**‘Log Normal Method Of Moments − Diffusion Coagulation’ (LNMOM-DC) Parameterization**

**Application to the Urban case – Helsinki environment M2**

**Introduction**

A plume containing aerosol particles is released from traffic emission source continuously, with an initial lognormal size distribution characterised by count median diameter (CMD) and geometric standard deviation (GSD, ). The particles in the plume undergo simultaneous dispersion and coagulation before they become part of background aerosols. The steady-state dispersion-coagulation equation is solved and the asymptotic total number concentration is given by,

(1)

where, is the total number concentration at a very large distance from the source (asymptotic), is the source emission rate in #/s, is the wind speed in m/s, is the initial plume width in m, and is the asymptotic survival fraction obtained from the solution of dispersion-coagulation equation (Anand and Mayya, 2011). Space or time dependent survival fraction also available in the case of weak coagulation. The survival fraction for the plume is given by,

(2)

where, , , is a constant and is the turbulent kinetic energy dissipation rate. The quantity, , indicates the dominating process in the given release scenario; higher value indicates coagulation as the governing process. is the effective coagulation coefficient obtained by integrating over the size dependent Fuchs kernel for the given lognormal aerosol size distribution as shown below:

(3)

where, is the size dependent Fuchs kernel for coagulating particles of diameter and in the entire size regime, and is the initial lognormal size distribution (at = 0) given by,

(4)

where, signifies the particle diameter,  denotes the modal geometric mean diameter (count median diameter, ),  is the modal geometric standard deviation, and  stands for the particle number concentration in mode *i*.

By applying method of moments to the governing dispersion-coagulation equation, asymptotic values of the and are obtained from zeroth (number concentration, ), first (mass concentration, ) and second moment () by using Hatch-Choate relations (Sarkar et al., 2020):

(5)

(6)

**Input parameters for the urban emission scenario – 13.12.2012 at 17-18 hrs**

**Table 1: Input parameters for the urban case simulation**

|  |  |
| --- | --- |
| **Parameters** | **Values** |
| Atmospheric stability condition | Stable |
| Wind speed () | 1 m/s |
| Initial plume width () | 20 m |
| Source emission rate () | 6.74 x 1013 #/s |
| Effective coagulation coefficient () from Eq.(3) | 3.2 x 10-15 m3/s |
| Turbulent kinetic energy dissipation rate ()\* | 0.01836 m2/s3 |
| Friction velocity ()\*\* | 0.232 m/s |
| Van Karman constant () | 0.4 |
| Release height () | 2.15 m |
| Monin Obukhov length () | 185.2 m |
| Mixing height () | 168 m |
| Roughness length () | 0.4 m |

\* - estimated using the formula for stable atmosphere,

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The initial size distribution parameters are obtained by fitting the measured data to bimodal lognormal distribution (Fig.1), and the basic parameters are given below.

**Table 2: Number size distribution of the emission source**

|  |  |  |
| --- | --- | --- |
| **Initial lognormal size distribution parameters** | | |
| Number of modes | 2 | |
| Count median diameter ( or ) | 20 nm | 90 nm |
| Geometric standard deviation () | 1.75 | 1.95 |
| Number concentration () | 1.1 x 1011 m-3 | 4.4 x 103 m-3 |



**Figure 1:** Aerosol particle size distribution near the emission source (at 0 m)

**Results and Discussion**

With all the input parameters mentioned in the Tables 1 and 2, the following important parameters are first estimated:

**1) Parameter : 0.00155872**

**2) Asymptotic survival fraction (): 0.998439 (from Eq.(2))**

**3) Total number concentration at large distance away from the source (): 1.6823 x 1011 m-3 (from Eq.(1)) while the initial concentration near the source is, 1.685 x 1011 m-3 (from Eq.(1)).**

Since, the values of parameters ( and ) are 1.6E-3 and ~1 respectively, the effect of coagulation is negligible. Also, the preliminary estimation shows that change in the total number concentration due to pure coagulation at 100 m (100 s) will be, ~2%. Hence, Eqs.(5) and (6) cannot be utilised to estimate the change in the size distribution parameters. To evaluate the change in the total number concentration, a standard line source dispersion model is attempted as shown below.

**Line source Gaussian model**

The ground level concentration () of a pollutant at a downwind distance () from an infinite line source perpendicular to the wind direction is given by (Chock, 1978; Luhar and Patil, 1989),

(7)

where, is the emission rate per unit length of the road (#/(m.s)), is the wind speed and is the release height. is the vertical dispersion coefficient at distance from road due to both atmospheric and traffic induced turbulence, and hence, for the stable atmospheric condition (Chock, 1978) is,

(8)

Using input parameters, = 2.93 x 1011 #/(m.s), = 1 m/s, = 2.15 m, the ground level total particle number concentration (Eq.(7)) is plotted as a function of downwind distance (Fig.2).



**Figure 2: Total number concentration as a function of downwind distance**