The use of optical counter as sizing instrument and as reference instrument for PM regulated monitoring

Bergmans B. – Lenartz F. – Spanu L. – Gerard G.

REGION WALLONNE

ISSEP : CORE BUSINESS

ISSeP : Main activity

ENVIRONMENTAL MONITORING
Air
Water
soil

RISK EVALUATION

RESEARCH & TECHNOLOGY

ENVIRONMENTAL MONITORING

Air
Water
soil






REGION WALLONNE

ISSEP : CORE BUSINESS

ISSeP : Main activity

ISSEP

PM monitor

Sizing monitor

Conclusions

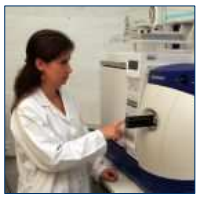
ENVIRONMENTAL MONITORING
Air
Water
soil

RISK EVALUATION

RESEARCH & TECHNOLOGY

REFERENCE LABORATORY FOR WALLONIA






REGION WALLONNE

ISSEP : CORE BUSINESS

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PM monitor

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OCAA: Optical Characteristic of Atmospheric Aerosol – Smolenice (Slovakia) – 4-8/11/2013

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PM monitor

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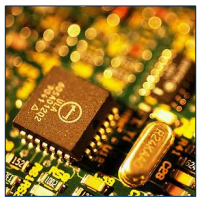

REGION WALLONNE

ISSEP : CORE BUSINESS

ISSeP : Air quality department

ISSEP

PM monitor

Sizing monitor

Conclusions

ENVIRONMENTAL MONITORING
Air
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RISK EVALUATION

RESEARCH & TECHNOLOGY

ENVIRONMENTAL MONITORING

Air

- AIR MONITORING
  - Ambient air network
  - Mobile laboratories
  - Emission monitoring
- REFERENCE LABORATORY
  - Audit RW
  - Sector operator (NBN)
- TECHNICAL ADVISE
- RESEARCH FACILITIES
  - Pilot installation
  - Research program

REGION WALLONNE

OPC for PM monitoring

Introduction

The use of optical counter as reference instrument for PM regulated monitoring

ISSEP

PM monitor

Sizing monitor

Conclusions

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OPC for PM monitoring

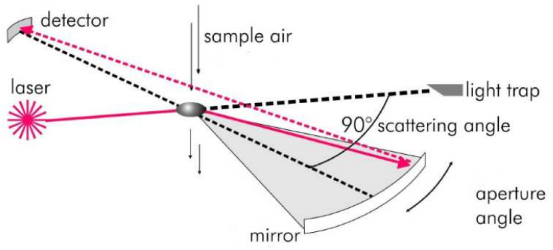
Introduction

ISSEP

PM monitor

Sizing monitor

Conclusions



+Telemetric network
+Low maintenance / cost
+Continuous monitoring
+PM10 / PM2.5 in one devise

-Spherical single particles
-“Average” density is used

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OCAA: Optical Characteristic of Atmospheric Aerosol – Smolenice (Slovakia) – 4-8/11/2013

OPC for PM monitoring

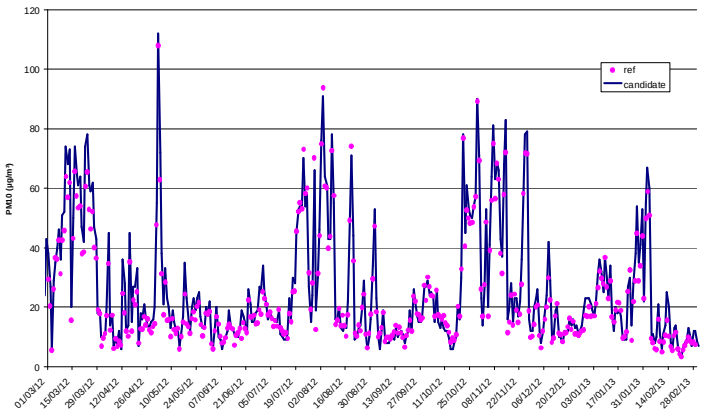
Raw result visualization

ISSEP

PM monitor

Sizing monitor

Conclusions



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OPC for PM monitoring

Intra-method variation

ISSEP

PM monitor

Sizing monitor

Conclusions

$$u_{bs}^2 = \frac{\sum_{i=1}^{n}(y_{i,1} - y_{i,2})^2}{2n}$$

where

$y_{i,1}$ and $y_{i,2}$ are the results of parallel measurements for a single 24-hour period i

n = number of 24-hour measurement results.

Ubs (µg/m³)	Sites				Full Data set		
Grimm EDM180	Angleur	Corroy	Jemeppe	Lodelinsart	U cand	> ou = VL	< VL
PM10	2,26	1,64	1,19	0,48	1,56	2,5	1,23
PM2,5	2,05	1,75	0,68	0,4	1,44	2,17	0,63

Ubs (µg/m³)	Sites				Full Data set		
LECKEL SEQ47/50	Angleur	Corroy	Jemeppe	Lodelinsart	U cand	> ou = VL	< VL
PM10	1,01	0,86	1,19	0,55	0,93	1,02	0,87
PM2,5	0,97	0,74	0,7	0,99	0,89	0,89	0,88

Intra-method variation is less below 2 µg/m³ which proved that both candidate and reference methods are well under control

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OPC for PM monitoring

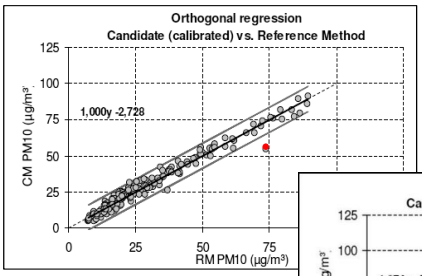
Data treatments

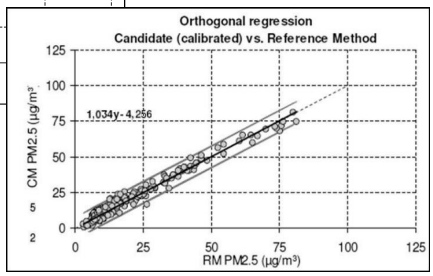
ISSEP

PM monitor

Sizing monitor

Conclusions





- Remove outliers
- Data correction
  (orthogonal regression)

OPC for PM monitoring

Inter-method comparison

ISSEP

PM monitor

Sizing monitor

Conclusions

$$Wcm = K \times \sqrt{\frac{\frac{\sum_{i=1}^{n}(y_i - a - bx_i)^2}{(n-2)} - u^2(x_i) + [a + (b-1)\,x_i]^2}{y^2}}$$

$RSS = \sum_{i=1}^{n}(y_i - a - bx_i)^2$ = sum of (relative) residuals

$u^2(x_i)$ = uncertainty of the results of the reference method.

K = 2

y^2 = 50 for PM10 and = 30 for PM2.5

	PM10		PM2.5	
	regression	Uwc	regression	Uwc
FDS 2011	y = 1.00 x	16.5%	y = 1.00 x	39.5%
FDS 2011	y = 1.00 x + 2.73	12.5%	y = 1.03 x - 4.26	17.7%

OPC for PM monitoring

Results for PM10 and discussion

ISSEP

PM monitor

Sizing monitor

Conclusions

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	PM10							
	ax	b	zx	Wcm site	Wcm FDS year	Wcm FDS 2011	Wcm 1/ 1.03	Wcm 1/ 1.10
Lodelinsart 2009	1.07	-0.48	1.06	8;56	8.56	9.73	10.02	11.42
Angleur 2010	1.02	-6.44	0.82	23.80	11.70	33.52	28.52	
Lodelinsart 2010	1.07	-0.48	0.86	27.50	12.50	38.54	32.52	
Jemeppe 2010	1.08	-5.84	0.93	17.60	17.60	23.40	19.62	
Corroy 2010	1.09	-6.12	0.88	10.60	10.90	19.40	15.50	
FDS 2010	1.03	-5.16	0.87	19.80	11.60	29.10	24.26	
Angleur 2011	1.05	0.16	1.05	13.90	12.50	12.50	10.40	14.90
Lodelinsart 2011	1.33	-3.04	1.18	55.30	44.50	44.50	44.90	57.40
Jemeppe 2011	0.92	5.51	1.14	16.30	16.10	16.10	14.70	14.30
Corroy 2011	1.00	2.28	1.05	14.40	11.30	11.30	11.50	20.80
FDS 2011	1.00	2.73	1.07	16.50	12.50	12.50	12.70	16.10
Angleur 2012	1.20	-1.43	1.15	35.40	25.00	25.00	28.50	19.90
Lodelinsart 2012	1.07	0.11	1.07	17.90	10.40	11.50	13.00	10.10
Herstal 2012	0.98	-0.67	0.96	12.80	23.50	20.80	16.40	30.10
Sinsin 2012	1.18	0.93	1.23	41.60	23.80	31.10	32.70	17.00
FDS 2012	1.08	0.11	1.08	21.00	12.50	14.50	16.00	15.70
MOYENNE	1.08	-1.25	1.03 1.10	23.93	18.32	23.97	22.36	23.06
SIGMA	0.11	3.60	0.13 0.08	13.71	9.87	10.94	10.83	15.08

OPC for PM monitoring

Results for PM10 and discussion

ISSEP

PM monitor

Sizing monitor

Conclusions

REGION WALLONNE

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OCAA: Optical Characteristic of Atmospheric Aerosol – Smolenice (Slovakia) – 4-8/11/2013

OPC for PM monitoring

Results for PM10 and discussion

ISSEP

PM monitor

Sizing monitor

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MOYENNE	1.08	-1.25	1.03	1.10	23.93	18.32	23.97	22.36	23.06
SIGMA	0.11	3.60	0.13	0.08	13.71	9.87	10.94	10.83	15.08

OPC for PM monitoring

Results for PM10 and discussion

ISSEP

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Sinsin 2012	1.18	0.93	1.23		41.60	23.80	31.10	32.70	17.00
FDS 2012	1.08	0.11	1.08		21.00	12.50	14.50	16.00	15.70
MOYENNE	1.08	-1.25	1.03	1.10	23.93	18.32	23.97	22.36	23.06
SIGMA	0.11	3.60	0.13	0.08	13.71	9.87	10.94	10.83	15.08

OCAA: Optical Characteristic of Atmospheric Aerosol – Smolenice (Slovakia) – 4-8/11/2013

OPC for PM monitoring

Results for PM10 and discussion

ISSEP

PM monitor

Sizing monitor

Conclusions

REGION WALLONNE

	PM10								
	ax	b	zx		Wcm site	Wcm FDS year	Wcm FDS 2011	Wcm 1/ 1.03	Wcm 1/ 1.10
Lodelinsart 2009	1.07	-0.48	1.06		8,56	8.56	9.73	10.02	11.42
Angleur 2010	1.02	-6.44	0.82		23.80	11.70	33.52	28.52	
Lodelinsart 2010	1.07	-0.48	0.86		27.50	12.50	38.54	32.52	
Jemeppe 2010	1.08	-5.84	0.93		17.60	17.60	23.40	19.62	
Corroy 2010	1.09	-6.12	0.88		10.60	10.90	19.40	15.50	
FDS 2010	1.03	-5.16	0.87		19.80	11.60	29.10	24.26	
Angleur 2011	1.05	0.16	1.05		13.90	12.50	12.50	10.40	14.90
Lodelinsart 2011	1.33	-3.04	1.18		55.30	44.50	44.50	44.90	57.40
Jemeppe 2011	0.92	5.51	1.14		16.30	16.10	16.10	14.70	14.30
Corroy 2011	1.00	2.28	1.05		14.40	11.30	11.30	11.50	20.80
FDS 2011	1.00	2.73	1.07		16.50	12.50	12.50	12.70	16.10
Angleur 2012	1.20	-1.43	1.15		35.40	25.00	25.00	28.50	19.90
Lodelinsart 2012	1.07	0.11	1.07		17.90	10.40	11.50	13.00	10.10
Herstal 2012	0.98	-0.67	0.96		12.80	23.50	20.80	16.40	30.10
Sinsin 2012	1.18	0.93	1.23		41.60	23.80	31.10	32.70	17.00
FDS 2012	1.08	0.11	1.08		21.00	12.50	14.50	16.00	15.70
MOYENNE	1.08	-1.25	1.03	1.10	23.93	18.32	23.97	22.36	23.06
SIGMA	0.11	3.60	0.13	0.08	13.71	9.87	10.94	10.83	15.08

OPC for PM monitoring

Results for PM2.5 and discussion

ISSEP

PM monitor

Sizing monitor

Conclusions

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	PM2.5								
	ax	b	Zx		Wcm site	Wcm FDS year	Wcm FDS 2011	Wcm 1/ 1.16	Wcm 1/ 1.25
Lodelinsart 2009	1.06	1.79	1.13		13.36	13.36	15.72	17.94	16.81
Angleur 2010	1.00	-2.06	0.91		15.00	6.60	6.82	1.18	-
Lodelinsart 2010	0.92	-1.21	0.89		25.00	12.10	34.80	42.58	-
Jemeppe 2010	0.95	-0.61	0.93		24.30	20.60	32.78	40.56	-
Corroy 2010	1.06	-2.02	0.97		6.00	16.50	30.22	25.76	-
FDS 2010	0.96	-1.15	0.92		19.80	13.50	33.46	39.32	-
Angleur 2011	0.92	4.58	1.10		31.00	12.30	12.30	9.90	14.90
Lodelinsart 2011	1.63	-1.13	1.51		120.00	81.50	81.50	76.00	57.40
Jemeppe 2011	1.04	4.14	1.37		42.70	21.90	21.90	19.70	14.30
Corroy 2011	1.04	5.67	1.18		48.20	19.80	19.80	20.80	20.80
FDS 2011	1.03	4.26	1.16		39.50	17.70	17.70	16.40	16.10
Angleur 2012	1.28	0.76	1.32		64.00	16.60	30.50	31.50	19.90
Lodelinsart 2012	1.21	0.76	1.25		48.30	10.80	16.30	18.00	10.10
Herstal 2012	1.01	1.25	1.07		16.60	35.30	34.30	21.10	30.10
Sinsin 2012	1.19	2.81	1.35		59.00	14.80	25.90	26.60	17.00
FDS 2012	1.22	1.06	1.27		53.90	15.40	23.20	23.80	15.70
MOYENNE	1.10	1.08	1.16	1.25	41.68	22.40	28.93	27.81	23.06
SIGMA	0.20	2.67	0.21	0.15	30.64	19.97	18.86	19.09	15.08

OPC for PM monitoring

Guard band based on data variability

ISSEP

PM monitor

Sizing monitor

Conclusions

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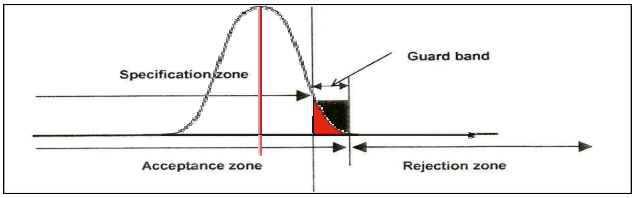


PM10			PM2.5		
SIGMA	U srm	Gard Band	SIGMA	U srm	Gard Band
0.08	1.2	4.1 µg/m³	0.15	1.0	4.5 µg/m³

With a limit value reduced to 46 µg/m³ the number of exceeding increase from 35 to 41 in 2011 and from 56 to 61 en 2012 for the 4 studied sites

OPC as Sizing Instrument

Verification of the sizing for the smallest range

ISSEP

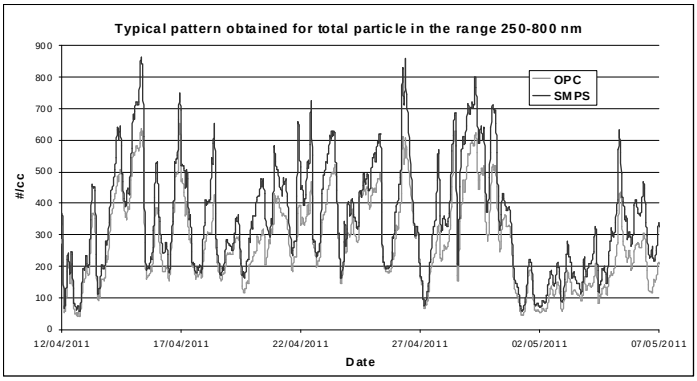
PM monitor

Sizing monitor

Conclusions

REGION WALLONNE

The use of optical counter as sizing instrument



OPC as Sizing Instrument

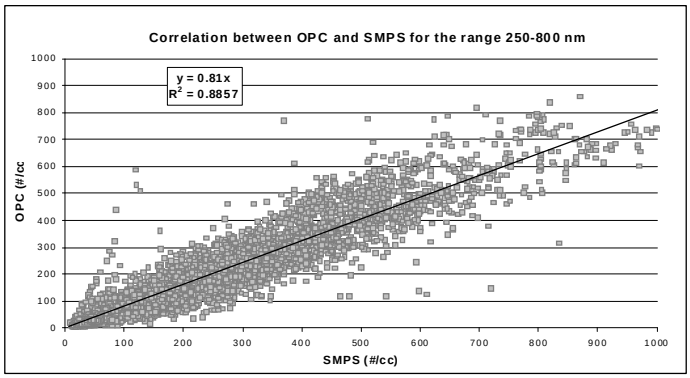
Correlation between OPC and SMPS measurements

ISSEP

PM monitor

Sizing monitor

Conclusions



A Pearson correlation coefficient R=0.94 is observed between OPC and SMPS for sizes between 250 and 800 nm

CONCLUSIONS

General Conclusions and future works

ISSEP

PM monitor

Sizing monitor

Conclusions

- OPC Grimm EDM180 has been proved as to be equivalent to the reference method for PM10 and PM2.5
- Variation of the calibration equation of the OPC between sites and time periods is limited
- Forcing the calibration equation trough zero help in result consistency and data treatment
- The average slope obtained for the regression curve is respectively 1.10 and 1.25 for PM10 and PM2.5
- Good instrument calibration and QA/QC follow up of the reference is compulsory to achieve this result
- Using the typical variability of the correction curve a guard band of 4µg/m³ has been established at the limit value for PM10.
- Data of 2013 trials will be added soon to verify the actual hypothesis
- This value is not too far from the tolerated combined intra-method uncertainty which confirm that the process is well under control.
- The potential overestimation of exceeding links to this value is limited to around 5% during the last two years for the four studied sites
- A Pearson correlation coefficient R=0.94 is observed between OPC and SMPS for sizes between 250 and 800 nm
- OPC can thus be used to determine size distribution on the all range

THANK YOU FOR YOUR ATTENTION

REGION WALLONNE