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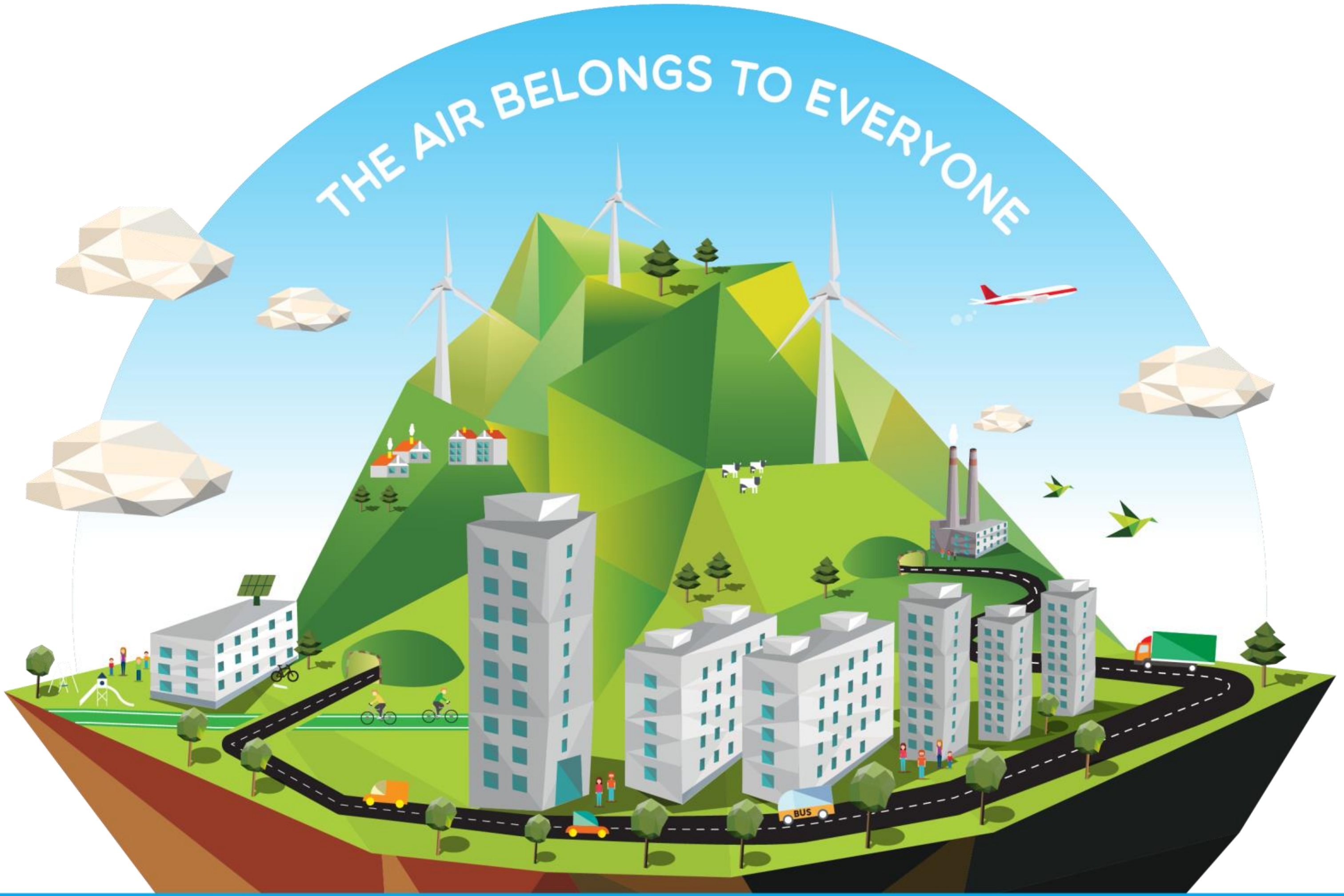

Technical Report on OP module for dose calculations

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Introduction

The operational platform includes the respiratory tract deposition model of the ExDoM2 (Chalvatzaki and Lazaridis, 2015). The respiratory tract deposition model of the ExDoM2 is a revised version of ExDoM (Aleksandropoulou and Lazaridis, 2013) and is based on ICRP (1994, 2015). In addition, inhalation only through the nose was considered and only three activities levels were added. Finally, the operational platform run each aerodynamic diameter as monodisperse (σ_g =1) using the geometric midpoint (square root of lower cut-off size × upper cut-off size) of each stage of the impactor as input data.

Equations and parameters

The deposition fraction DE in each filter j was calculated using the following equation: (Aleksandropoulou, 2010; ICRP, 1994):

$$DE_j = n_j \phi_j \prod_{jj=0}^{j-1} \left(1 - n_{jj}\right) \qquad (1)$$

where, n_j is the deposition efficiency of the j filter, ϕ_j is the fraction of tidal air that reaches the j filter and n_0 is the prefiltration efficiency. The number of filters were 9 and hence the parameter j =1:9.

The deposition efficiency n_j was calculated using the equation (Aleksandropoulou, 2010; ICRP, 1994):

$$n_j = (n_{ae}^2 + n_{th}^2)^{1/2} \qquad (2)$$

where, n_{ae} is the aerodynamic deposition efficiency due to impaction and gravitational settling and n_{th} is the thermodynamic deposition efficiency due to diffusion.For equation (2) the parameter j =1:9. The parameters n_{ae} and n_{th} were calculated as shown in Table 1.

Table 1.Regional deposition efficiency (inhaled and exhaled through the nose)(Aleksandropoulou, 2010; ICRP, 1994).

Phase	Filter j	Region	Regional deposition efficiency, n_j					
			Aerodynamic			Thermodynamic		
			$n_{ae} = 1 - \exp(-aR^p)$			$n_{th} = 1 - \exp(-aR^p)$		
			a	R	p	a	R	p
INHALATION	1	ET1*	3.0 × 10-4	$d_{ae}^2 \times \dot{V}_n \times SF_t^3$	1	18	$D \times (\dot{V}_n \times SF_t)^{-1/4}$	1/2
	2	ET2**	5.5 × 10-5	$d_{ae}^2 \times \dot{V}_n \times SF_t^3$	1.17	15.1	$D \times (\dot{V}_n \times SF_t)^{-1/4}$	0.538
	3	BB	4.08 × 10-6	$d_{ae}^2 \times \dot{V} \times SF_t^{2.3}$	1.152	$22.02 \times SF_t^{1.24} \times \psi_{th}$	$D \times t_B$	0.6391
	4	bb	0.1147	$(0.056 + t_b^{1.5}) \times d_{ae}^{t_b^{-0.25}}$	1.173	$-76.8 + 167 \times SF_b^{0.65}$	$D \times t_b$	0.5676
	5	AI	$0.146 \times SF_A^{0.98}$	$d_{ae}^2 \times t_A$	0.6495	$170 + 103 \times SF_A^{2.13}$	$D \times t_A$	0.6101
EXHALATION	6	bb	0.1147	$(0.056 + t_b^{1.5}) \times d_{ae}^{t_b^{-0.25}}$	1.173	$-76.8 + 167 \times SF_b^{0.65}$	$D \times t_b$	0.5676
	7	BB	2.04 × 10-6	$d_{ae}^2 \times \dot{V} \times SF_t^{2.3}$	1.152	$22.02 \times SF_t^{1.24} \times \psi_{th}$	$D \times t_B$	0.6391
	8	ET2**	5.5 × 10-5	$d_{ae}^2 \times \dot{V}_n \times SF_t^3$	1.17	15.1	$D \times (\dot{V}_n \times SF_t)^{-1/4}$	0.538
	9	ET1*	3.0 × 10-4	$d_{ae}^2 \times \dot{V}_n \times SF_t^3$	1	18	$D \times (\dot{V}_n \times SF_t)^{-1/4}$	1/2

$^{*}n_{ae} = 0.5 \times [1 - 1/(aR^p + 1)]$, $^{*}n_{th} = 0.5 \times [1 - \exp(-aR^p)]$

$^{**}n_{ae} = 1 - 1/(aR^p + 1)$, $^{**}n_{th} = 1 - \exp(-aR^p)$,

The component of the total volumetric flow rate (ml/sec) that is inspired through the nose $\dot{V}_n$ was calculated with the following equation (ICRP, 1994):

$$\dot{V}_n = FN \times \dot{V} \tag{3}$$

where FN is the fraction of total ventilatory airflow passing through the nose and $\dot{V}$ is the volumetric flow rate of inspired air (mL/sec).The fraction of total ventilatory airflow passing through the nose is equal to 1 for all exposed subjects and for the three activities levels while the volumetric flow rate of inspired air depends on the activity level and the exposed subject. The parameter $\dot{V}$ and the other physiological parameters are presented in Table 2 while the anatomical parameters are presented in the Table 3.

Table 2: Physiological parameters (Aleksandropoulou, 2010; ICRP, 1994).

	Exposed Subject		
Parameters	Adult Male	10 year old child	5 year old child
ACTIVITY: Sleep			
Ventilation or inhalation rate B (m^3/h)	0.45	0.31	0.24
Tidal volume of exposed subject V_T (mL)	625	304	174
Volumetric flow rate of inspired air $\dot{V}$ (mL/sec)	250	172	133
Respiration frequency f(min^{-1})	12	17	23
Fraction of total ventilatory airflow passing through the nose *(FN)*	1	1	1
ACTIVITY: Sitting			
Ventilation or inhalation rate B (m^3/h)	0.54	0.38	0.32
Tidal volume of exposed subject V_T (mL)	750	333	213
Volumetric flow rate of inspired air $\dot{V}$ (mL/sec)	300	211	178
Respiration frequency f(min^{-1})	12	19	25
Fraction of total ventilatory airflow passing through the nose *(FN)*	1	1	1
ACTIVITY: Light exercise			
Ventilation or inhalation rate B (m^3/h)	1.5	1.12	0.57
Tidal volume of exposed subject V_T (mL)	1250	583	244
Volumetric flow rate of inspired air $\dot{V}$ (mL/sec)	833	622	317
Respiration frequency f(min^{-1})	20	32	39
Fraction of total ventilatory airflow passing through the nose *(FN)*	1	1	1

Table 3: Anatomical parameters (Aleksandropoulou, 2010; ICRP, 1994).

	Exposed subject		
Parameters	Adult Male	10 year old child	5 year old child
Functional residual capacity of the exposed subject, FRC (mL)	3301	1484	767
Anatomical dead space in the extrathoracic region, $V_D(ET)$ (mL)	50	25	13.3
Anatomical dead space of the trachea and bronchi (Bronchial) region, $V_D(BB)$ (mL)	49	26	15.5
Anatomical dead space of the bronchioles (Bronchiolar), $V_D(bb)$ (mL)	47	26	16.7
The ratio of the diameter of the trachea in the reference adult male to that in the subject, (SF_t)	1	1.26	1.55
The ratio of the diameter of the first bronchiolar airways in the reference adult male to that in the subject (SF_b)	1	1.16	1.30
The ratio of the diameter of the first respiratory bronchiole in the reference adult male to that in the subject (SF_A)	1	1.31	1.63

The time constant for conduction of air through the trachea and bronchi (t_B), the time constant for conduction of air through the brochioles (t_b) and the time constant for residence of air in the alveolar-interstitial airways (t_A) were calculated with the following equations (Aleksandropoulou, 2010; ICRP, 1994):

$$t_B = \frac{V_D(BB) \times \left(1 + 0.5 \times V_T / FRC\right)}{\dot{V}} \tag{4}$$

$$t_b = \frac{V_D(bb) \times \left(1 + 0.5 \times V_T / FRC\right)}{\dot{V}} \tag{5}$$

$$t_A = \frac{V_T - V_D(ET) - \left[V_D(BB) + V_D(bb)\right] \times (1 + V_T / FRC)}{\dot{V}} \tag{6}$$

where V_D is the anatomical dead space (mL), V is the volumetric flow rate of inspired air (mL/sec) and FRC is the functional residual capacity of the exposed subject (mL). The units of time constants are seconds.

The equations for the parameter ϕ_j are presented on Table 4.

Table 4: Volumetric fraction for each filter (ϕ_j) (Aleksandropoulou, 2010; ICRP,1994).

Phase	Filter j	Region	Volumetric fraction ϕ_j^*
INHALATION	1	ET1	1
	2	ET2	1
	3	BB	$1-\frac{V_D(ET)}{V_T}$
	4	bb	$1-\frac{[V_D(ET)+V'_D(BB)]}{V_T}$
INHALATION / EXHALATION	5	AI	$1-\frac{[V_D(ET)+V'_D(BB)+V'_D(bb)]}{V_T}$
EXHALATION	6	bb	$1-\frac{[V_D(ET)+V'_D(BB)]}{V_T}$
	7	BB	$1-\frac{V_D(ET)}{V_T}$
	8	ET2	1
	9	ET1	1

$^* V'_D(BB)=V_D(BB)\times\left(1+\frac{V_T}{FRC}\right)$, $^* V'_D(bb)=V_D(bb)\times\left(1+\frac{V_T}{FRC}\right)$

Therefore, based on Table 4 the parameter ϕ_j during exhalation can be calculated with the following equation (Aleksandropoulou, 2010; ICRP,1994):

$$\phi_j=\phi_{9-j+1} \quad \text{for } j = 6:9 \qquad (7)$$

The particle diffusion coefficient (cm^2/s) was calculated as (Aleksandropoulou, 2010; ICRP, 1994):

$$D=\frac{k\times C(d_{th})\times 310.15\times 1.0132\times 10^{13}}{3\times\pi\times\mu\times d_{th}} \qquad (8)$$

where d_{th} is the thermodynamic diameter (μm), $C(d_{th})$ is the slip correction factor for a particle of thermodynamic diameter, π =3.141592654, μ =0.000188 Poise and k =0.013622779×10^{-23}.

The empirical correction factor was calculated with the following equation (Aleksandropoulou, 2010; ICRP, 1994):

$$\psi_{th} = 1 + 100 \times \exp\left[-\left[\log_{10}\left(100 + 10/d_{th}^{0.9}\right)\right]^2\right] \quad (9)$$

The thermodynamic diameter (d_{th}) and the slip correction factor for a particle of thermodynamic diameter $C(d_{th})$ were calculated using the following equations (Aleksandropoulou, 2010; ICRP, 1994):

$d_{th} = d_e$ for d_e ≥0.002 μm (10)

$C(d_{th}) = C(d_e)$ for d_e ≥0.002 μm (11)

$d_{th} = d_e \times \left[1 + 3 \times \exp\left(-2.20 \times 10^3 \times d_e\right)\right]$ for d_e <0.002 μm (12)

$C(d_{th}) = 1 + (0.0683/d_{th}) \times \{2.514 + 0.8 \times \exp[-0.55(d_{th}/0.0683)]\}$ for d_e <0.002 μm (13) where d_e is the equivalent volume diameter (μm).

The equivalent volume diameter d_e was calculated by (Aleksandropoulou, 2010; ICRP, 1994):

$$d_e = d_{ae}\sqrt{\frac{\chi}{\rho} \times \frac{C(d_{ae})}{C(d_e)}} \quad (14)$$

$$C(d_{ae}) = 1 + (0.0683/d_{ae}) \times \{2.514 + 0.8 \times \exp[-0.55(d_{ae}/0.0683)]\} \quad (15)$$

$$C(d_e) = 1 + (0.0683/d_e) \times \{2.514 + 0.8 \times \exp[-0.55(d_e/0.0683)]\} \quad (16)$$

where d_{ae} is the aerodynamic diameter (μm), $C(d_{ae})$ is the slip correction factor for a particle of aerodynamic diameter , $C(d_e)$ is the slip correction for a particle of equivalent volume diameter, ρ is the density of the particle (gr/cm^3). It is necessary to solve equation (14) recursively (trial and error method; Aleksandropoulou, 2010), this solution can be approximated by initially setting $d_e(1) = d_{ae}\sqrt{\frac{\chi}{\rho}}$ (Aleksandropoulou, 2010; ICRP, 1994). The iterative solution then converges rapidly (<10) to the correct value for d_e (ICRP, 1994).

The prefiltration efficiency (n_0) was calculated by (ICRP, 1994):

$$n_0 = 1 - n_I \quad (17)$$

where, n_I is the inhalability of particles.

The inhalability of particles n_I was calculated from (Aleksandropoulou and Lazaridis, 2013; ICRP, 1994; Ménache et al. (1995)):

$$n_I = 1 - \left[1 + \exp\left(13.56 + 0.4343 \times (-4.88) \times \log_{10}\left(d_{ae}\right)\right)\right]^{-1} \text{ for u <1 m/s} \quad (18)$$

$$n_I = 1 - 0.5 \times \left(1 - \left[7.6 \times 10^{-4} \times d_{ae}^{2.8} + 1\right]^{-1}\right) + 1.0 \times 10^{-5} \times u^{2.75} \times \exp\left(0.055 \times d_{ae}\right) \text{ for u≥1 m/s} \quad (19)$$

where u is the wind speed (m/s) and d_{ae} is the aerodynamic diameter (μm).

The deposition fractions of ET1 and ET2 regions were summed to estimate the deposition fraction in the ET region and then re-partitioned 65% to ET1 region and 35% to ET2 region (Chalvatzaki and Lazaridis, 2015; ICRP, 2015). Therefore, the deposition fraction in ET1 and ET2 region of the respiratory tract was calculated with the following equations (ICRP, 2015):

$$\mathbf{DE_{ETin}=DE_1 + DE_2} \quad \mathbf{(20)}$$

$$DE_1=0.65 \times DE_{ETin} \quad (21)$$

$$DE_2=0.35 \times DE_{ETin} \quad (22)$$

$$DE_{ETexh}=DE_9 + DE_8 \quad (23)$$

$$DE_9=0.65 \times DE_{ETexh} \quad (24)$$

$$DE_8=0.35 \times DE_{ETexh} \quad (25)$$

The deposition fraction DE in each region of the respiratory tract was calculated with the following equations (ICRP, 1994):

$$\mathbf{DE_{ET1}= DE_1 + DE_9} \quad \mathbf{(26)}$$

$$\mathbf{DE_{ET2} = DE_2 + DE_8} \quad \mathbf{(27)}$$

$$\mathbf{DE_{BB}= DE_3 + DE_7} \quad \mathbf{(28)}$$

$$\mathbf{DE_{bb}= DE_4 + DE_6} \quad \mathbf{(29)}$$

$$DE_{AI}= DE_5 \quad (30)$$

The deposited dose rate (μg/h) is the product of inhalation rate, exposure concentration and deposition fraction (Aleksandropoulou and Lazaridis, 2013).The operational platform run each diameter as monodisperse (σ_g =1). Therefore, based on the above mentioned the deposited dose rate (μg/h) in the five regions of the respiratory tract and for each diameter of fine particles was calculated with the following equations:

$$\mathrm{HET1binF}_{i,k} = B_i \times C_i \times MF_{i,k} \times DE_{ET1_{i,k}} \quad (31)$$

$$\mathrm{HET2binF}_{i,k} = B_i \times C_i \times MF_{i,k} \times DE_{ET2_{i,k}} \quad (32)$$

$$\mathrm{HBBbinF}_{i,k} = B_i \times C_i \times MF_{i,k} \times DE_{BB_{i,k}} \quad (33)$$

$$\text{HbbbinF}_{i,k} = B_i \times C_i \times MF_{i,k} \times DE_{bb_{i,k}} \quad (34)$$

$$\text{HAIbinF}_{i,k} = B_i \times C_i \times MF_{i,k} \times DE_{AI_{i,k}} \quad (35)$$

where B is the inhalation rate (m^3/h), C is the concentration (μg/m^3) of total particles (e.g.PM_{10} for Lisbon), MF is the mass fraction for each diameter, DE_{ET1} is the deposition fraction in the ET1 region, DE_{ET2} is the deposition fraction in the ET2 region, DE_{BB} is the deposition fraction in the BB region, DE_{bb} is the deposition fraction in the bb region and DE_{AI} is the deposition fraction in the AI region. The deposition fraction was calculated separately for each diameter of fine particles. The parameter i =1:duration while the parameter k =1:N1. The parameter duration is the exposure duration in hours while N1 is the number of stages of fine particles.

The deposited dose rate (μg/h) in the five regions of the respiratory tract for fine particles was calculated as:

$$\text{sumbinFET1}_{i,N1} = \sum_{k=1}^{N1} \text{HET1binF}_{i,k} \quad (36)$$

$$\text{sumbinFET2}_{i,N1} = \sum_{k=1}^{N1} \text{HET2binF}_{i,k} \quad (37)$$

$$\text{sumbinFBB}_{i,N1} = \sum_{k=1}^{N1} \text{HBBbinF}_{i,k} \quad (38)$$

$$\text{sumbinFbb}_{i,N1} = \sum_{k=1}^{N1} \text{HbbbinF}_{i,k} \quad (39)$$

$$\text{sumbinFAI}_{i,N1} = \sum_{k=1}^{N1} \text{HAIbinF}_{i,k} \quad (40)$$

where, the parameter i =1:duration while the parameter k =1:N1. The parameter duration is the exposure duration in hours while N1 is the number of stages of fine particles.

The deposited dose rate (μg/h) in the five regions of the respiratory tract for fine particles was saved in a table with 6 columns with the sum of the five regions being in the sixth column. Therefore, the following equations were used:

$$\text{HFINE}_{i,1} = \text{sumbinFET1}_{i,N1} \quad (41)$$

$$\text{HFINE}_{i,2} = \text{sumbinFET2}_{i,N1} \quad (42)$$

$$\text{HFINE}_{i,3} = \text{sumbinFBB}_{i,N1} \quad (43)$$

$$\text{HFINE}_{i,4} = \text{sumbinFbb}_{i,N1} \quad (44)$$

$$\text{HFINE}_{i,5} = \text{sumbinFAI}_{i,N1} \quad (45)$$

$$\text{HFINE}_{i,6} = \text{sumbinFET1}_{i,N1} + \text{sumbinFET2}_{i,N1} + \text{sumbinFBB}_{i,N1} + \text{sumbinFbb}_{i,N1} + \text{sumbinFAI}_{i,N1} \quad (46)$$

where, HFINE is the deposited dose rate (μg/h) of fine particles for ET1, ET2, BB, bb, AI regions and TOTAL (sum of the five regions; respiratory tract).

Likewise, the same methodology was implemented for coarse particles.Based on the above methodology the deposited dose rate (μg/h) in the five regions of the respiratory tract and for each diameter of coarse particles was calculated with the following equations:

$$\mathrm{HET1binC}_{i,q} = B_i \times C_i \times MF_{i,q} \times DE_{ET1_{i,q}} \tag{47}$$

$$\mathrm{HET2binC}_{i,q} = B_i \times C_i \times MF_{i,q} \times DE_{ET2_{i,q}} \tag{48}$$

$$\mathrm{HBBbinC}_{i,q} = B_i \times C_i \times MF_{i,q} \times DE_{BB_{i,q}} \tag{49}$$

$$\mathrm{HbbbinC}_{i,q} = B_i \times C_i \times MF_{i,q} \times DE_{bb_{i,q}} \tag{50}$$

$$\mathrm{HAIbinC}_{i,q} = B_i \times C_i \times MF_{i,q} \times DE_{AI_{i,q}} \tag{51}$$

where B is the inhalation rate (m^3/h), C is the concentration (μg/m^3) of total particles (e.g. PM_{10} for Lisbon), MF is the mass fraction for each diameter, DE_{ET1} is the deposition fraction in the ET1 region, DE_{ET2} is the deposition fraction in the ET2 region, DE_{BB} is the deposition fraction in the BB region, DE_{bb} is the deposition fraction in the bb region and DE_{AI} is the deposition fraction in the AI region. The deposition fraction was calculated separately for each diameter of coarse particles. The parameter i =1:duration while the parameter q =(N1+1):NIMPACTOR. The parameter duration is the exposure duration in hours while N1 is the number of stages of fine particles and NIMPACTOR is the number of stages of impactor.

The deposited dose rate (μg/h) in the five regions of the respiratory tract for coarse particles was calculated with the following equations:

$$\mathrm{sumbinCET1}_{i,NIMPACTOR} = \sum_{q=(N1+1)}^{NIMPACTOR} \mathrm{HET1binC}_{i,q} \tag{52}$$

$$\mathrm{sumbinCET2}_{i,NIMPACTOR} = \sum_{q=(N1+1)}^{NIMPACTOR} \mathrm{HET2binC}_{i,q} \tag{53}$$

$$\mathrm{sumbinCBB}_{i,NIMPACTOR} = \sum_{q=(N1+1)}^{NIMPACTOR} \mathrm{HBBbinC}_{i,q} \tag{54}$$

$$\mathrm{sumbinCbb}_{i,NIMPACTOR} = \sum_{q=(N1+1)}^{NIMPACTOR} \mathrm{HbbbinC}_{i,q} \tag{55}$$

$$\mathrm{sumbinCAI}_{i,NIMPACTOR} = \sum_{q=(N1+1)}^{NIMPACTOR} \mathrm{HAIbinC}_{i,q} \tag{56}$$

where, the parameter i =1:duration while the parameter q =(N1+1):NIMPACTOR. The parameter duration is the exposure duration in hours while N1 is the number of stages of fine particles and NIMPACTOR is the number of stages of the impactor.

Again, the deposited dose rate (μg/h) in the five regions of the respiratory tract for coarse particles was saved in a table with 6 columns with the sum of the five regions is the sixth column. The following equations were used:

$$\mathrm{HCOARSE}_{i,1} = \mathrm{sumbinCET1}_{i,NIMPACTOR} \quad (57)$$

$$\mathrm{HCOARSE}_{i,2} = \mathrm{sumbinCET2}_{i,NIMPACTOR} \quad (58)$$

$$\mathrm{HCOARSE}_{i,3} = \mathrm{sumbinCBB}_{i,NIMPACTOR} \quad (59)$$

$$\mathrm{HCOASRSE}_{i,4} = \mathrm{sumbinCbb}_{i,NIMPACTOR} \quad (60)$$

$$\mathrm{H}COARSE_{i,5} = \mathrm{sumbinCAI}_{i,NIMPACTOR} \quad (61)$$

$$\mathrm{HCOARSE}_{i,6} = \mathrm{sumbinCET1}_{i,NIMPACTOR} + \mathrm{sumbinCET2}_{i,NIMPACTOR} + \mathrm{sumbinCBB}_{i,NIMPACTOR} + \mathrm{sumbinCbb}_{i,NIMPACTOR} + \mathrm{sumbinCAI}_{i,NIMPACTOR} \quad (62)$$

where, HCOARSE is the deposited dose rate (μg/h) of coarse particles for ET1, ET2, BB, bb, AI regions and TOTAL (sum of the five regions; respiratory tract).

In addition, the deposited dose rate (μg/h) for total particles (e.g. PM_{10} for Lisbon) was calculated using the following equations:

$$\mathrm{HTOTAL}_{i,1} = \mathrm{HFINE}_{i,1} + \mathrm{HCOARSE}_{i,1} \quad (63)$$

$$\mathrm{HTOTAL}_{i,2} = \mathrm{HFINE}_{i,2} + \mathrm{HCOARSE}_{i,2} \quad (64)$$

$$\mathrm{HTOTAL}_{i,3} = \mathrm{HFINE}_{i,3} + \mathrm{HCOARSE}_{i,3} \quad (65)$$

$$\mathrm{HTOTAL}_{i,4} = \mathrm{HFINE}_{i,4} + \mathrm{HCOARSE}_{i,4} \quad (66)$$

$$\mathrm{HTOTAL}_{i,5} = \mathrm{HFINE}_{i,5} + \mathrm{HCOARSE}_{i,5} \quad (67)$$

$$\mathrm{HTOTAL}_{i,6} = \mathrm{HFINE}_{i,6} + \mathrm{HCOARSE}_{i,6} \quad (68)$$

where, HTOTAL is the deposited dose rate (μg/h) of total particles for ET1, ET2, BB, bb, AI regions and TOTAL (sum of the five regions; respiratory tract).

The cumulative deposited dose (μg) for fine particles was calculated by:

$$\mathrm{cumET1FINE}_{i,1}(\mu g) = \sum_{r=1}^{i} \left(\mathrm{HFINE}_{r,1}(\mu g/h) \times 1(h) \right) \quad (69)$$

$$\text{cumET2FINE}_{i,1}(\mu g) = \sum_{r=1}^{i}\left(\text{HFINE}_{r,2}(\mu g/h) \times 1(h)\right) \quad (70)$$

$$\text{cumBBFINE}_{i,1}(\mu g) = \sum_{r=1}^{i}\left(\text{HFINE}_{r,3}(\mu g/h) \times 1(h)\right) \quad (71)$$

$$\text{cumbbFINE}_{i,1}(\mu g) = \sum_{r=1}^{i}\left(\text{HFINE}_{r,4}(\mu g/h) \times 1(h)\right) \quad (72)$$

$$\text{cumAIFINE}_{i,1}(\mu g) = \sum_{r=1}^{i}\left(\text{HFINE}_{r,5}(\mu g/h) \times 1(h)\right) \quad (73)$$

$$\text{cumTOTALFINE}_{i,1}(\mu g) = \sum_{r=1}^{i}\left(\text{HFINE}_{r,6}(\mu g/h) \times 1(h)\right) \quad (74)$$

where,the parameter i =1:duration. The parameter duration is the exposure duration in hours.

On the other hand, the cumulative deposited dose (μg) for coarse particle was calculated by:

$$\text{cumET1COARSE}_{i,1}(\mu g) = \sum_{r=1}^{i}\left(\text{HCOARSE}_{r,1}(\mu g/h) \times 1(h)\right) \quad (75)$$

$$\text{cumET2COARSE}_{i,1}(\mu g) = \sum_{r=1}^{i}\left(\text{HCOARSE}_{r,2}(\mu g/h) \times 1(h)\right) \quad (76)$$

$$\text{cumBBCOARSE}_{i,1}(\mu g) = \sum_{r=1}^{i}\left(\text{HCOARSE}_{r,3}(\mu g/h) \times 1(h)\right) \quad (77)$$

$$\text{cumbbCOARSE}_{i,1}(\mu g) = \sum_{r=1}^{i}\left(\text{HCOARSE}_{r,4}(\mu g/h) \times 1(h)\right) \quad (78)$$

$$\text{cumAICOARSE}_{i,1}(\mu g) = \sum_{r=1}^{i}\left(\text{HCOARSE}_{r,5}(\mu g/h) \times 1(h)\right) \quad (79)$$

$$\text{cumTOTALCOARSE}_{i,1}(\mu g) = \sum_{r=1}^{i}\left(\text{HCOARSE}_{r,6}(\mu g/h) \times 1(h)\right) \quad (80)$$

where,the parameter i =1:duration. The parameter duration is the exposure duration in hours.

Finally, the cumulative deposited dose (μg) for total particle was calculated with the following equations:

$$\text{cumET1TOTAL}_{i,1} = \text{cumET1FINE}_{i,1} + \text{cumET1COARSE}_{i,1} \quad (81)$$

$$\text{cumET2TOTAL}_{i,1} = \text{cumET2FINE}_{i,1} + \text{cumET2COARSE}_{i,1} \quad (82)$$

$$\text{cumBBTOTAL}_{i,1} = \text{cumBBFINE}_{i,1} + \text{cumBBCOARSE}_{i,1} \quad (83)$$

$$\mathrm{cumbbTOTAL}_{i,1} = \mathrm{cumbbFINE}_{i,1} + \mathrm{cumbbCOARSE}_{i,1} \quad (84)$$

$$\mathrm{cumAITOTAL}_{i,1} = \mathrm{cumAIFINE}_{i,1} + \mathrm{cumAICOARSE}_{i,1} \quad (85)$$

$$\mathrm{cum2TOTAL}_{i,1} = \mathrm{cumTOTALFINE}_{i,1} + \mathrm{cumTOTALCOARSE}_{i,1} \quad (86)$$

It should be noted that the symbols of parameters and equations in the pdf file are different from the matlab code. Likewise, nomenclature in tables differs.

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