# ESTIMATION OF CANCER RISK BY BENZENE EMITTED FROM VEHICLES

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## ABSTRACT

The estimation of the benzene emission factors from the result of continuous monitoring of benzene and NOX concentration near a main road in Shijonawate City (Japan) in 2003, and the monitoring result of benzene and $NO_2$ concentration near a road in Hanoi City, carried out in December 2003, was reported. To the data in Shijonawate City, the benzene emission factors for gasoline vehicles and diesel cars were estimated to be 12.3 and 13.0mg/km/vehicle, respectively, from the annual average concentration of benzene and NOX, the traffic volume data and NOX emission factors. The monitoring result in Hanoi City showed that the maximum of 1 hour average concentration in the monitoring term had reached to 20 $\mu$ g /$m^3$. Since the correlation between the traffic volume and benzene concentration was low, the emission factors of benzene could not be estimated in this monitoring.

## KEYWORDS

Benzene, emission factor, regression analysis, risk evaluation

## INTRODUCTION

Benzene is a chemical which has carcinogenic and the environmental standard in Japan is determined to be 3 $\mu$ g /$m^3$ in annual average. In Japan, the amount of discharge in 2002 estimated from PRTR data was 19,000 t/year, and it is presumed that 85% of the total benzene was discharged from automobiles or two-wheeled vehicles. Therefore, it is thought that the cancer risk by benzene exposure becomes high to the residents who live near a main road with heavy traffics. The purpose of our joint research project is clarifying the actual condition of the benzene concentration in the atmosphere near a main road with heavy traffics, and evaluating residents' cancer risk in large cities in Japan and in Vietnam.

In the Annual Report of FY2003 of the Program, we reported the monitoring of the benzene concentration near a main road in Ashiya City (Japan) and Hanoi City, and showed that at the monitoring point of both cities the maximum of 1 hour average concentration in the monitoring term had reached to 20 $\mu$ g /$m^3$. Moreover, from the monitoring result of the benzene concentration in Ashiya City, the benzene emission factors for gasoline vehicles and diesel cars were estimated to be 12.2 and 14.4mg/km /vehicle, respectively, and the cancer risk of residents living near the road was estimated through the benzene dispersion calculation using the emission factors. The data used for benzene risk evaluation were meteorological data, geometry of the road space and the buildings near the road, traffic volume, the benzene emission factors, the unit risk of benzene and population distribution. Among these data, the benzene emission factors have uncertainty depending on the traveling condition of vehicles, composition of fuels and the performance of exhaust gas processing equipment. Therefore, in this report we estimated again the benzene emission factors from the benzene concentration data continuously monitored in Shijonawate City by Osaka Prefecture.

Moreover, since the monitoring of this year in Hanoi City is planed to carry out in this October, in this paper, the result in December 2003, which will be included in the Annual Report of FY2003, is presented again.

## ESTIMATION OF BENZENE EMISSION FACTORS FROM VEHICLES

### Shijonawate Air Pollutants Monitoring Station

In Shijonawate City in Osaka Prefecture, Osaka Prefecture is monitoring the 1-hour average value of air pollutants concentration including benzene continuously at the place along a main road. The map and the photo of the monitoring point are shown in Fig. 1 and Fig. 2, respectively. The monitoring point is located in the east side of Route 170, which is one of the trunk roads in Osaka Prefecture. The annual average benzene concentration of this point was 2.9 $\mu$ g /m$^3$ in 2003, and had cleared environmental standard in Japan barely. The time variation of benzene and NOX concentration calculated by averaging the data in 2003 of weekdays when the main wind direction of the day was west, namely in case the monitoring point was the lee of the road, is shown in Fig. 3. Moreover, the typical time variation of the traffic volume of gasoline vehicles and diesel cars, calculated from the time variation of the total traffic volume monitored by Osaka Prefecture and the ratio of gasoline vehicles and diesel cars which we monitored, is shown in Fig. 4.


Fig.1 Map near themonitoring station

Fig.2 Photo near the monitoring station

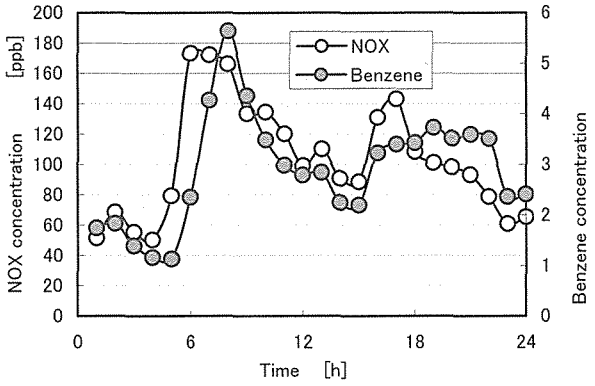


Fig.3 NOX and benzene concentration

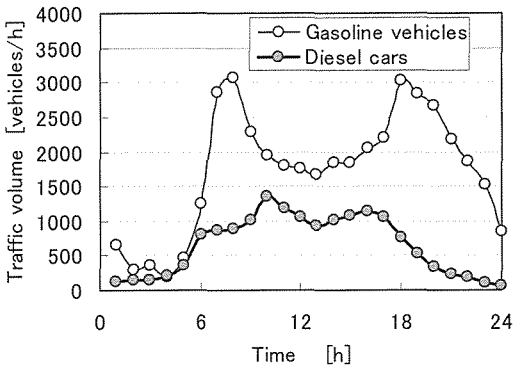


Fig.4 Traffic volume

### Regression Equation to Estimate Benzene Emission Factors

The regression equation given by eq.(1) was applied to estimate the benzene emission factors.

$$(C_B - C_{B0})/(C_N - C_{N0}) = (F_{BG}T_G + F_{BD}T_D)/(F_{NG}T_G + F_{ND}T_D) \quad (1)$$

Here $C_B$ and $C_N$ are measured concentrations of benzene and NOX, respectively. $C_{B0}$ and $C_{N0}$

are the background concentrations due to generation sources other than the vehicles which are running on Rout 170, respectively. $F_{BG}$ and $F_{BD}$ are the benzene emission factors of gasoline vehicles and diesel cars, respectively. $F_{NG}$ and $F_{ND}$ are the NOX emission factors of gasoline vehicles and diesel cars, respectively. $T_G$ and $T_D$ are the traffic volume of gasoline vehicles and diesel cars, respectively. NOX emission factor of 0.08 and 1.78g/km/vehicle for gasoline vehicles and diesel cars were used as an average value in Japan.

**Estimation of Background Concentration**

$C_{B0}$ and $C_{N0}$ were estimated from the relationship between traffic volume and atmospheric concentration. Fig. 5 shows the relation between $C_B$ and $T_G + T_D . C_{B0}$ was assumed to be 1.1 $\mu$ g /m$^3$ as the value of $C_B$ at $T_G + T_D = 0$. Fig. 6 shows the relationship between $C_N$ and estimated NOX emission amount,

$$Q_N = F_{NG} T_G + F_{ND} T_D \tag{2}$$

considering that the emission factor of NOX for gasoline vehicles and diesel cars are different significantly. $C_{N0}$ was assumed to be 58.0ppb as the value of $C_N$ at $Q_N = 0$.

**Estimation of Benzene Emission Factors**

The value of $F_{BG}$ and $F_{BD}$ estimated became to be 12.3 and 13.0mg /km/vehicle, respectively. The correlation $R^2$ of the satisfaction of Eq.(1) was 0.77 as shown in Fig.7. The estimated result of the benzene emission factors in this report became the similar value estimated in Ashiya City.

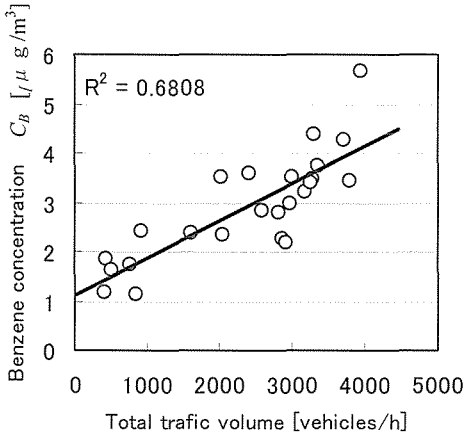


Fig.5 Traffic volume and benzene concentration

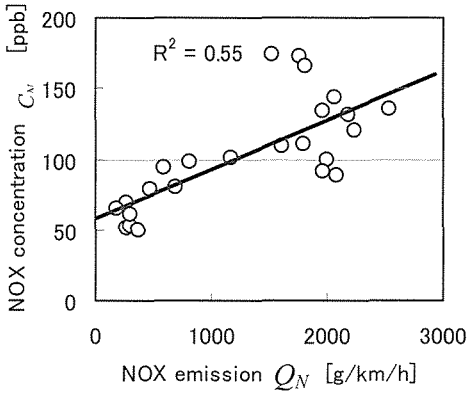


Fig.6 NOX emission and NOX concentration

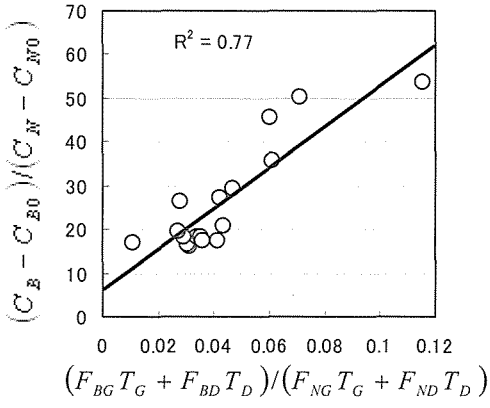


Fig.7 Correlation of regression equation

## BENZENE CONCENTRATION IN HANOI CITY

Benzene concentration was monitored at the Institute of Chemistry, NCST, faced to a road on 2nd and 3rd December 2003. At the same time, $NO_2$ and traffic volume, wind speed and wind direction were also monitored. Benzene in the atmosphere was captured by absorption tubes every 1 hour, and analyzed by GC/MS with the thermal desrober. The situation is shown in Fig.8. The diurnal variations of benzene concentration, $NO_2$ concentration, traffic volume and wind speed are shown in Fig.9. $NO_2$ concentration had two peaks at 9:00 and 17:00. Its level was 60ppb. These peaks corresponded to commuter time and to traffic volume. In Hanoi City, most of the vehicles were bikes. The number of bike traffic volume exceeded 5,000/h. Benzene concentration level became high during daytime (from 9:00 a.m. to 16:00). But its level was decreased to less than 1 $\mu$ g /$m^3$ after 16:00. This variation was not similar to the variation of $NO_2$ concentration and of traffic volume. We cannot find out the obvious reason why the diurnal variation of benzene concentration indicated such behavior. We will measure benzene concentration again to elucidate the reason.

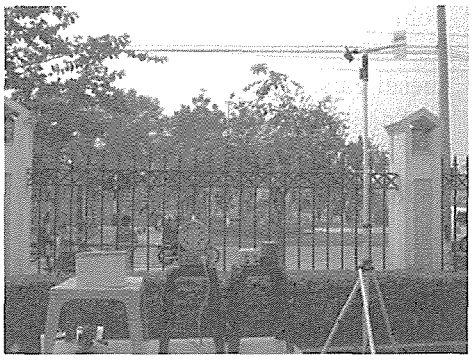

Fig.8 Photo of monitoring point

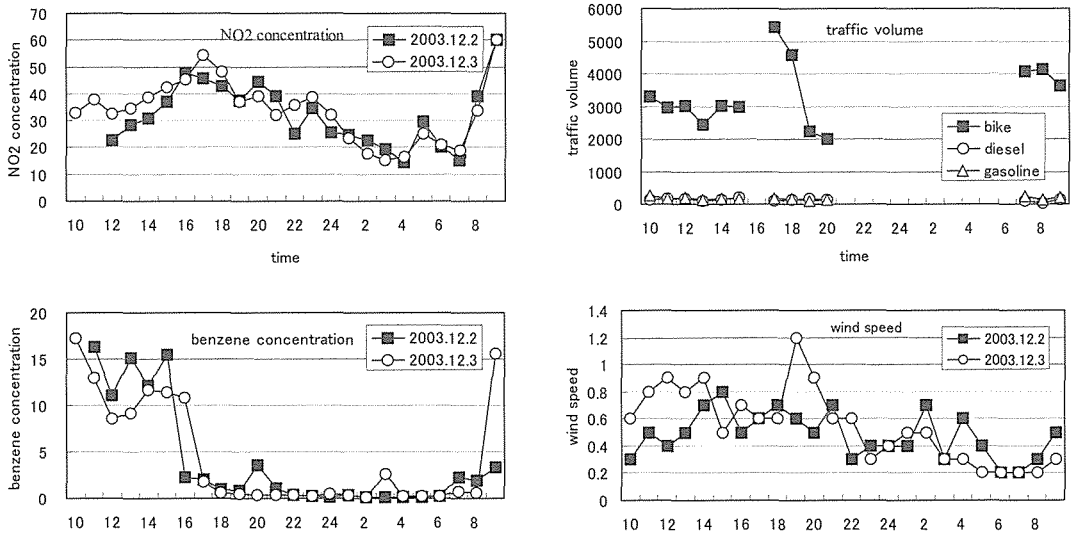


Fig9. The diurnal variations of benzene concentration, $NO_2$ concentration, traffic volume and wind speed

## CONCLUSIONS

The benzene emission factors for gasoline vehicles and diesel cars estimated from the monitoring result near a main road in SHijonawate City were 12.3 and 13.0mg/km /vehicle, respectively. For the monitoring result in Hanoi City, the correlation between traffic volume data and benzene concentration was very low. The additional monitoring will be required besides the inspection of the reason of low correlation.