



## Monitoring of benzene, toluene, ethylbenzene and xylene [BTEX] at Taj Mahal, Agra

Vineet Bhardwaj<sup>1</sup>, Ashwin Kumar Mishra<sup>2</sup> and Ashok Kumar<sup>3</sup>

<sup>1,3</sup>*School of Chemical Science, Department of Chemistry,  
St. John's College Agra, Uttar Pradesh (India)*

<sup>2</sup>*Department of Botany, St. John's College, Agra, 282002, Uttar Pradesh (India)*

### ABSTRACT

Due to the rapid industrialization, development in recent decades attract the interest of several researchers towards the problems related to pollution of BTEX in air. In this context, we monitor the BTEX in ambient air around the Taj Mahal in Agra. The objective of this study is to present the levels of BTEX from three locations around the Taj in Agra. BTEX sampling was carried out by using the Respo Rae Ultra VOCs Monitor for four hours at each sampling sites for five times in a month. The BTEX levels were higher in Southern gate location at Taj Mahal and followed by the Western gate and Eastern gate. The annual mean levels of BTEX at three locations were ranged from  $3.6 \mu\text{g}/\text{m}^3 - 16.3 \mu\text{g}/\text{m}^3$ ,  $6.3 \mu\text{g}/\text{m}^3 - 31.1 \mu\text{g}/\text{m}^3$ ,  $1.4 \mu\text{g}/\text{m}^3 - 7.3 \mu\text{g}/\text{m}^3$ , and  $1.1 \mu\text{g}/\text{m}^3 - 5.4 \mu\text{g}/\text{m}^3$  respectively. We found that, in comparison with other studies, our levels of BTEX were quite low. Still, due to the small sample size of the present study, further studies are needed to be carried out at other historical monuments in Agra, which help us to prepare the strategic plan to control the BTEX levels.

**Key words :- Appetite, BTEX, Correction factor, Discharge lamp, Electron volt, Fatigue.**

### I. INTRODUCTION

The beautiful city of Agra witnesses its historical background in the world. There are many historical monuments. Amongst, the Taj Mahal is one of them. Taj Mahal is one of the famous buildings in the world, the mausoleum of Shah Jahan's favorite wife, Mumtaz Mahal. It is one of the new seven wonders of the world and one of the three world heritage sites in Agra. Million's of visitors from each part of the world, come in Agra to visit the Taj Mahal. Therefore, it is necessary to monitor the BTEX at Taj Mahal in Agra.

The rapid industrialization, increasing number of vehicles, construction of buildings, roads and bridges in recent decades have led to serious environmental problems including emission of benzene, toluene, ethylbenzene and xylene into the urban atmosphere of Agra. Benzene, toluene, ethylbenzene and xylene, known as BTEX, are the important volatile organic compounds. These BTEX compounds are emitted into the atmosphere from both artificial and natural sources [1]. The most important sources for outdoor ambient air pollution are evaporation, leaking from underground fuel tanks as a result of poor maintenance, vehicle exhaust emissions, combustions of fossil fuels and evaporative emissions from refueling vehicles and other petroleum products [2]. A significant causes of cancer in human and developing neurological disorders and symptoms such as weakness, loss of appetite, fatigue, confusion and the nausea related to the BTEX [3].

Since, there are no data published on BTEX concentrations in Agra city at Taj Mahal, therefore, it is important to monitor BTEX levels in Agra at Taj Mahal to pursue proper planning and management policies. Hence, the concentrations of benzene, toluene, ethylbenzene and xylene were monitored in ambient air around the Taj Mahal in Agra.

**II. METHODOLOGY**

In this study, three sites around the Taj Mahal in Agra were selected and their ambient air levels were monitored for BTEX compounds. The three selected sites around the Taj Mahal are : Eastern gate, Western gate and Southern gate of the Taj Mahal. Air samples were taken from standing breathing zone of tourists, at 150 cm above the ground level and 100 cm away from the each gate of the Taj Mahal by following the legislation of the Indian Government. All the samples were collected by using Respo Rae 3000 Ultra VOCs Monitor, which is a programmable compound specific photo-ionization detector (PID) and monitor BTEX by utilizing a gas separation tube with 9.8 eV gas discharge lamp[4]. Prior to taking air samples, the instrument calibrated by the isobutylene gas. After calibration, by utilizing the gas separation tube say BTEX, the air samples were collected each selected sites during the November 2008 to October 2009. However, correction factor (CF) have been determined the quantity of BTEX gases in ambient air. The sample size for pre-concentration step was four hours for using the Respo Rae 3000 Ultra VOCs Monitor. Samples were collected for six times in a month, during peak hours at all the selected three locations.

**III. RESULTS AND DISCUSSIONS**

In this study, concentrations of BTEX were measured in ambient air at the three selected locations at Taj Mahal in Agra, during November 2008 to October 2009. Table 1. Summarizes the levels of BTEX measured in ambient air at all the three locations around the Taj Mahal in Agra.

**TABLE -1. Ambient levels of BTEX around the Taj Mahal in Agra during Nov. 2008 to Oct. 2009 (  $\mu\text{g}/\text{m}^3$  )**

NAME OF SITE	Conc ( $\mu\text{g}/\text{m}^3$ )	Benzene	Toluene	Et.benzene	Xylene
1.Eastern Gate	Min.	3.6	6.3	1.4	1.1
	Max.	12.6	22.4	5.3	3.8
	Mean	6.7	12.2	3.1	2.2
2.Western Gate	Min.	4.3	7.9	1.8	1.4
	Max.	14.6	28	6.6	4.8
	Mean	7.9	15.2	3.8	2.6
3. Southern Gate	Min.	4.8	8.9	2.1	1.6
	Max.	16.3	31.1	7.3	5.4
	Mean	8.8	16.9	4.2	2.9



From the Table 1, it was shown that the concentrations of benzene ranged from  $3.6\mu\text{g}/\text{m}^3 - 16.3\mu\text{g}/\text{m}^3$ , for toluene,  $6.3\mu\text{g}/\text{m}^3 - 31.1\mu\text{g}/\text{m}^3$ , for ethylbenzene  $1.4\mu\text{g}/\text{m}^3 - 7.3\mu\text{g}/\text{m}^3$ , and for xylene  $1.1\mu\text{g}/\text{m}^3 - 5.4\mu\text{g}/\text{m}^3$  respectively. Within the BTEX compounds, only toluene concentrations significantly highest at Southern gate of the Taj Mahal and the lowest concentrations of toluene was observed at Eastern gate of Taj Mahal. The levels of BTEX at all the selected locations follow the given trends : **Toluene > Benzene > Ethylbenzene > Xylene**

The highest concentrations of toluene at Southern gate is due to several human activities, vehicle exhaust emissions, combustions of fossil fuels, and the usage of solvent by the handicrafts shopkeepers. The composition of BTEX around the Taj Mahal was shown in table- 2.

**Table- 2. The composition of BTEX around the Taj Mahal [  $\mu\text{g}/\text{m}^3$  ]**

Site	Benzene	Toluene	Ethylbenzene	Xylene	Total
Eastern gate	6.7	12.2	3.1	2.2	24.2
Western gate	7.9	15.2	3.8	2.6	29.5
Southern gate	8.8	16.9	4.2	2.9	32.8
Total	23.4	44.3	11.1	7.7	86.5

From table- 2, it was shown that the toluene has the highest contribution species in the total BTEX compounds. The percentage composition of BTEX are as follows : 27.1 % for benzene, 51.2 % for toluene, 12.8 % for ethylbenzene and 8.9 % for xylene. The monthly mean variation of BTEX were shown in figures 1-3.

**Figure-1. Monthly mean concentrations of BTEX [  $\mu\text{g}/\text{m}^3$  ] at Eastern gate.**

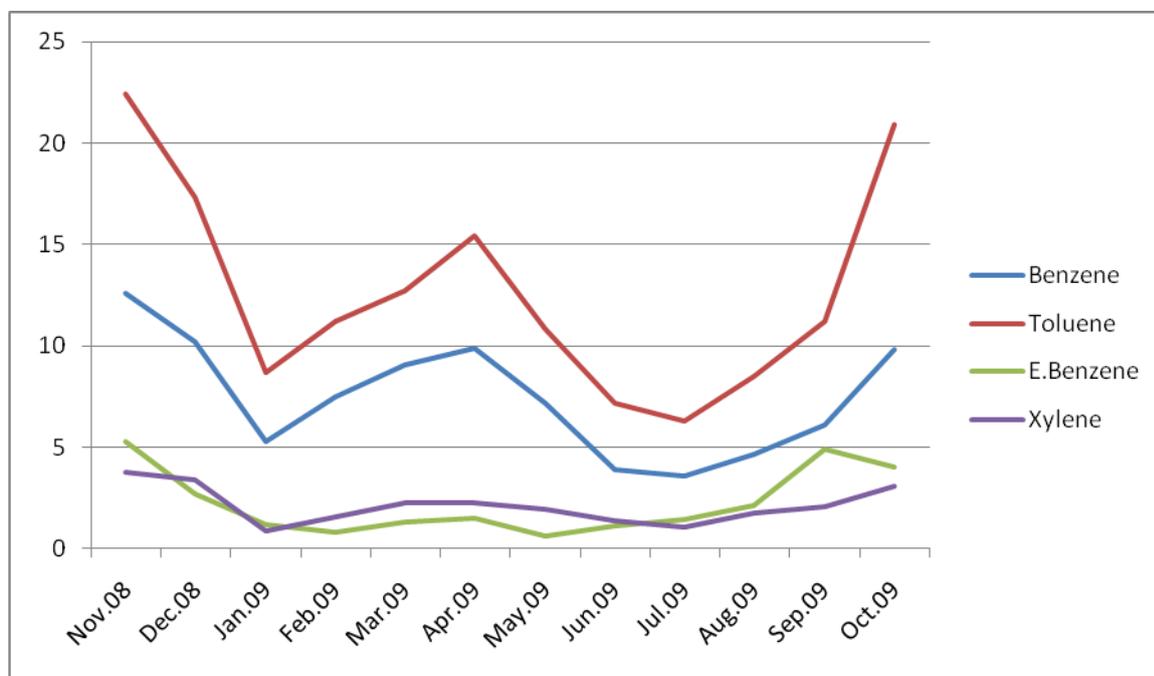




Figure-2. Monthly mean concentrations of BTEX [ $\mu\text{g}/\text{m}^3$ ] at Western gate

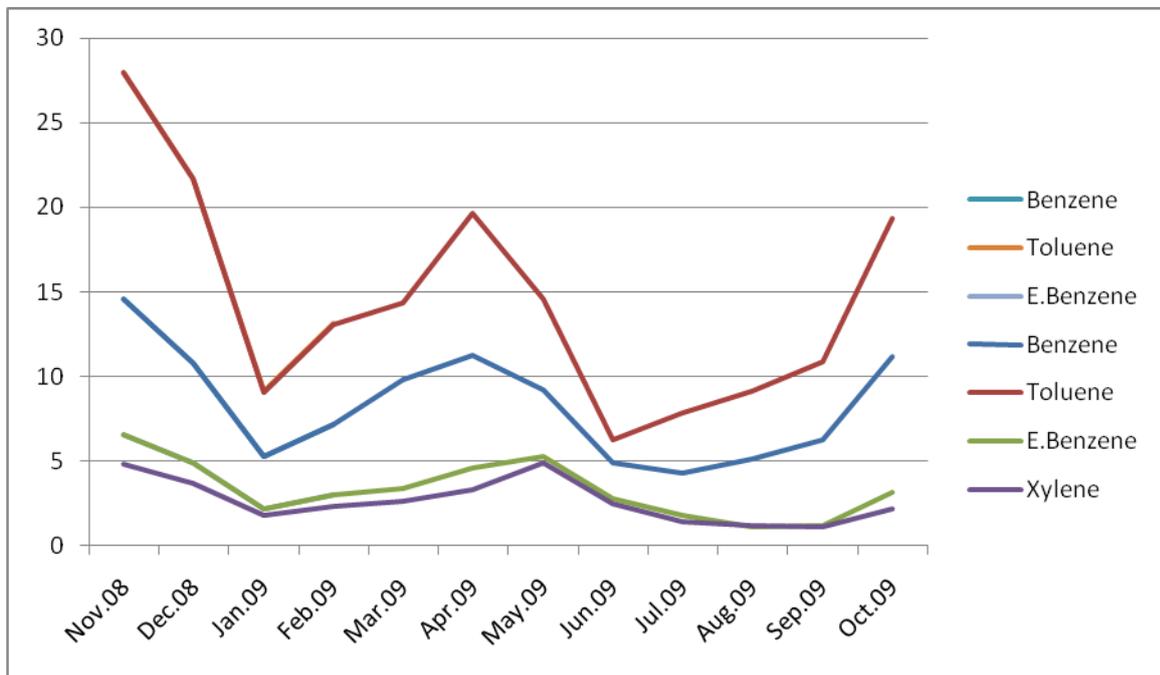
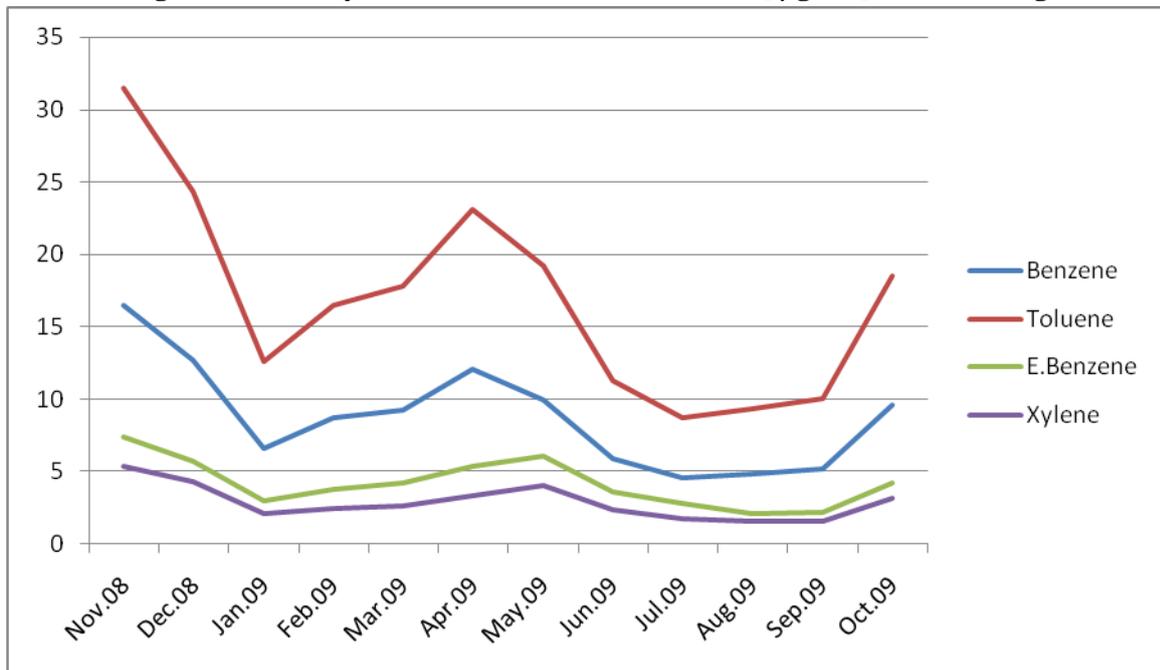


Figure-3. Monthly mean concentrations of BTEX [ $\mu\text{g}/\text{m}^3$ ] at Southern gate.



Figures 1-3, shown that the highest concentrations of BTEX were observed in winter season and lowest concentrations were observed in summer. The seasonal patterns of BTEX as follows : **Winter > Post Monsoon > Monsoon > Summer**. It is due to the higher incremental reactivity of BTEX in summer than winter. On comparing the data with other studies performed in over the world, we found that the BTEX concentrations were much lower than that of studies in several countries of the world [Table-3].

**Table-3. BTEX levels [  $\mu\text{g}/\text{m}^3$  ] reported in ambient air in other countries.**

Country	City	Benzene	Toluene	Ethylbenzene	Xylene	Reference
Thailand	Khartoum	281	736	27	50	[5]
Iran	Tehran	5200	1025	1996	1532	[6]
Brazil	Rio de Janeiro	29.7	47.7	23.3	61.2	[7]
Iran	Ardabil	1932	667	148	340	[8,9]
India	Delhi	48	85	7	15	[10]
GreaterCairo	Haram	58.5	138.6	32.4	99.6	[11]
Africa	Algeries	26.8	63.3	12	46.8	[12]

#### IV. CONCLUSIONS

We have monitored the ambient levels of BTEX at Taj Mahal, in Agra, Uttar Pradesh, India, by using Respo Rae Ultra VOCs Monitor at the three distinct gates of Taj Mahal based on load of tourists, vehicles, and other human activities. In Agra, at Taj Mahal, the mean ambient levels of BTEX were quite low and comparable to other studies done in mega- cities of India and other countries of the world, due to use of petrol and automobiles at busy roads. Other sources and anthropogenic activities, also contributes to an extent to BTEX levels in ambient air. The variations of BTEX ambient air levels were found at all the three entry gates of Taj Mahal viz. Southern gate, Eastern gate and Western gate. The levels of BTEX in ambient air were found to be dependent on the season and metrological parameter such as humidity in air, temperature, speed of winds and the directions of winds too. Sampling sites also were found to be influenced the BTEX levels in ambient air of Taj Mahal in Agra. Thus, we have to need to prepare the strategic plan to control the BTEX levels in ambient air of Agra specially concern with the all historical monument in Agra. This study will attract the interest of several researchers and local agencies which are involve in the studies of air pollution concerns.

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