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Comparison study particulate samplers

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A Comparison of the Performance of Samplers for Respirable Dust in Workplaces and Laboratory Analysis for Respirable Quartz

Verpaele S., Joret J., A comparison of respirable dust sampling techniques and the analysing techniques for respirable quartz, *Annals of Occupational Hygiene*, Vol 57 number 1, January 2013

A Comparison of Samplers for Inhalable Welding Fumes and Laboratory Analysis for Manganese

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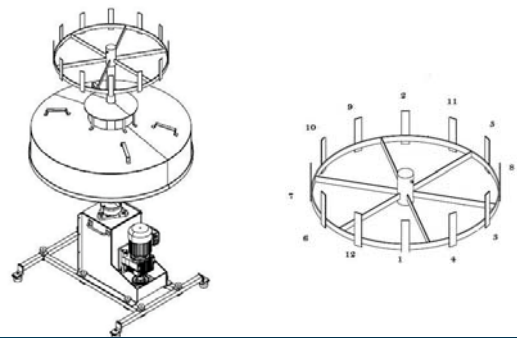


Introduction

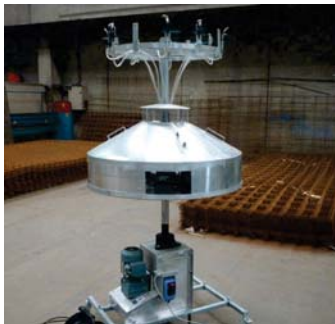
- All samples were taken with the Workplace Atmosphere Multisampler
- Real workplace samples
- Goal:
- What are the differences in methods and techniques and how are these figures related?
- Can we use the WAM for workplace comparison studies?



Materials



Workplace Atmosphere Multisampler: WAM

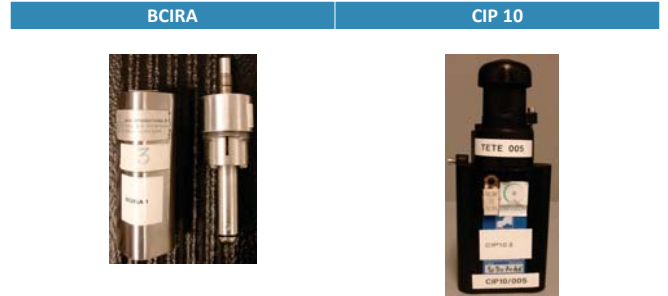


Workplace Atmosphere Multisampler: WAM



Respirable sampler study

Materials



Materials

Casella SIMPEDS (Reference sampler)
SKC Conductive Plastic Cyclone



Materials

Dorr Oliver 10 mm nylon cyclone
SKC Conductive Plastic Cyclone

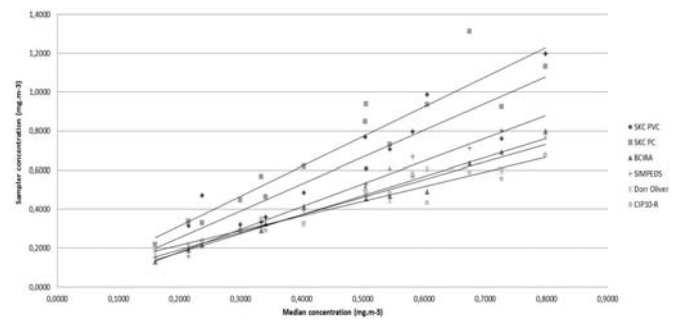


Materials

Sampler	Pump	Filter(Diameter, pore size)	Analytical method(s)/ laboratory	Standard/normative	Equipment
SKC 1	Back-VSS 5	PVC 25mm (5 µm)	IR direct-on-filter IR KBr disk method	MDHS 101 (HSE, 2005) NIOSH 7602 (NIOSH, 2003)	Bruker Tensor 27 Perkin Elmer 100 FTIR
SKC 2	Gilair 5000	PC 25 mm (0.8 µm)	XRD direct-on-filter	MDHS 101 (HSE, 2005)	Panalytical PW3830
BCIRA	Gilair-5	PC 25mm (0.8 µm)	XRD direct-on-filter	MDHS 101 (HSE, 2005)	Panalytical PW1729
SIMPEDS	Back-VSS 5	PVC 25mm (5 µm)	XRD direct-on-filter	MDHS 101 (HSE, 2005)	Panalytical X-pert pro-MPD
Dorr Oliver	Back-VSS 5	PVC 25mm (5 µm)	XRD direct-on-filter (in-house method)	NIOSH 7500 (calibration line) (NIOSH, 2003)	Bruker D8
CIP10-R	PUR 45 ppi		XRD re-deposition	NF X 43-295 (AFNOR, 1995a) NF X 43-296 (AFNOR, 1995b)	Bruker D8

- Calibration before and after sampling (same sampling train)
 - Bios DryCal and Sensidyne Gilibrator
 - Photo tachometer (CIP10-R)
- Each laboratory analyzed their own samples
- Leak tests for all samplers (0,1 bar drop as leak-free limit)

Gravimetric results



Gravimetric results

Sampler	Trend equations	R ²
SKC PC	$y = 1.52x + 0.008$	0.90
SKC PVC	$y = 1.35x - 0.013$	0.84
SIMPEDS	$y = 1.14x - 0.045$	0.98
BCIRA	$y = 0.96x - 0.012$	0.97
Dorr Oliver	$y = 0.90x + 0.008$	0.96
CIP10-R	$y = 0.74x + 0.068$	0.92

- Slopes from 0.74 to 1.52
- Comparable results in the WP-WAM as in the laboratory (Stacey 2010, Mecchia 2009)
 - SKC HD oversamples (35-52% relative)
 - CIP10-R undersamples (26% relative)
- BCIRA, SIMPEDS and Dorr Oliver closest to median amount of dust
- We should be aware of the influence of the filter
 - SKC HD cyclones, especially with PC filter, gave lower p-values
 - SKC HD with PC filter slightly oversamples in comparison with SKC HD with PVC
- Significant differences in the quartz and brickworks industry for the SKC HD cyclones (<.005)

Impact of deposition on Quartz analysis



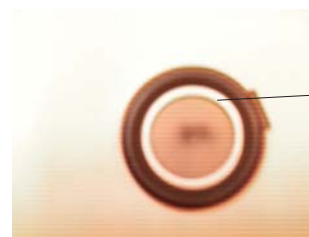
SKC cyclone – more dust in the middle → direct analyses will give a higher result

Impact of deposition on Quartz analysis



BCIRA cyclone – more uniform distribution → more accurate result

Impact of deposition on Quartz analysis



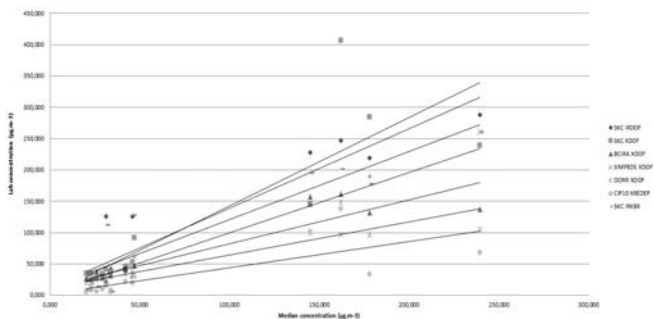
Dust on the edge → typical for a leaking cyclone

Casella cyclone – more dust in the middle and the edges → direct analyses will give different results

leak in the cyclone

Remark – this is depending on the workplace dust

Quartz analysis



Quartz analysis

Analysis	Trend equations	R ²
SKC PC	$y = 1.41x + 1.325$	0.75
SKC PVC IRDOF	$y = 1.27x + 12.69$	0.88
SKC PVC KBr	$y = 1.09x + 11.99$	0.85
SIMPEDS	$y = 0.96x + 3.093$	0.92
BCIRA	$y = 0.70x + 12.19$	0.86
Dorr Oliver	$y = 0.53x + 11.44$	0.82
CIP10-R	$y = 0.42x + 2.430$	0.57

- Slopes from 0.42 to 1.41
- Of course, differences obtained in dust concentrations influence the amount of quartz
- Underestimation of quartz for the CIP10-R (p<.005)
- IR methods (DOF & KBr) show significant differences (p<.005)
- Due to oversampling
- Surprisingly difference for techniques using IR when cristobalite was sampled in quartz industry
- R² decreasing compared to gravimetric data

Inhalable sampler study

Materials

Conductive plastic IOM

Stainless steel IOM



Validation inhalable sampler comparison

- According to Witschger et al. "Simplified Method for Testing Personal Inhalable Aerosol Samplers", J. of Aerosol Science, 29:855-874 (1998) a torso is needed when inhalable samplers are compared
- A torso was used next to the WAM runs



WAM: Validation - results

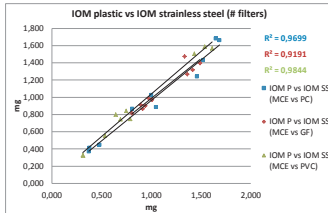
- Is a torso required in a workplace – calm air conditions?
 - The variation between the WAM and the Simplified Torso was not more than 4,9% → OK
- Does the WAM equally sample?
 - The average variation of the 3 runs was 5,5% → OK



WAM can be used for a comparison study of inhalable samplers

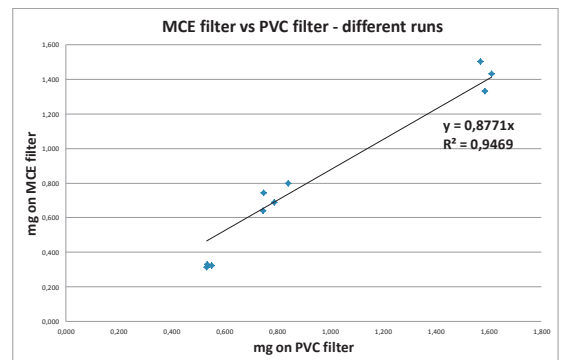
Results - Comparison inhalable samplers

- 2 types of samplers were compared with different filters
 - MCE filter was used as a reference filter
 - Plastic IOM and cassette vs Stainless steel IOM and cassette

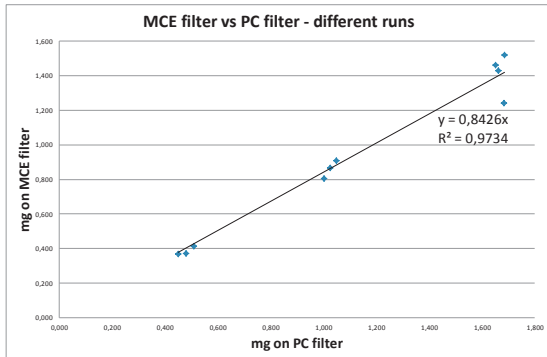


No significant difference between the two samplers

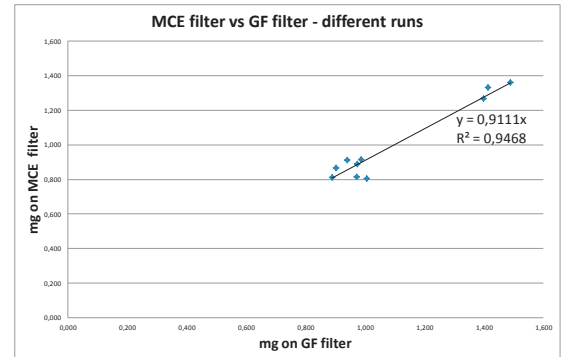
Results - Comparison filters used



Results - Comparison filters used



Results - Comparison filters used

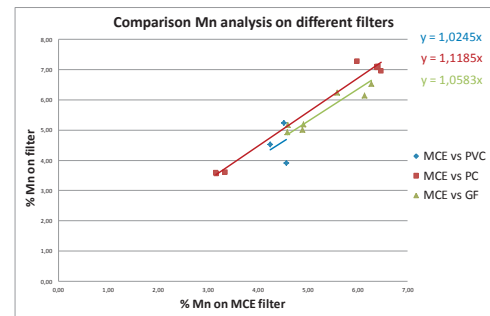


Results - Comparison Manganese analysis

- Three different laboratories performed the analysis of manganese on the different filters:
 - Using there in house method
 - 2 laboratories used Inductive Coupled Plasma (ICP)
 - One laboratory used ICP-AES
 - One laboratory used ICP-MS
 - 1 laboratory used Atomic Absorption Spectroscopy AAS



Results - Comparison Manganese analysis



More results needed to verify those preliminary results



Conclusion

- 3 mayor groups of respirable samplers
 - SKC HD: oversampling
 - BCIRA, SIMPEDS and Dorr Oliver: median
 - CIP10-R: under sampling
- Importance of different filters used in inhalable samplers
 - Gravimetric analysis found that the MCE filters were under sampling
 - compared to the PVC ($y=0.88x$)
 - compared to the PC ($y = 0.82x$)
 - compared to the GF ($y = 0.91x$)
 - No significant differences were found in between the types of filters
 - No significant differences were found between the IOM plastic sampler and cassette and the IOM stainless steel sampler and cassette



Conclusion

- No significant differences where found between the methods. Although it seems that lower concentrations are more accurately measured by ICP techniques
- Manganese analysis showed that MCE filters retain more manganese compared to PC and GF
- Manganese analysis showed that MCE filters retain more manganese compared to the other filters
 - 2% more than PVC filters
 - 6% more compared to GF filters
 - 13% more compared to PC filters



Discussion

- Usage of the WAM made it possible to organise a comparison in the workplace
- There is a necessity of using overall SOP's (following international standards as strictly as possible)
- Reproducible results between the laboratory and the workplace have been demonstrated
 - Further work is needed in the workplace
 - Interferences
 - Behaviour of the sampler
 - Combined with impactor data to interpret the differences in sampling efficiency (thus amount of sampled dust)



Discussion

- Further research is necessary to determine the retention of metals and metalloids on different filters
- More comparisons of analysing techniques for metals and metalloids are necessary to have a better understanding of the differences (low concentration range)
- Could those differences explain the differences in metabolite results? Especially for welding fumes.




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Merci pour votre attention

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