ASSESSMENT OF BENZENE RISK AROUND ROADSIDE AT ASHIYA CITY, JAPAN

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ABSTRACT

Benzene is a carcinogen and a chemistry substance with many amounts of emission. The main sources are considered to be automobile exhaust gases. Therefore, it is thought that the benzene concentration near the road is high and its amount of exposure of the residents is also large. We measured the benzene concentration at Ashiya City. The distribution of the benzen concentration around the roadside was estimated by the tank experiment and by the numerical simulation with considering building structure, and the number of cancers patients by benzene of 50×10^{-4} / 2000 persons were computed.

KEYWORDS

Benzene, Numerical Simulation, Risk assessment, Water Tank Experiment

INTRODUCTION

The automobile exhaust gas containing carbon dioxide and toxic substances occupies the social interest, and the benzene is especially attracted attention in recent years. Benzene is one of the hazardous atmospheric pollutants with many amounts of emission, and is the carcinogenic chemical substance. Benzene has been added in order to raise the octane number of gasoline. However, since benzene has the toxicity, the permissible value of the amount of benzene addition in the gasoline in Japan has been regulated to less than 5% in 1996 and to less than 1% in 2000. The environmental standard of benzene in Japan is regulated to 3 μ g/m^3, and the unit risk of the benzene of 2.2 - 7.8 $\times$ 10^{-6} m^3/ μ g is reported by U.S. EPA. The threshold value for the carcinogenic chemical substance like benzene does not exist. Therefore, the risk management based on the amount of exposure as well as the regulation of the emission amount will be needed.
In this research, we established the assessment method of benzene risk and estimated the cancers risk by benzene for the residents who live near the national road 43 at Ashiya City, where the benzene concentration is considered to be locally high.

MEASUREMENT OF BENZENE CONCENTRATION

The measurement of benzene concentration was performed at Uchide automatic monitoring station for automobile, which is located at the north side of the national road 43 (see Fig.1). The benzene in the air was captured by the absorption tube every 1 hour. The benzene concentration was analyzed by GC/MS with the thermal desrober. There is the good correlation between benzene concentration and NOx concentration as shown in Fig.2. The correlation coefficient was 0.6 and the ratio of benzene concentration to NOx concentration was 0.0183.

ESTIMATION OF AMOUNT OF BENZENE EMISSION

The ratio of the amount of the benzene emission from automobile to the amount of the NOx emission from automobile was assumed to be equivalent to the ratio of benzene concentration to NOx concentration. Based on this assumption, the amount of the benzene emission from automobile of 41.8g/m/day was estimated from the data of traffic volume, of the emission coefficient for NOx, and of the ratio of benzene concentration to NOx concentration shown in Fig.2.

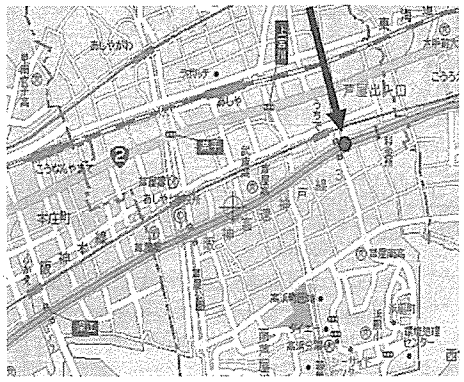


Fig 1 Map of Ashiya City

WATER TANK EXPERIMET AND NUMERICAL SIMULATION

The water tank experiment and the numerical simulation were performed in order to understand the characteristic of the diffusion of the automobile gas near the road. The building configuration near the road was assumed to be approximately two dimensions. The velocity distribution and the concentration distribution in the cross section of the water tank shown in Fig.3 were measured. Simultaneously the numerical simulation was carried out. Both results were compared to verify the accuracy of the numerical simulation. The vertical average velocity in the water tank was 13cm/s and Reynolds number was about 1.2×10^4. Since the flow was fully turbulence, the similarity was thought to be materialized. Four experiments shown in Fig.4 were performed.

PIV system by TIS Co. was used for the measurement of the velocity distribution. The average velocity was calculated by the method of the cross correlation. The velocity patterns for four experiments were shown in Fig.4. The flow has the wake in the front of the building of the upwind side. In the case-4 with the highway road, two vortexes can be seen. The results of the case-1 and the case-4 calculated by k- ε model were shown in Fig.5. The wake and the vortexes seen in the water tank experiment were reproduced by the numerical simulations.

The concentration distributions for four experiments were shown in Fig.6. In all cases, the high concentration can be seen at the upwind side into the road. The concentration at the downwind side was comparatively low. The concentration in the case-4 was the highest because of the bad ventilation by two vortexes. The results of the case-1 and the case-4 calculated by k- ε model were shown in Fig.7. The calculations were reproduced the characteristic of the concentration of the water tank experiment.

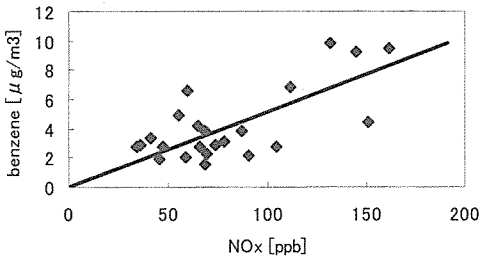


Fig 2 Correlation of benzene concentration and NOx concentration

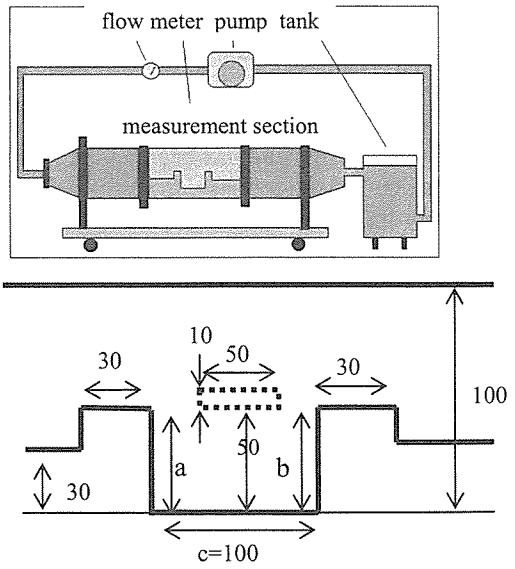
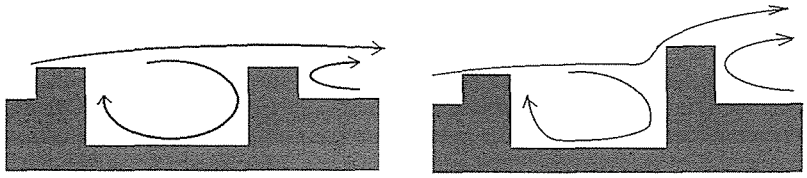
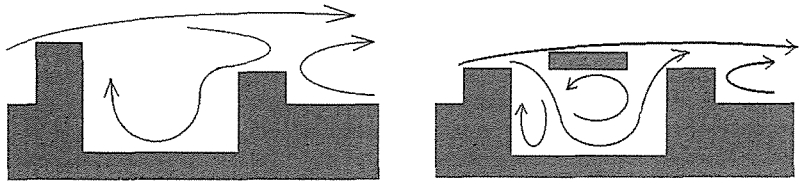


Fig.3 Water tank experiment appratus and cross secsion of measurement

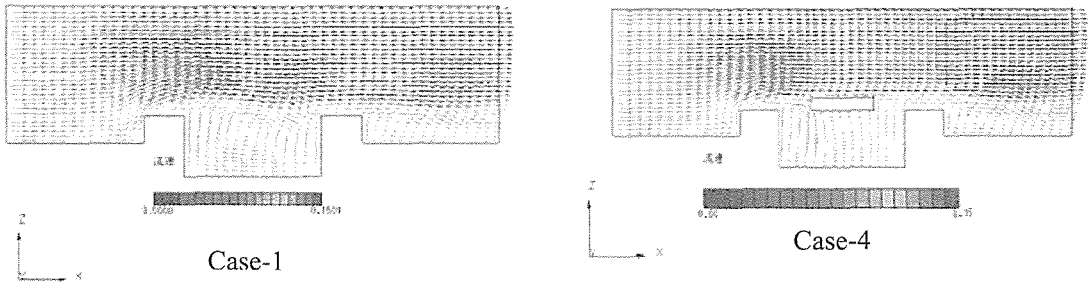


Case-1 Case-2



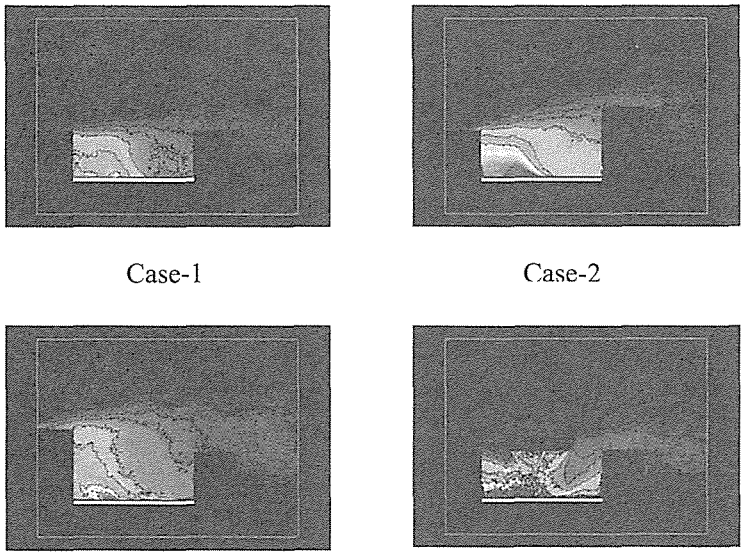
Case-3 Case-4

Fig.4 Flow patterns for four water tank experiments



Case-1 Case-4

Fig.5 Velocity distribution calculated by k- ε model



Case-1 Case-2

Case-3 Case-4

Fig.6 Concentration distributions for four water tank

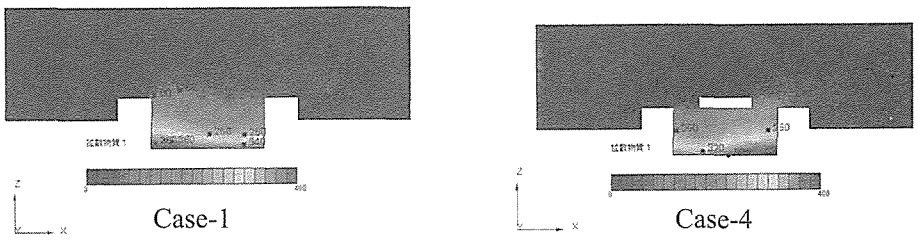


Fig.7 Concentration distributions calculated by k- ε

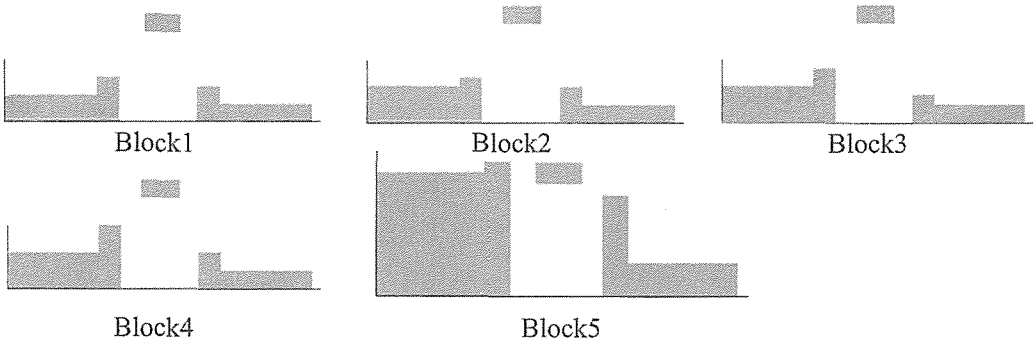


Fig.8 Building configuration each block

Table 1 The number of cancers patients for each block

	Block 1	Block 2	Block 3	Block 4	Block 5	Total
Cancers	5.12×10^{-4}	16.2×10^{-4}	12.9×10^{-4}	8.64×10^{-4}	6.47×10^{-4}	49.3×10^{-4}
Population	323	536	477	353	334	2023

ESTIMATION OF CANCERS RISK BY BENZENE

The region around the national road 43 at Ashiya City was divided into five blocks with the interval of 600m, and the building configuration shown in Fig.8 was extracted by the field investigation. The annual average benzene concentration for each block was calculated by the numerical simulation. The number of cancers patients by benzene was given by

$$R = (\Sigma U \cdot Bi \cdot Pi) / L$$

where R is the number of cancers patients of the target region, $U(=5\times10^{-6}\ m^3/\mu g^3)$ is the unit risk, Bi is benzene concentration at the location i, Pi is the population at location i, and L (=70years) is the average life.

Table 1 showed the number of cancers patients and the population. The number of cancers patients of the target population of 2000 persons was 50×10^{-4}.If the population converts into 100 million persons, the number of cancers patients will become about 250 persons.

CONCLUSIONS

The assessment method of the benzene risk around the road was proposed and was applied to the national road 43 at Ashiya City. It was found that the number of cancers patients of the target population of 2000 persons was 50×10^{-4}. We plan to apply this approach to Hanoi, Vietnam.

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