Characterization of Exposure to Metal from Furnace and Casting Process in The Aluminum Smelter Industry

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The whole study was conducted total dust and metal concentrations at furnace area and casting area in three selected aluminium smelter industries in Taiwan. Samplings were conducted to long-term personal sampling (n=18), area sampling (n=19), and short-term personal sampling (n=9), respectively. The ICP / MS analysis was used to characterize composite of metals emitted from the workplace.

The results showed that the arithmetic mean concentration (AM_{MVUE}) and GSD of total dust concentrations were 1.38 mg / m^3 and 2.24 in the furnace area (n = 14) and 1.14 mg / m^3 and 2.89 in the casting area (n = 10), respectively. The 95% confidence interval (CI) of total dust concentrations were 0.98-2.45 in the furnace area and 0.68-3.85 in the casting area. These above results clearly indicated the average total dust concentration in the furnace area was greater than the casting area. The mean concentrations of heavy metals contained in the dust were 66μg/m^3 and 63μg/m^3 obtained by personal sampling and area sampling time, respectively. To conduct the composite of heavy metals obtained from personal sampling in the furnace area, the concentration of Al was 62% of the total heavy metal, and Mg and Fe were 18% and 13%, respectively. The consistent results of samples obtained by long term and short term sampling were found in the furnace area. On the other hand, the highest exposure concentrations of the metal were compared to the occupational exposure limit (OEL) of UK, we found that Al and Pb were over to 3% and 2% OEL and the other heavy metals are less than 1% OEL. Therefore, measurements, such as the installation of effective ventilation systems and the use proper personal respiratory protection equipment, are suggested for these industries in order to effectively reduce workers' inhalatory heavy metal exposures.

Table 1 The total dust concentrations obtained from the selected factories (mg/m^3).

Factory working area	AM_{MVUE} (min-max)	GSD	95% Confidence interval	Log-Normal distribution
A				
furnace area (n=8)	0.67 (0.33-1.22)	1.63	0.44-0.89	Yes
casting area (n=3)	0.32 (0.21-0.41)	1.4	0.16-0.49	Yes
B				
furnace area (n=4)	2.56 (0.87-4.44)	1.99	0.78-4.33	Yes
casting area (n=4)	0.77 (0.29-1.99)	2.41	0.19-1.74	Yes
C				
furnace area (n=2)	1.92 (1.92-1.921)	1.01	1.91-1.93	Yes
casting area (n=3)	2.71 (0.84-4.40)	2.36	0.29-5.71	Yes

Table 2. The metal concentrations (μg/m^3) obtained from the selected work area in A factory.

Metal	Furnace area						Casting area	
	Personal sampling(n=5)		8hrs area sampling(n=8)		15 mins personal sampling(n=4		8hrs area sampling(n=3)	
	mean (min-max)	GSD	mean (min-max)	GSD	mean (min-max)	GSD	mean (min-max)	GSD
Al	22.26 (11.38-42.04)	1.71	17.1 (6.86-30.9)	1.65	56.42 (15.8-150)	2.63	9.07 (6.38-12.55)	1.41
Cr	0.067 (0.05-0.11)	1.38	0.04 (0.01-0.11)	2.29	0.71 (0.30-1.68)	2.16	0.03 (0.009-0.05)	2.49
Mg	9.68 (5.91-21.19)	1.69	6.39 (2.60-11.9)	1.67	31.0 (17.3-63.8)	1.8	2.93 (2.47-3.46)	1.18
Fe	7.51 (4.62-9.82)	1.38	3.83 (1.69-9.83)	1.74	12.0 (2.06-35.2)	3.28	1.44 (0.82-1.82)	1.55
Co	0.02 (0.01-0.02)	1.22	0.03 (0.003-0.098)	2.75	0.08 (0.002-0.41)	8.55	0.10 (0.002-0.03)	3.63
Ni	0.13 (0.01-0.26)	3.45	0.20 (0.011-0.59)	3.7	0.24 (0.06-0.55)	2.63	0.12 (0.11-0.13)	1.09
Cu	0.28 (0.11-0.56)	1.8	0.23 (0.06-0.58)	2.02	1.20 (0.35-3.08)	2.57	0.10 (0.07-0.13)	1.37
Zn	3.75 (2.64-5.36)	1.35	3.55 (1.65-11.8)	1.89	7.62 (1.26-21.0)	3.34	3.78 (1.05-8.76)	3.1
Pb	0.28 (0.06-0.46)	2.33	0.31 (0.07-0.48)	1.95	0.77 (0.70-0.84)	1.14	0.25 (0.04-0.20)	2.46

Table 3. The metal concentrations (μg/m^3) obtained from the selected work area in B factory.

Metal	Furnace area						Casting area			
	8hrs personal sampling(n=3)		8hrs area sampling(n=3)		15 mins personal sampling(n=4		8hrs personal sampling(n=2)		8hrs area sampling(n=3)	
	mean (min-max)	GSD	mean (min-max)	GSD	mean (min-max)	GSD	mean (min-max)	GSD	mean (min-max)	GSD
Al	72.1 (68.5-75.8)	1.05	108 (28.5-175)	2.62	116 (64-207)	1.88	11.7 (9.99-13.5)	1.24	7.19 (6.19-8.19)	1.15
Cr	0.10 (0.07-0.12)	1.38	0.16 (0.08-0.20)	1.63	0.29 (0.19-0.55)	1.61	0.10 (0.03-0.17)	3.09	0.03 (0.01-0.07)	2.76
Mg	14.9 (13.3-15.9)	1.1	23.0 (6.32-37.4)	2.55	39.3 (21.4-65.8)	1.61	9.91 (8.45-11.4)	1.23	3.82 (3.05-5.02)	1.3
Fe	10.8 (9.16-12.7)	1.18	14.3 (4.27-22.0)	2.41	14.2 (4.48-25.3)	2.4	7.86 (7.79-7.93)	1.01	3.79 (2.52-5.09)	1.42
Co	0.02 (0.02-0.03)	1.23	0.02 (0.005-0.04)	3.09	0.03 (0.02-0.22)	3.10	0.004 (0.004-0.005)	1.08	0.005 (0.003-0.008)	1.58
Ni	0.13 (0.12-0.14)	1.07	0.17 (0.04-0.25)	2.75	1.20 (0.33-1.99)	2.53	0.05 (0.04-0.07)	1.47	0.04 (0.036-0.038)	1.04
Cu	0.36 (0.31-0.40)	1.14	0.49 (0.19-0.78)	2.01	0.83 (0.51-1.65)	1.74	0.12 (0.098-0.14)	1.25	0.07 (0.05-0.08)	1.22
Zn	3.14 (2.77-3.42)	1.12	3.59 (0.88-5.14)	2.71	5.23 (1.20-13.1)	3.83	1.28 (1.21-1.35)	1.08	0.82 (0.65-0.99)	1.24
Pb	0.16 (0.09-0.22)	1.82	0.14 (0.09-0.22)	1.65	0.92 (0.22-1.45)	2.75	0.06 (0.05-0.06)	1.24	0.07 (0.02-0.11)	2.33

Table 4. The metal concentrations (μg/m^3) obtained from the selected work area in C factory.

Metal	Furnace area				Casting area	
	15 mins personal sampling(n=1)		8hrs area sampling(n=2)		8hrs personal sampling(n=8)	
	mean (min-max)	GSD	mean (min-max)	GSD	mean (min-max)	GSD
Al	112	-	18.1 (10.5-25.8)	1.89	41.4 (8.36-181)	2.51
Cr	*	-	*	-	0.20 (0.04-0.31)	2.1
Mg	26.3	-	3.23 (2.04-4.43)	1.73	16.9 (2.78-64.2)	2.91
Fe	49.3	-	5.48 (2.93-8.02)	2.04	14.8 (5.43-22.9)	1.61
Co	0.14	-	0.08**	-	0.02 (0.02-0.05)	1.51
Ni	0.14	-	0.25**	-	0.08 (0.02-0.18)	2
Cu	0.42	-	0.16**	-	0.58 (0.05-1.62)	3.27
Zn	5.18	-	1.65 (1.25-2.05)	1.42	3.45 (0.87-14.5)	2.45
Pb	0.23	-	0.23**	-	0.16 (0.11-0.73)	1.97

* : <1/2 MDL, ** : n=1

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