

# Particle size distributions of PAHs in workplace atmospheres and their exposure concentrations to workers in a steal and iron manufacturing factory

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The objective of this study was set out to characterize size distributions of polycyclic aromatic hydrocarbons (PAHs) in three workplace atmospheres of the electric arc furnace, ladle and metalluray in a steal and iron manufacturing factory and to assess their exposures to workers when they are on maintenance and on activity, respectively. Particle size segregating samplings were conducted on the workplace atmospheres of the three selected industrial processes by using the modified Marple 8-stage cascade impactor (*m*-Marple).

We found that mass median aerodynamic diameter (MMAD) of the fine mode and coarse mode fell to the range 0.222–1.57  $\mu\text{m}$  and 16.1–22.7  $\mu\text{m}$  on maintenance, respectively (Table 1). The MMAD of the fine mode and coarse mode fell to the range 0.373–2.35  $\mu\text{m}$  and 26.1–31.3  $\mu\text{m}$  on activity, respectively (Table 2).

Personal inhalable PAHs samplings on maintenance were conducted on workers in the three selected working area revealed their exposure levels as: ladle workers (6918  $\text{ng}/\text{m}^3$ ) > metalluray workers (5818  $\text{ng}/\text{m}^3$ ) > electric arc furnace workers (3361  $\text{ng}/\text{m}^3$ ). On activity, their exposure levels were the same trend as: ladle workers (8294  $\text{ng}/\text{m}^3$ ) > metalluray workers (6700  $\text{ng}/\text{m}^3$ ) > electric arc furnace workers (5369  $\text{ng}/\text{m}^3$ ) (Table 3). Our results clearly suggest that appropriate control measures should be taken by the steal and iron manufacturing factory, particularly for the abatement of PAHs exposure concentrations of the inhalable fraction. The fractions of inhaled particles deposited to different regions of the respiratory tracts found that the alveolar region was consistently higher than both head and tracheobronchial regions in all three studied exposure working area (Table 4). The above results clearly indicated that most PAHs generated from the steal and iron manufacturing process might be able to reach the deep lung (i.e., the alveolar region).

Table 1 Particle size distributions of the selected sampling areas on maintenance in steal and iron manufacturing workplaces.

area	stastics	Fine mode			Coarse mode		
		Mean	Min	Max	Mean	Min	Max
Electric arc furnace	MMAD	1.04	0.904	1.08	20.6	17.8	26.0
	GSD	1.58	1.20	3.50	2.55	2.27	3.50
	Fraction (%)	7.21	6.28	12.3	92.8	87.7	93.7
Ladle	MMAD	1.57	0.197	2.82	22.7	15.8	35.8
	GSD	3.08	1.61	3.50	3.02	1.70	3.16
	Fraction (%)	5.70	2.76	7.08	94.3	92.9	97.2
Metalluray	MMAD	0.222	0.198	0.514	16.1	10.3	24.6
	GSD	2.80	2.60	3.50	2.26	1.98	3.50
	Fraction (%)	23.9	11.4	26.3	76.1	73.7	88.6

Table 2 Particle size distributions of the selected sampling areas on activity in steal and iron manufacturing workplaces.

area	stastics	Fine mode			Coarse mode		
		Mean	Min	Max	Mean	Min	Max
Electric arc furnace	MMAD	2.35	0.700	3.12	31.3	26.3	35.2
	GSD	2.57	1.36	3.25	3.44	2.65	3.50
	Fraction (%)	10.2	2.00	15.8	89.8	84.2	98.0
Ladle	MMAD	0.575	0.152	0.829	26.1	23.6	32.7
	GSD	1.51	1.20	2.95	2.56	2.14	3.17
	Fraction (%)	1.60	0.432	2.22	98.4	97.8	99.6
Metalluray	MMAD	0.373	0.100	0.537	27.6	21.3	30.5
	GSD	1.91	1.20	3.50	2.85	2.47	3.50
	Fraction (%)	12.5	8.01	17.2	87.5	0.778	92.0

Table 3 Estimated the concentrations and fraction of PAHs exposed to different regions of the respiratory tract for workers of the selected working areas.

Area	work situation	Conc ( $\text{ng}/\text{m}^3$ )	Inh/total (%)	Thorac/total (%)	Resp/total (%)
Electric arc furnace	maintenance	3,361	84.0	65.4	48.5
	activity	5,369	86.4	71.3	57.8
Ladle	maintenance	6,918	83.5	64.9	49.4
	activity	8,294	81.4	60.8	42.0
Metalluray	maintenance	5,818	79.4	60.1	50.1
	activity	6,700	77.9	52.2	32.3

Table 4 The fraction of PAHs deposited in different respiratory tract on maintenance and activity for workers of the selected working areas.

Area	work situation	Head (%)	TB* (%)	AL** (%)
Electric arc furnace	maintenance	22.1	20.1	57.8
	activity	17.5	15.6	66.9
Ladle	maintenance	22.3	18.5	59.2
	activity	25.3	23.1	51.6
Metalluray	maintenance	24.3	12.6	63.0
	activity	32.9	25.6	41.4

\*TB : Trachea bronchial ; \*\* AL : Alveolar

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