm	Max. ppm	Min. ppm	Mean ppm	Max. ppm	Min. ppm	Mean ppm	Max. ppm	Min. ppm
Residential *n*=8	8.0	10.40	05.60	2.5	03.61	01.40	2.0	02.80	01.20
Site street *n*=10	12.2	18.99	11.91	5.9	13.64	02.22	2.1	04.35	00.20
Direct street *n*=6	11.5	13.80	09.20	3.3	04.77	01.46	2.7	02.83	02.10

*TLV=Threshold limit value

Table 3: The concentration of common pollutants in all sites of near to fuel stations in city 2

Sites near to fuel station	Benzene TLV ppm 0.5 ppm			Toluene TLV ppm 20 ppm			Xylene TLV ppm 100 ppm		
	Mean ppm	Max. ppm	Min. ppm	Mean ppm	Max. ppm	Min. ppm	Mean ppm	Max. ppm	Min. ppm
Residential *n*=4	8.0	10.40	05.60	2.5	03.61	01.40	2.0	02.80	01.20
Side street *n*=5	12.2	18.99	11.91	5.9	13.64	02.22	2.1	04.35	00.20
Direct street *n*=7	11.5	13.80	09.20	3.3	04.77	01.46	2.7	02.83	02.10

Table 4: Concentration of benzene, toluene, and xylene (BTEX) in different areas of fuel stations at city 2

Areas	*t*-test	Mean difference	*P*
Residential, side street and direct street	8.13	10.56	0.05

*Independent sample test

Table 5: The hazard quotient (HQ) for benzene, toluene, and xylenes

Areas	Benzene	Toluene	Xylenes
Residential	1.76	10.48	11.75
Side street	2.34	12.77	11.89
Direct street	3.45	13.87	12.23

An HQ >1 is considered an adverse carcinogenic effect of concern.

of air quality criteria, significant differences were found between the levels of toluene and xylene among fuel petrol stations. HQ found that there is risk of probability of cancers to nearby living population.

These findings are in accordance with many recent studies that revealed that apart from the increasing vehicular traffic, another major cause of worry are unacceptably high air quality concentrations of BTX in and around refueling stations. Petroleum stations are the primary man-made releases of BTX compounds in both cities and are in accordance with different recent similar studies.[19]

These findings also highlight the increased potential toxins and carcinogens to which the people in the eastern province are exposed to; toxic compounds of fuel such as BTX and its alkyl derivatives are harmful for human health because of their toxic, mutagenic, or carcinogenic properties; the same results were produced by the previous study.[20]

Although BTX concentrations between the residential area and the side street and/or direct streets were different as reported, the highest levels were found in the side street and/or direct street, where the petroleum station located and higher traffic were increased. The relationships between the overall concentrations of pollutants and traffic volume were found to be a co factor for elevated values for pollutants in fuel petrol stations in both cities. The results of similar studies[21] indicated that the levels of BTX and air pollution gases may also be affected from the atmospheric condition, the traffic density, and different activity in gas stations. In the case of gasoline, pollutants are the chemicals of the greatest concern because of their toxicity and carcinogenic activity.

The allowed levels of these compounds in the atmosphere for BTX are 0.5, 50, 100, and 100 ppm, respectively. The National Institute for Occupational Safety and Health (NIOSH) issued guidelines for BTX are 0.1, 100, 100, and100 ppm, respectively.[22] The only significant differences in pollutant concentration levels between side street and residential area were found in the levels of benzene and toluene. These findings are in accordance with recent studies which revealed that apart from the increasing vehicular traffic, the another major cause of worry is unacceptably high concentrations of air quality gases and pollutants in and around refueling stations. Our study finding are consistent with previous studies finding which revealed that apart from the increasing vehicular traffic, the another major cause of worry is unacceptably high concentrations of air quality gases and pollutants in and around refueling stations.[23,24]

The presence of pollutants in the fuel/gas products are highly risky for human health, specifically benzene compounds.[25] Their concentration should be at normal level as recommended by international agencies. The results of this study found that benzene concentrations present in the fuel/gas products are above the normal level; it is recommended that the level should be normal level to prevent the health hazards of human body.[26]

Conclusions

There are high level of common pollutant BTX find in fuel stations, residential area near to fuel station, and adjoining traffic streets. The population living nearby the station and workers working in the station are the affected population of carcinogenic effect of these toxic compounds. Therefore, effective intervention is needed to prevent harmful health effects.

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Conflicts of interest

There are no conflicts of interest.

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