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A METHOD OF BENZENE EXPPOSURE ESTIMATION CONSIDERING THE INFLUENCE OF THE BUILDI) NG FORM FACED TO MAIN

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ABSTRACT

There are many places, also in Japan, where the benzene concentration in the atmosphere near a main road does not satisfy the environmental standard of Japan. The concentration in Hanoi City is more than ten times higher compared with Japan. Since one of the main emission sources of benzene is considered to be automobiles, a technique of the gas dispersion calculation taking into consideration the form of the buildings which faced the road together with the data of traffic volume and emission factors for the evaluation of exposure. In this paper, an example of the technique is proposed and the result applied to Osaka-City is shown.

KEYWORDS

Benzene, automobile exhaust gas, exposure evaluation, dispersion model, road space, k-ε model, Gaussian model, Osaka-City, evaluation

INTRODUCTION

There are many places, also in Japan, where the benzene concentration in the atmosphere near a main road does not satisfy the environmental standard of Japan. According to the monitoring result executed by P.H.Viet et al, the concentration near main roads in Hanoi City is more than ten times higher compared with Japan. Since the environmental concentration of benzene near a road originating in automobile exhaust gas is influenced of the geometrical form of a road and its circumference, a simple model (for example, flat field and a line source) which disregards it cannot estimate the concentration adequately. On the other hand, the evaluation which modeled the geometrical form of a road and its circumference correctly is possible only after pinpointing a place, and it is difficult to carry out such detailed evaluation over a wide area. In this paper, an example of a technique to performs the evaluation of environmental benzene concentration over a wide area taking into consideration the geometrical form of a road and its circumference approximately was proposed. By this technique, exposure concentration and health risk evaluation in a wide area are attained, and the places where monitoring and detailed evaluation of the environment is required can be pinpointed

SIMPLIFIED GEOMETRY OF A ROAD

The geometry near a road was simplified as shown in fig. 1. Here, H is the average building height of a block of buildings, W is road width and D is the average gap between blocks which contain narrow lanes and open spaces. It was verified by comparison with the calculation result of a detailed geometric model that the mean concentration in a road space does not differ greatly by such a

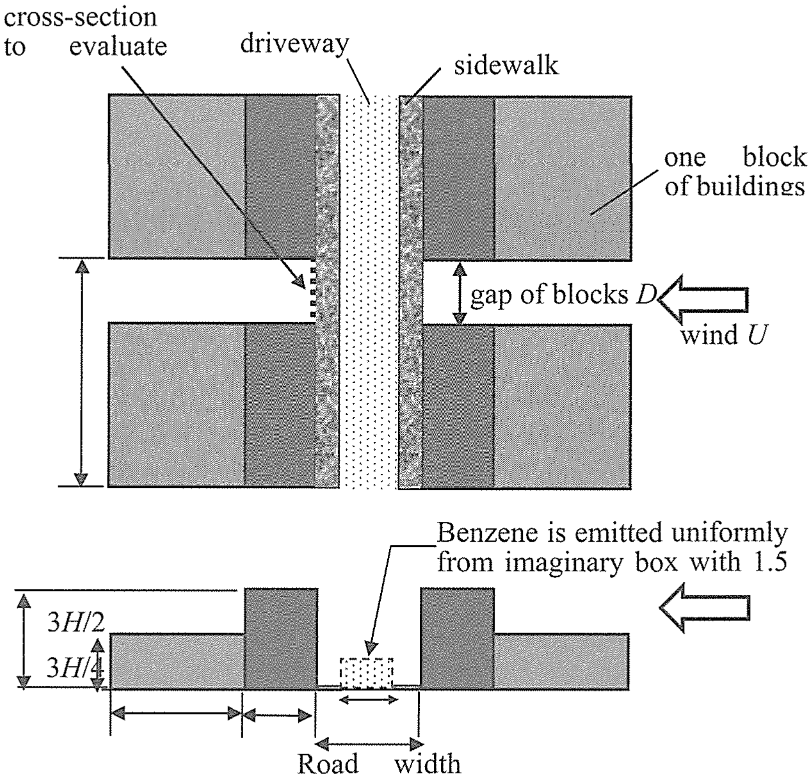

Figure 1 Simplified geometry of a road space

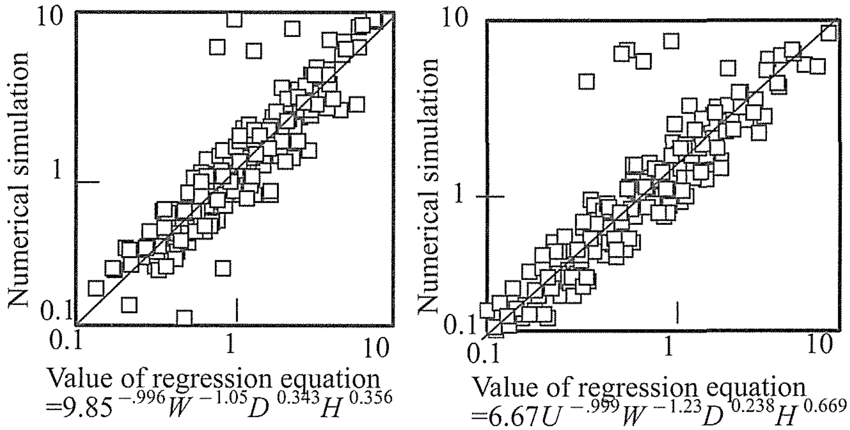

Figure 2 Accuracy of the approximation equations

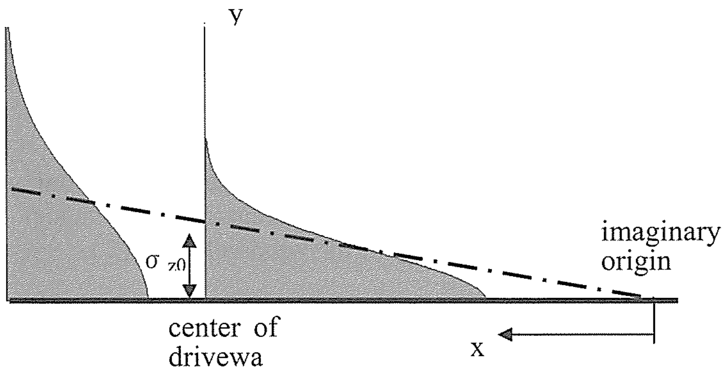

Figure 3 Concentration decrease in a gap is approximated by a line source

simplification [1]. The average Benzene concentration at a height of 1.5m in the centre of downwind and upwind sidewalk and the flux of Benzene which flows into the gap between blocks, in case unit amount Benzene is emitted on the driveway, was approximated by the following equation, as a function of geometric form and wind velocity, and the coefficients, were determined from 200 cases of numerical simulation results using the *k*-ε turbulent flow model.

$$(\textit{concentration on the sidewalk or flux}) = aU^{m1} W^{m2} D^{m3} H^{m4} \tag{1}$$

Examples of the accuracy of the approximation equation are shown in fig. 2.
The Benzene concentration in the gap between blocks was approximated by the following Gaussian dispersion model from a line source (fig.3).

$$C(x,z) = \frac{1}{\sqrt{\pi/2}} \frac{q}{U\sigma_z} \exp\left\{-\frac{z_0}{2\sigma_z^2}\right\} \tag{2}$$

Here, q (μg /ms) is the strength of the line source estimated from the Benzene flux between blocks, Z_0 is the height of 1.5m, and σ_z is the diffusion width of the z-direction, and was given by Pasquill-Gifford Chart. σ_z at the centre of a driveway, σ_{z0}, was assumed to be 1 m (fig.1).

APPLICATION TO OSAKA-CITY

After preparing procedures above mentioned, the Benzene concentration of Osaka-City whole region was evaluated. One hundred eighty four roads are taken up as trunk roads and shown in Fig. 4. To these roads, traffic volume has been measured by day and night, and by weekday and weekend. Moreover, in Osaka-City, the statistic data of total floor area, building area and road area are prepared for every 500m × 500m mesh. Here, those data is used to presume mean building height H and mean gap D for 36×40 meshes by the following equation.

$$(\text{mean building height } H) = (\text{total floor area / building area}) \times 3\text{m} \tag{3}$$

$$(\text{mean gap } D) = (\text{mesh area} - \text{building area} - \text{trunk road area}) / 10 \tag{4}$$

Factor 10 is derived by the assumption that the length of one block along a main road is 50 m and

therefore 10 gaps exist in a mesh.
On the other hand, the annual wind data was analyzed to calculate the wind velocity distribution by the windward and the lee depending on the road direction, and the annual average benzene concentration by the emission from automobiles running on each road was calculated by the following formula.

$$\begin{aligned}(\text{sidewalk concentration}) = \Sigma\ &(\text{concentration at wind velocity } W\text{i by unit amount of emission})\\ &\times(\text{traffic volume}) \times(\text{benzene emission factor})\\ &\times(\text{frequency of the wind velocity } W\text{i}) \qquad (5)\end{aligned}$$

The benzene concentration in a gap between blocks was also calculated with similar way.

Figure 4 Main roads in Osaka-City

An example of a calculated result is shown in Fig. 5. Figure 5 expressed the annual average benzene concentration of the central part in Osaka-City in the daytime of weekdays with the resolution of 1 pixel/(10m×10m) on the original image. In creation of this figure, the technique drawing road shapes shifted repeatedly to the lee was used. By overlapping the benzene concentration distribution due to the emission from narrow lanes assumed as area sources and the distribution due to the emission from highways assumed as line sources having emission height on Fig.5, we can estimate the Benzene concentration distribution of the Osaka-City whole region with the spatial resolution of 10m×10m.

CONCLUSION

An example of a technique to performs the evaluation of environmental benzene concentration over a wide area taking into consideration the geometrical form of a road and its circumference approximately was proposed, and applied to Osaka-City. By this technique, exposure concentration and health risk evaluation in a wide area are attained, and the places where monitoring and detailed evaluation of the environment is required can be pinpointed. In many cities in Vietnam, since it is predicted that benzene concentration is much higher compared to Japan, the possibility of exposure evaluation by the same technique should be investigated.

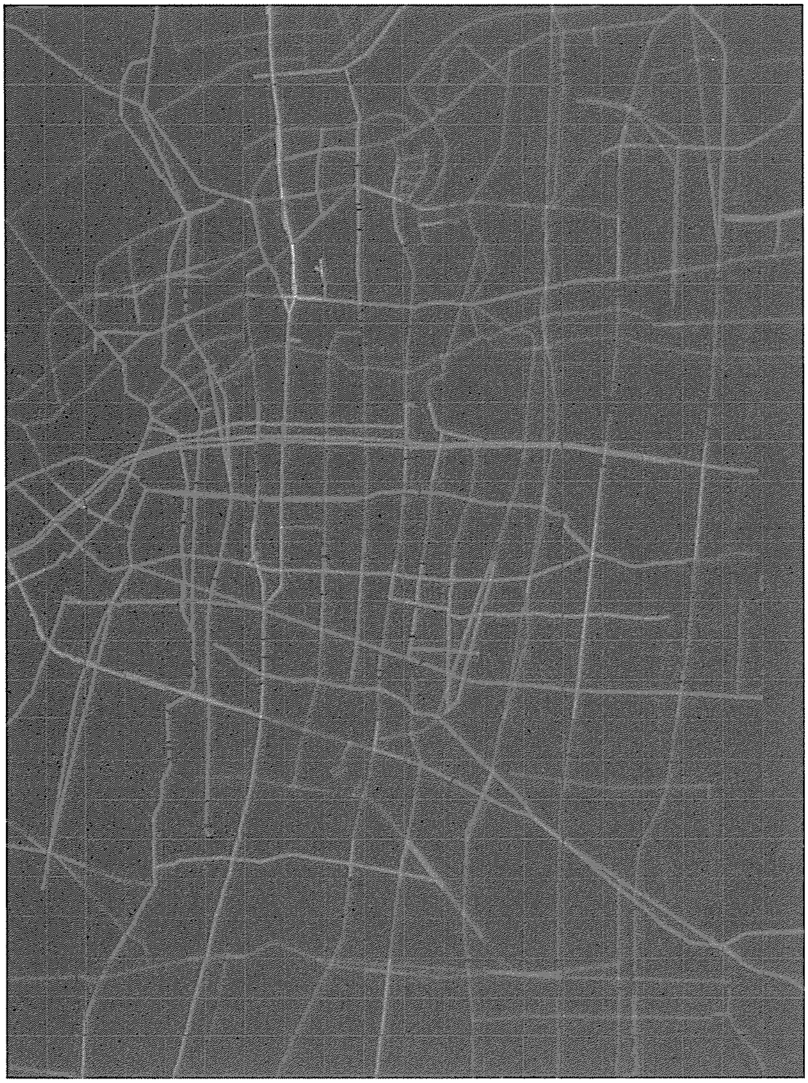

Figure 5 Benzene concentration distribution due to the emission from main roads in central Osaka-City

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