

# Occupational Exposure of Petroleum Depot Workers to BTEX Compounds

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## Abstract

**Background:** Benzene, toluene, ethylbenzene and xylene (BTEX) are the most important toxic volatile compounds in the air and could be easily absorbed through the respiratory tract. In recent years, the risk of exposure to BTEX compounds, especially benzene as a carcinogen, has been considered in petroleum depot stations.

**Objective:** To assess the occupational exposure of petroleum depot workers in Iran to BTEX compounds.

**Methods:** After completing a questionnaire and assessing occupational exposure to BTEX compounds, 78 (46 exposed and 32 non-exposed) depot workers were randomly selected to participate in this study. Air sampling and analysis of BTEX was conducted according to the NIOSH method No. 1501. Analysis of urinary hippuric acid, as an indicator of toluene exposure, was carried out according to NIOSH method No. 8300. Personal monitoring of the high exposure group to BTEX compounds was repeated to verify the results obtained in the first phase of the monitoring.

**Results:** Among the 9 operating groups studied, occupational exposure to benzene and toluene was higher in quality control and gasoline loading operators—the median exposure ranged from 0.16 to 1.63 ppm for benzene and 0.2 to 2.72 ppm for toluene. Median exposure of other group members to BTEX compounds was below the detection limit of analytical method (0.07, 0.06, 0.05, and 0.05 ppm, respectively). The level of toluene exposure measured showed correlation with neither post-shift urinary hippuric acid (Spearman's  $\rho=0.128$ ,  $p=0.982$ ) nor with the difference between post- and pre-shift urinary hippuric acid (Spearman's  $\rho=0.089$ ,  $p=0.847$ ) in depot operational workers.

**Conclusion:** Gasoline loading operators are exposed to a relatively high level of benzene.

**Keywords:** Benzene; Toluene; Ethylbenzene; Xylene; Hippuric acid; Occupational exposure; Petroleum; Worker

## Introduction

Petroleum products consist of hundreds of short-chain organic compounds, light-chain volatile compounds, and heavy-chain hydrocarbons. Despite the variety of petroleum products, only few compounds are designated

as toxic compounds to man. Toxic petroleum products are mainly light-chain volatile aromatic compounds such as benzene, toluene, ethylbenzene and xylene, a group of compounds the so-called BTEX.<sup>1</sup> These compounds are all strong neurotoxic and irritant—benzene and ethylbenzene are classified as group 1 and 2b car-

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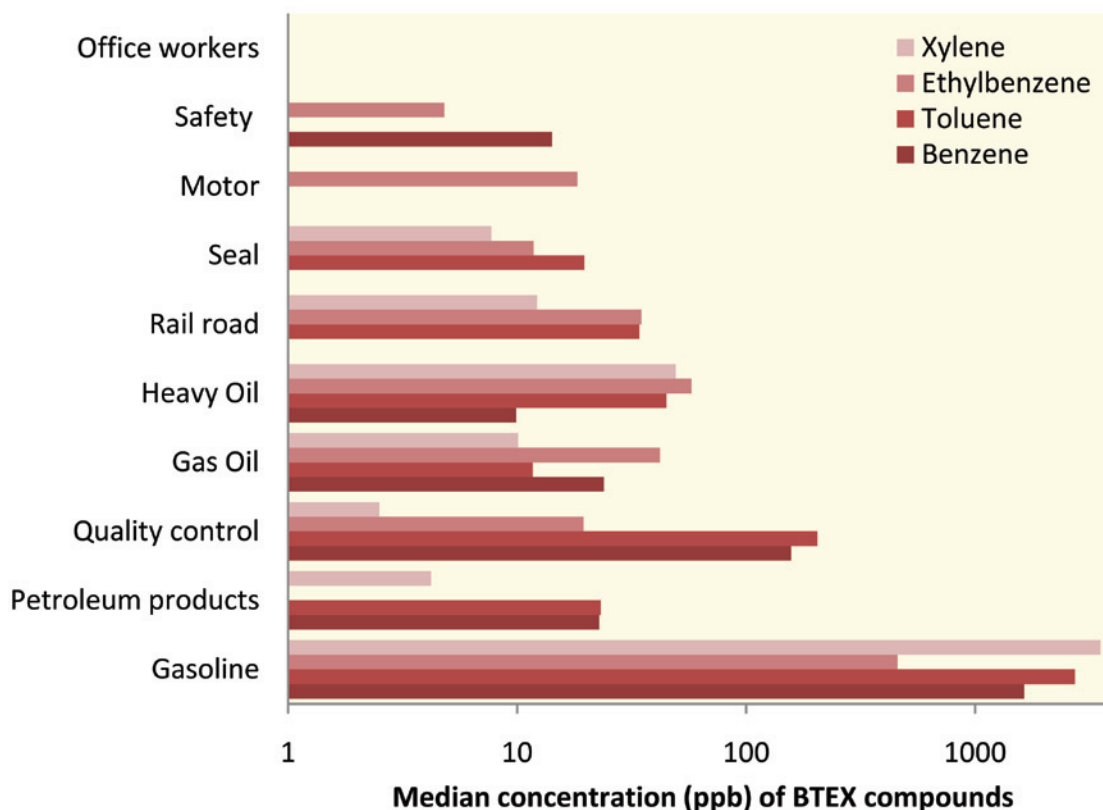


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**Figure 1:** Median exposure of operational groups and office workers to BTEX compounds. Note that the horizontal axis has a logarithmic scale.

cinogens according to IARC.<sup>2</sup>

A wide range of harmful effects of exposure to BTEX compounds have been reported. Those included cancer and a number of chronic disorders such as aplastic anemia and pancytopenia; lung problems such as shortness of breath and upper respiratory irritation; conjunctivitis; neurological disturbances such as blurred vision; and increased rate of leukemia and lung cancer.<sup>3-6</sup>

Various workers such as fuel depot workers, are exposed to high concentration of volatile compounds. Several studies were conducted on this group of workers for the possibility of exposure to volatile organic compounds.<sup>7</sup> A recent dissertation showed a significant toluene

exposure in workers engaged in gas filling operation working in Tehran gas stations.<sup>8</sup>

Biological monitoring is a more accurate way for evaluation of occupational exposure to volatile organic compounds such as toluene.<sup>9</sup> Biological monitoring, however, possesses inter-individual differences due to variable absorption, metabolism, excretion and biological availability of chemicals in exposed doses<sup>10</sup> and is normally evaluated against a standard named biological exposure index (BEI).<sup>11</sup> Up to 75% of the inhaled toluene in humans is metabolized to hippuric acid and excreted to urine.<sup>12</sup> Biological monitoring of occupational exposure to toluene could be done by measuring urinary o-cerosol

**Table 1:** Operational and office exposures (ppm) to BTEX expressed as median (IQR)

Task of operators	n	Benzene TLV=0.5 ppm	Toluene TLV=20 ppm	Ethylbenzene TLV=100 ppm	Xylene TLV=100 ppm
Gasoline loading	6	1.63 (3.92)	2.72 (19.33)	0.46 (1.61)	3.53 (10.84)
Petroleum products	5	<DL (0.24)	<DL (0.18)	<DL (0.55)	<DL (<DL)
Quality control	5	0.16 (3.18)	0.20 (1.86)	<DL (0.10)	<DL (1.04)
Gas Oil	7	<DL (0.39)	<DL (0.11)	<DL (0.17)	<DL (0.44)
Heavy Oil	5	<DL (<DL)	<DL (0.18)	<DL (0.15)	<DL (0.35)
Rail road	5	<DL (0.50)	<DL (2.71)	<DL (0.38)	<DL (2.57)
Seal	6	<DL (<DL)	<DL (<DL)	<DL (<DL)	<DL (<DL)
Motor	3	<DL (<DL)	<DL (<DL)	<DL (<DL)	<DL (<DL)
Safety supervisor	4	<DL (<DL)	<DL (<DL)	<DL (<DL)	<DL (<DL)
Office workers	32	<DL (<DL)	<DL (<DL)	<DL (<DL)	<DL (<DL)

DL: Detection limit

Detection limits for BTEX compounds are 0.07, 0.06, 0.05 and 0.05 ppm, respectively.

and blood toluene.<sup>13</sup> However, some experts prefer urinary hippuric acid to other biomarkers of toluene for measurement purposes.<sup>14</sup> This study was conducted to assess the occupational exposure of petroleum depot workers in Iran to BTEX compounds.

### Materials and Methods

We studied 87 workers—46 fuel depot operational workers and 32 office workers. At the time of study, all workers were working in a depot station with and without direct exposure to BTEX compounds. Demographic data consisting of nutritional habits, smoking, drug consumption and use of personal protective equipment were obtained by a questionnaire

at the beginning of the study. All similar exposed groups and control groups were verbally informed of personal and biological monitoring prior to the start of the study (Table 1).

All similar exposed groups and office workers were personally monitored for BTEX compounds. Personal samplings were taken by activated charcoal tubes mounted in the breathing zone of workers; the breathing air was drawn through activated charcoal, desorbed by carbon disulfide and analyzed using gas chromatography with flame ionization detector according to NIOSH method No. 1501. The detection limit of BTEX analysis was computed according to the respective peaks three times bigger than noise peaks in chromatogram.<sup>15</sup> All workers exposed

above the threshold limit value (TLV) were monitored for a second time to verify the accuracy of the demonstrated level of exposure.

Pre- and post-shift urine samples were collected from fuel depot operational workers and office workers for biological monitoring of toluene exposure. Samples were analyzed for hippuric acid according to NIOSH Method No. 8300.<sup>16</sup> Urinary creatinine was also measured according to the method developed by Azari, *et al.*<sup>17</sup>

Normally distributed continuous variables were presented as mean±SD and analyzed by parametric statistical methods. Continuous variables not normally distributed, were presented as median (interquartile range [IQR]) and analyzed by non-parametric statistical methods. Normality of variables was tested by one-sample Kolmogorov-Smirnov test.

## Results

Neither BTEX compounds concentrations measured in air samples nor hippuric acid levels measured in urine samples had normal distribution. The level of exposure in office workers to BTEX was significantly ( $p < 0.05$ ) lower than fuel depot operational workers. Among the nine operational groups studied, exposure of quality control and gasoline loading operators were higher than other groups; the median exposure ranged from 0.16 to 1.63 ppm for benzene and 0.2 to 2.72 ppm for toluene (Table 1). Generally, 17% of fuel depot operational workers were exposed to a benzene level higher than the threshold limit value (TLV-TWA) of 0.71 to 6.87 ppm.<sup>13</sup> These workers were monitored again; their exposure in the second round of measurements ranged from 0.13 to 8.51 ppm, which were not significantly different from the first measurements ( $p = 0.686$ ).

Occupational exposures of the most

fuel depot operational workers other than gasoline loading and quality control operators were below the detection limits for BTEX compounds in magnitude of 0.07, 0.06, 0.05 and 0.05 ppm, respectively (Table 1).

The post-shift urinary hippuric acid level was significantly different from the pre-shift level in neither depot operational workers ( $p = 0.397$ ) nor office workers ( $p = 0.155$ ). The level of toluene exposure measured showed correlation with neither post-shift urinary hippuric acid (Spearman's  $\rho = 0.128$ ,  $p = 0.982$ ) nor with the difference between post- and pre-shift urinary hippuric acid (Spearman's  $\rho = 0.089$ ,  $p = 0.847$ ) in depot operational workers.

## Discussion

Contrary to the results obtained in a dissertation on exposure of Tehran gas station personnel to volatile organic compounds which revealed a significant occupational exposure to toluene compound,<sup>8</sup> we found that occupational exposure of fuel depot workers to toluene was below the TLV of 20 ppm.<sup>13</sup> Urinary hippuric acid measurements of fuel depot workers, as a biomarker of their exposure to toluene, also reflected their low exposures. Urinary hippuric acid level of operational groups was not significantly higher than that of office workers, which is another reason for the low level of exposure of operational workers to toluene.

We found that benzene was the most important chemical of BTEX compounds so that 17% of fuel depot operational workers—mainly gasoline filling operators—were exposed to a benzene level higher than the TLV of 0.5 ppm.<sup>13</sup> Actually, having known the results of the present study, we should have considered biological monitoring for benzene exposure.<sup>18</sup> As biological monitoring for tolu-

ene exposure in our study showed worker were at low exposure to toluene, it is recommended that more attention be paid to benzene exposure in future studies.

We showed that the exposure to benzene in studied gasoline filling operators was not significantly higher than that in their British counterparts whose median exposure level in early 1970s ranged from 1.1 to 1.3 ppm.<sup>7</sup> Recently, operational depot workers in India were monitored for benzene exposure which found to be in the range of 0.60 to 0.25 ppm.<sup>3</sup> The studied gasoline filling operators in our study, with a median exposure level of 1.63 ppm, had a higher exposure compared to their Indian counterparts.

The studied operational workers in fuel depot who found to have exposure to benzene higher than the TLV were monitored for a second time; the difference between these two readings was not statistically significant reflecting reliability of our measurements.

Generally, occupational exposure of operational groups to toluene, methylbenzene and xylene compounds was not higher than the respective TLVs.<sup>13</sup> This might be due to the composition of petroleum in use which was similar to that a group of operational workers were working with in India.<sup>3</sup> To decrease the exposure level of operational depot workers to benzene, use of the latest technologies for bottom loading of fuel, vapor recovery and pumping are recommended.<sup>19</sup>

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**Conflicts of Interest:** None declared.

## References

1. Todd D, Chessin R, Colman J. Toxicological Profile for Total Petroleum Hydrocarbons (TPH). In: U.S, ed: Health and Human Services Public Health Service Agency for Toxic Substances and Disease Registry, September **1999**.
2. IARC. Some industrial chemicals. Ethylbenzene. IARC Monographs on the evaluation of carcinogenic risks to humans. *World Health Organization, International Agency for Research on Cancer* 2000;**77**.
3. Pandya G, Gavane A, Kondawar V. Assessment of Occupational Exposure to VOCs at the Gantry Gasoline Terminal. *Environ Science Eng* 2006; **48**:175-82.
4. Hopf N, Kirkeleit J, Bratveit M, *et al*. Evaluation of exposure biomarkers in offshore workers exposed to low benzene and toluene concentrations. *Int Arch Occup Environ Health* 2011. DOI: 10.1007/s00420-011-0664-1.
5. ATSDR. Toxicological profile for toluene. 2000. Available from <http://www.atsdr.cdc.gov/toxprofiles/tp56.html> (Accessed November 25, 2011).
6. IRIS. Integrated Risk Information System on Xylenes In: U.S, ed: *Environmental Protection Agency: National Center for Environmental Assessment, Office of Research and Development*, Washington DC, **1999**.
7. Sherwood R. Evaluation of exposure to benzene vapour during loading of petrol. *Brit J Industr Med* 1972;**29**:65-9.
8. Karimian B. [Assessment of occupational exposure to BTEX (benzene, toluene, ethylbenzene and xylenes) in gasoline service stations of Tehran occupational health]. Shahid Beheshti University of Medical Sciences School of Public Health, **2010**. [In Persian]
9. Heinrich-ramm R, Jakubowski M, Heinzow B, *et al*. Biological monitoring for exposure to volatile organic compounds (vocs). *Pure appl. Chem* 2000IUPAC;**72**:385-436.
10. Lauwerys R, Hoet P. *Industrial chemical exposure: guide-lines for biological monitoring*. Boca Raton, Lewis Publishers, London **1993**.
11. Jakubowski M, Ochocka M. Biological monitoring

- of exposure: trends and key developments. *Occup Health* 2005;**47**:22-48.
12. American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the threshold limit values and biologic exposure indices, 7th ed, American Conference of Governmental Industrial Hygienist, **2001**.
  13. American Conference & Governmental Industrial Hygiene (ACGIH), Threshold Limit Values for Chemical Substances in the Work Environment **2010**.
  14. Ukai H, Kawai T, Inoue O, *et al*. Comparative evaluation of biomarkers of occupational exposure to toluene. *Int Arch Occup Environ Health* 2007;**81**:81- 93.
  15. NIOSH. Manual of Analytical Methods (NMAM), Fourth Edition. Hydrocarbons, aromatic: Method 1501. 15 March 2003:2-7. Available from <http://www.cdc.gov/niosh/docs/2003-154/pdfs/1501.pdf> (Accessed November 25, 2011)
  16. NIOSH. Manual of Analytical Methods (NMAM), Fourth ed. Hippuric acid in urine: Method 8300, 15 August **1994**: 2-3.
  17. Azari M, Williams F, Blain P, Edwards J. Potential biomarkers of exposure and effect among glass craftsmen and braziers exposed to nitrogen oxides. *Biomarkers* 1997;**2**:249-354.
  18. Kirkeleit J, Riise T, Bratveit M, *et al*. Biological monitoring of benzene exposure during maintenance work in crude oil cargo tanks. *Chemico-Biological Interactions* 2006;**164**:60- 7.
  19. Bottom Loading and vapour recovery, Loading and unloading of road tankers a Gardner Denver Company (EMCO Wheaton UK LTD).

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