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# AIR QUALITY STATUS OF BENZENE, TOLUENE, ETHYLBENZENE AND XYLENE IN MUMBAI CITY

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## ABSTRACT

An attempt has been made to determine the levels of Benzene, Toluene, Ethyl benzene and Xylene (BTEX) in air at different locations of Mumbai city. The locations were selected so as to represent five categories viz. residential, commercial, and industrial, traffic intersections and petrol pump. Three locations in each category were selected for monitoring. Levels of BTEX have been determined by using USEPA TO 17 Compendium Method. The result shows high concentrations of benzene at all the locations exceeding the WHO guideline value of 5-20 $\mu g/m^3$.

**Key Words :** BTEX, air quality, Mumbai

## 1. INTRODUCTION

Volatile Organic Compounds(VOC's) are ubiquitous atmospheric species of both natural and anthropogenic sources (Ciccioli et. al. 1993). Some VOC's are themselves toxic having both carcinogenic and non-carcinogenic hazard e.g Benzene, Formaldehyde, while others react in air to form other harmful substances. USEPA study on Air Toxics related to vehicular emission (USEPA 1993) establishes benzene in air as a pollutant strictly related to industrial emissions and automotive emissions. Efforts to reduce lead content of the fuel gasoline and to maintain the octane number has led to increase in benzene and other aromatic hydrocarbons in gasoline.. Benzene content in petrol in different cities of India – Delhi : 1% of the total volume, Mumbai : 3% of total, Ahmedabad : 5% of total, rest of India : 5% of total volume. This paper presents a study of Benzene, Toluene, Xylene and Ethyl benzene in ambient air of Mumbai city during June 2001 to May 2002.Three location each in residential, commercial, industrial, traffic intersection and petrol pumps were selected for monitoring.

Mumbai is located on west coast of India. The population density of Greater Mumbai averages about 16,500 persons per $km^2$. In 2001 the population is over 12 million. Mumbai is India's main industrial city with many air polluting industries located in Chembur, in eastern Mumbai. Municipal and commercial activity is concentrated in the city's southern part. Commuting to and from populated areas to the south, places a large burden on the road system. Traffic flows in Mumbai can be divided into four cordons namely Mid-city, Mid-suburban, Island and Outer cordon. Maximum traffic flow (Annual Average Daily Traffic –AADT) at a road section was about 1,200,000 vehicles per day in 1995. Three suburban surface, electric train systems provide the

main public transportation to 4 million passenger /day. Municipal Corporation owned buses caters to the need of 4.5 million people /day.

## 2. SELECTION OF SAMPLING LOCATIONS

The locations were in each category were selected to as to represent important areas of Mumbai city in southern, northern and central Mumbai (Figure 1). Three locations were selected for residential area one each in south, central and north Mumbai. R1 falls under residential cum commercial area. R2 is a purely residential area adjacent to Mahim Creek R3 residential cum commercial area adjacent to Malad creek. C1, C2 and C3 represent the commercial areas. C1 is a wholesale market in south of the Mumbai city. C2 is in the central part of the Mumbai city. Monitoring was carried out near railway station. C3 is a suburban region in northern Mumbai. Sampling location was selected near a shopping centre, opposite local railway station. In the industrial category, three notified industrial areas I1, I2 and I3 were chosen. I1 is in the western part of Mumbai city. The area has a large number of small scale industries. The traffic of heavy duty vehicles, passenger vehicles and buses is quite high in this area. Sampling location I2, was in front of a main gate of Petroleum refinery. I3 is an industrial area under the Maharashtra Industrial Development Corporation (MIDC). Monitoring was carried out near an industrial site. Traffic intersections, chosen for this study are T1, T2 and T3 these are junctions of multiple roads and number of vehicles that ply up and down direction during peak hours is large. Three petrol pump chosen are P1, P2 and P3. All the three petrol pumps have heavy traffic inflow. Samplings were carried out in the middle of petrol pumps, where vehicles halt for filling petrol.

## 3. MONITORING METHODOLOGY

Ambient air samples were collected on adsorption tubes in accordance with TO-17 compendium method using low volume samplers (USEPA 1999). A battery operated personal air sampler Staplex Model PST – 3000A was used to sample ambient air at the rate of 20 ml/min. All locations were monitored during 8 am to 12 noon and 5 pm to 9 pm once a month. VOCs were thermally desorbed and analyzed on Varian GC-MS. Quantification of VOCs was carried out using VOC Mix 15 of Dr. Erhenstrofer as standard with an accuracy of ±15%.

## 4. RESULTS AND DISCUSSIONS

High levels of benzene have been observed at all the locations monitored. Similar results have been reported earlier (Srivastava, et.al., June 2004). Observed annual concentrations (average of 24 values) of BTEX species at each category viz. residential, commercial, industrial, traffic intersections and petrol pumps is presented in Figure 2. Residential location R3 showed highest concentrations and these may be due to being a residential cum commercial site. Among the commercial areas higher concentrations were observed at C2 and C3 as compared to C1 and residential areas. Heavy traffic in the vicinity of commercial sites contributes to VOC levels.

Concentrations at the industrial sites were higher in terms of benzene as compared to residential and commercial areas whereas, toluene, ethyl benzene and xylene were observed to be in the comparable range. Petrol refinery, small and medium scale industries contribute to VOC concentrations in this category. At a traffic intersection T1and T3, the traffic consists of Taxi, Private Vehicles and Local Buses. At Traffic Intersection T2 along with taxis and Private vehicles, heavy duty vehicles form a major portion of the traffic. Close to traffic intersection T2, there are a large number of repair garages. Degreasing, auto repair, diesel internal combustion, vehicle exhaust and evaporative emissions contribute to ambient VOC levels. There is a truck terminal close to the intersection. Concentrations of toluene observed at traffic intersections were higher than those observed at other locations. Concentrations of BTEX observed at petrol pumps were higher in terms of benzene as compared to other categories. At petrol pumps vehicle exhaust diesel internal combustion and degreasing activities along with evaporative emissions of petrol form the major sources of VOC emissions.

Higher concentrations of benzene observed at traffic intersections and petrol pumps may be attributed to evaporative emissions from fuel tanks of vehicles and spillage at petrol pumps. (Srivastava, et.al., 2004). Table 1 gives a B/T ratio observed at different category of locations. Sweet and Vermette, 1992; Scheff and Wadden, 1993 have related B/T ratio of 0.5 to vehicular exhaust. In the present study B/T ratios have been observed to be higher than 0.5 at all locations.

Table 1. Benzene to Toluene Ratio

| **Category** | **B/T** |
|---|---|
| Residential | 2.5 |
| Commercial | 1.0 |
| Industrial | 1.6 |
| Traffic Intersection | 0.8 |
| Petrol Pump | 10.2 |

It indicates additional source of benzene other than vehicular emissions or long range transport. Life times of benzene, toluene and xylene in tropics have been reported to be 4.8, 0.9 and 0.4 days respectively (Singh and Zimmermon, 1992). Highly reactive species of VOCs react near the vicinity of sources while slow reacting species may be transported over large distances. Toluene has much shorter life time than benzene. So higher B/T ratio is expected to be observed in aged air due to long range transport. In an urban area most BTEX comes from vehicle exhaust, thus B/T can be used to predict whether the pollutants to remote site have influenced the local source via transport. The observed high B/T values can be attributed to both evaporative emissions and long range transport (Srivastava, 2004). Being a coastal city the land and sea winds dilute the effect of long range transport. The wind rose pattern (Figure 3) shows that the winds are predominately from north and north-west. Levels of benzene are above the WHO guideline value of 5-20 $\mu g/m^3$. Levels of toluene, ethyl benzene and xylene were observed to be within the safe levels recommended by

WHO (Toluene -260 μg/$m^3$ –one week average, ethyl benzene – 22,000 –one year average, xylene -870 –one year average).

## 5. CONCLUSIONS

Higher concentrations of benzene have been observed at all the locations. These levels can be attributed to evaporative emissions predominately and to some extent to long range transport. Observed high levels benzene necessitates the need for control of VOCs. In order to control VOC's in air the management strategy should thus focus on cost effective vapour recovery systems at refueling stations and in vehicles. Effective inspection and maintenance programs and measures against tampering and spillage can reduce evaporative and exhaust VOC emissions. Besides this fuel volatility control can be an effective measure to reduce VOC emissions from in use motor vehicle.

## 6. ACKNOWLEDGEMENT

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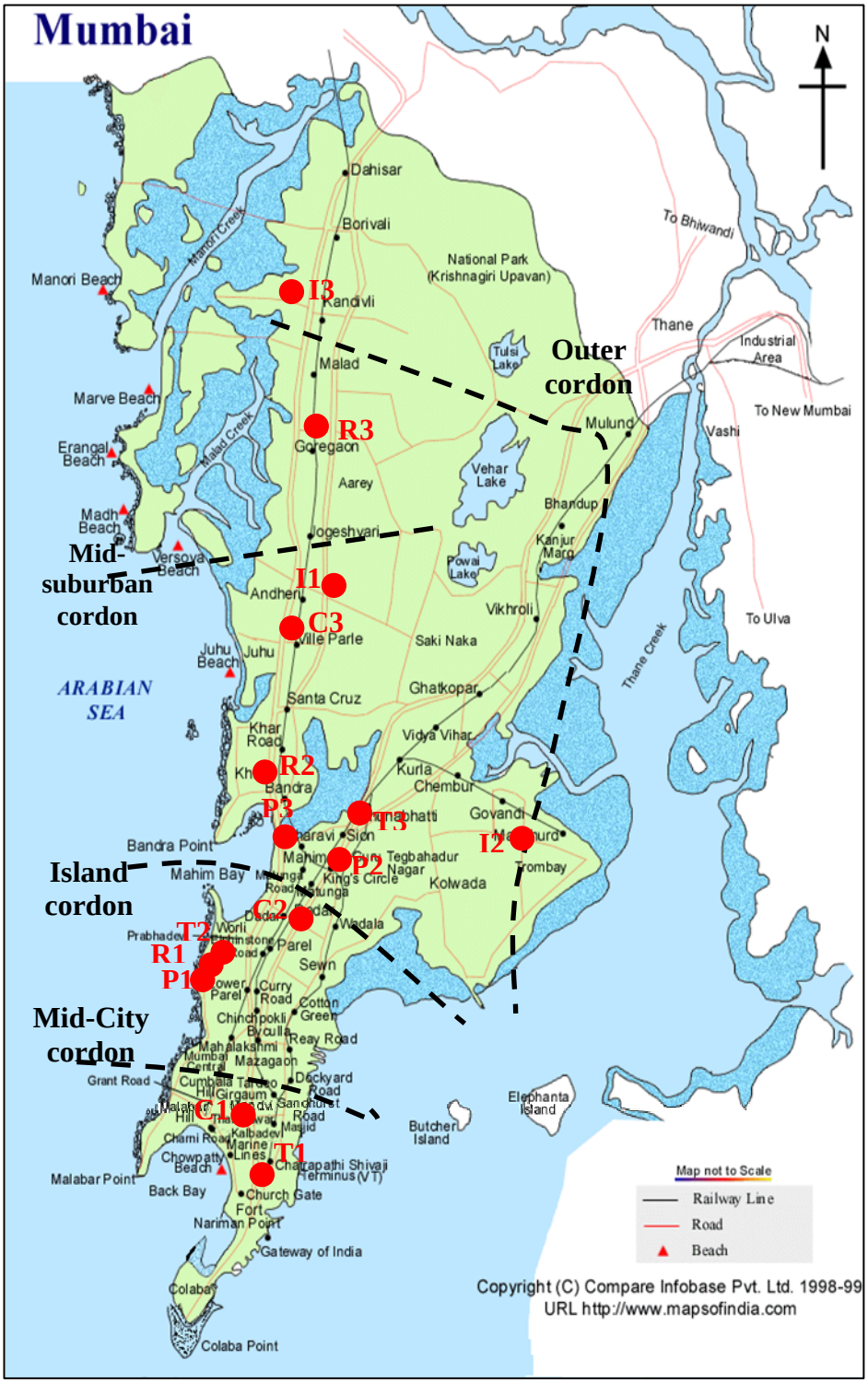


Figure 1. Sampling Locations in Mumbai Metropolitan Region

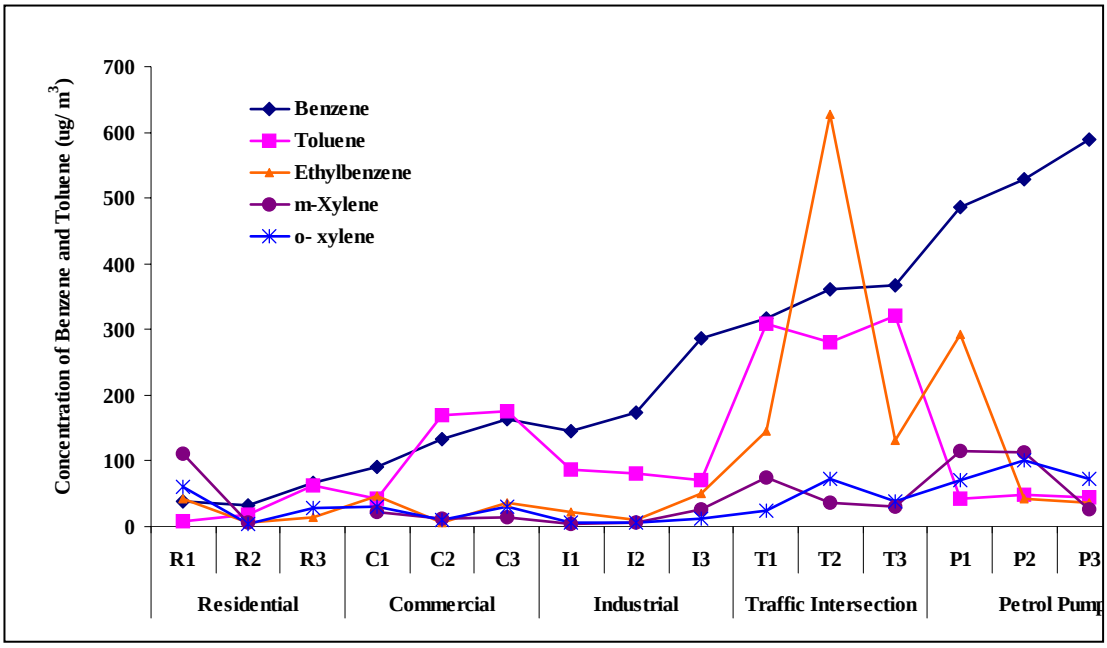


Figure 2. Ambient Concentration of Benzene, Toluene: Ethyl benzene and Xylenes (BTEX)

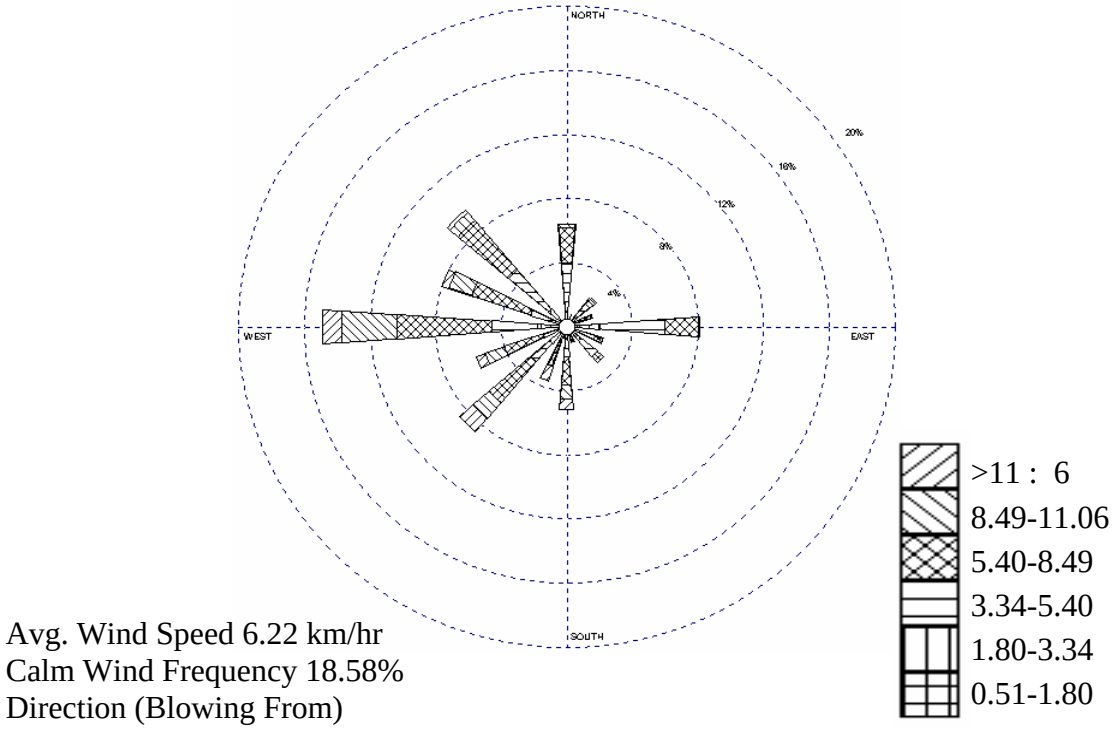


Figure 3. Annual Windrose for Mumbai City