MEASUREMENTS OF PARTICULATE MATTER AT INTERSECTION IN HONG KONG

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Abstract
An experimental study of particulate matter from vehicle emission was carried out at a typical traffic intersection in Hong Kong downtown area and aimed to explore the varying trends of particulate matter on roadides. Seven particle number concentrations with different size groups (0.02-0.3μm, 0.3-0.49μm, 0.5-0.99μm, 1-1.99μm, 2-4.99μm, 5-9.99μm, and >10μm) were collected and analyzed. It was found that the particulate levels, in general, present periodic variations with the traffic signal intervals. The concentrations of the particulate matter increase and accumulate to the corresponding peak points during the green time and then diffuse to a relatively stable level during the red one. In addition, the principal component analysis (PCA) was utilized to reveal the correlation between the measured particulate matters. The results show that particles between size range of 0.02-0.3μm and 0.5-4.99μm have similar characteristics and can be combined as the first principal components, followed by particles larger than 5μm and within the range of 0.3-0.49μm. It can be deduced that the particle size in 0.02-0.3μm and 0.5-4.99μm are mostly originated from traffic emission.

Key words: particulate matter, intersection

1. INTRODUCTION

Regulations controlling the emission of ambient particulate matter have been based on limits for PM10 (particles less than 10μm in diameter) or PM2.5 in terms of total mass concentration. Recent toxicological studies have suggested that the ultrafine fraction such as PM1, which contribute very little to the total mass concentration of particles (Kittleson, 1998) but are the main component, by number concentration of particulate pollution. Additionally epidemiological studies reveal correlation between exposure to ambient ultrafine particles at high number concentration, and adverse health effects (Pope, 2000; Davidson et al., 2005). Hence, it is necessary and significant to study the variation of number concentration of particulate matter at urban intersection.

2. MEASUREMENT

The measurements of particulate matter were performed in afternoon rush hours respectively at a selected traffic intersection in Mong Kok, Hong Kong. Particulate matter was measured by a Fluke 983 Particle Counter. To simplify the situation, the traffic signal is regarded as two phases, i.e., red and green ones; while yellow signal is ignored.

3. RESULTS AND DISCUSSION

During the green period, the vehicles in queue start to move and the vehicle emissions tend to increase. Fig. 1 presents the variation of particulate matter within the whole signal period. From the figure, two facts can be addressed. The first is that the number concentrations of particulate matter in the green period are higher than those in the red period. The second is that all concentration curves vary with the same pace as traffic signal intervals especially those particles within the range of 0.02-0.3μm and 0.5-4.99μm, which can be interpreted that particles fall in this range are mainly driven and diluted by the momentum of surrounding wind but less affected by the corresponding gravity.

In addition, the particle size distributions are studied and shown in Fig.2. The units are divided by dlogDp (Dp: aerodynamic diameter) in the figure and this method has been commonly used to draw logarithmic distributions of particles (Harris and Maricq, 2001; Pakkanen et al., 2001). Due to wide range of size group in this experiment, the overall shape of particle size distributions was slightly similar and fitted to a part of logarithmic distributions, which is agreement with experiments in other studies (Wehner and Wiedensohler, 2003; Kumar et al., 2008). Additionally, a clear increase in particle number concentrations at beginning of signal period can be seen from the figure, demonstrating the dominant role of traffic emission throughout the submicron size range between 0.5-4.99μm.

Furthermore, the principal component analysis (PCA) method is applied in this study. PCA is a statistical technique that transforms the original set of inter-correlated variables into a new set of an equal number of independent uncorrelated variables or principal components (PCs) that are linear combinations of the original variables. The principal components are ordered in such a way that the first PC explains most of the variance in
the data, and each subsequent one accounts for the largest proportion of variability that has not been accounted for by its predecessors (Abdul-Wahab et al., 2005; Sousa et al., 2007). From the analysis result, it can be found that the particles between 0.02-0.3μm and 0.5-4.99μm present similar behaviour and combined as the first principal component to explain 41.2% of the total variance. It can be judged that particles in this range are originated from traffic emission. The second principal component in morning is mainly constituted of particles larger 5μm and takes up of 18.6% of total variance, which can be deduced that the gravity plays an important role and result in this phenomenon.

Fig. 1 the variation of particulate matter within the whole period

Fig. 2 Particle size distribution

4. CONCLUSION

A detailed investigation on various behaviours of particulate matter from vehicle emissions at a selected traffic intersection of street canyon in Hong Kong is reported in this paper. Six particle levels with different sizes were measured and collected. The results show that the majority of collected particulate matter levels vary periodically with traffic signal intervals. Additionally the PCA was applied to inspect the correlation between the measured particulate matters. It can be found that particles between size range of 0.02-0.3μm and 0.5-4.99μm represents similar behaviour and can be combined as the first principal components. The particles in these ranges are concluded mainly from traffic emission.

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References