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ASSESSMENT OF DUST EMISSIONS FROM QUARRIES FOR INVENTORIES AND AIR QUALITY IMPACT STUDIES

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Task Force on Emission Inventories and Projections

25/04/2018 - 27/04/2018

Outline

Implementation of the US AP42 method for the French emission inventory and plant emission reporting

CORTEA EMCAIR research project (Impact assessment of quarries on air quality)

Outline

Implementation of the US AP42 method for the French emission inventory and plant emission reporting

Implementation of the US EPA AP-42 methodology to estimate PM emissions from quarries

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- ✓ Better represent PM emissions from quarries in inventories
  - Based on a recognized methodology (US EPA) already used in several national emission inventories (UK, Germany, Belgium)
- ✓ Develop a calculation tool for emissions reporting (E-PRTR) by plant operators
- ✓ Better assess the impacts of quarries on ambient air quality

One of the largest French quarry (near Calais) (hard rock)

Implementation of the US EPA AP-42 methodology to estimate PM emissions from quarries

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5 main activities causing PM emissions:

1 - Drilling and blasting

2- Treatment installation

crushing/screening/washing/transfer points

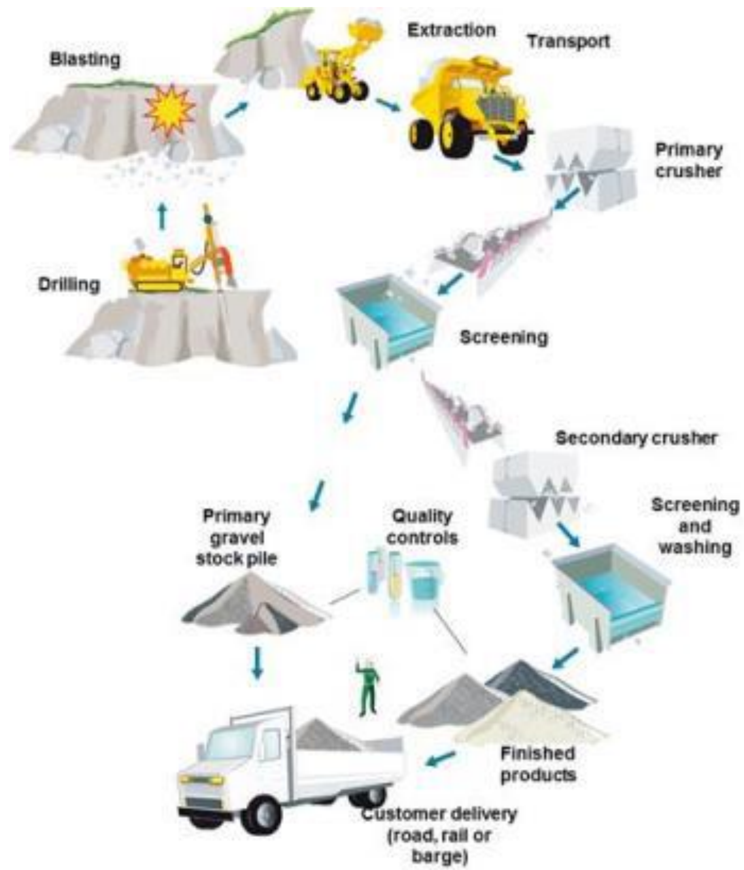
3- Internal transport

From extraction -> treatment and stock -> release career

4 - Storage management

loading/unloading

5 - Erosion of stocks



Hard rock quarrying process

Main characteristics of the US EPA AP-42 methodology for PM emission estimation from quarries

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- ✓ A series of equations developed for the different operations carried out in quarries
- ✓ Many parameters considered such as : type of materials processed, meteorological conditions, type of operations,
- ✓ Abatement measures implemented
- ✓ …

Drilling and blasting

$$E_{TSP} = 0,59 \times N_{trou} + 0,00022 \times S^{1,5} \times N_{tir}$$

With:

- E_{TSP} emissions of TSP (kg)
- N_{trou}: number of holes
- S: area blasted (m^2)
- N_{tir}: number of blasts

Definition of influencing parameters

For the national emission inventory:

- ✓ Definition of 3 types of quarries (more than 4000 quarries in France),
- ✓ Main types of operations carried out,
- ✓ Average rates of use of abatement techniques (such as water spray, filter, enclosure, *etc.*),
- ✓ Average annual meteorological conditions (wind speed, rain…),
- ✓ …

Parameters defined with the help of industry experts, based on national enquiries

For the plant emission reporting (GEREP/EPRTR), definition of specific parameters for the quarry:

- ✓ Materials treated and operations carried out,
- ✓ Observed rate of use of reduction techniques,
- ✓ Observed meteorological conditions…

Parameters specific to each quarry

Operations considered in each type of quarries

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3 main types of quarries considered in the inventory with the following operations:

	Hard rock	Alluvial rock	Recycling
1 - Drilling and Blasting	X		
2- Treatment operations	X	X	X
3- Internal transport in the quarry	X	X	
4 - Storage management	X	X	X
5 - Erosion of stocks	X	X	X

Emission factors determined from US EPA 42 method

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AP-42 methodology applied for TSP, PM10 and PM2.5.

Type of quarry	*PM fraction*	*% distribution*	Emission factor (g/t)
Hard rock	TSP		**178.8**
	PM_{10}	31 %	55.2
	$PM_{2.5}$	4 %	6.7
	$PM_{1.0}$	*(nd)*	-
Alluvial rock	TSP		**11.3**
	PM_{10}	29 %	3.3
	$PM_{2.5}$	3 %	0.4
	$PM_{1.0}$	*(nd)*	-
Recycling	TSP		**43.7**
	PM_{10}	37 %	16.0
	$PM_{2.5}$	5 %	2.2
	$PM_{1.0}$	*(nd)*	-

Hard rock quarries are the most emissive

[OMINEA, 2017]

Comparison of new EF determined with EMEP guidebook EF for France

g/t materials	Average EF estimated (2016)	EMEP GUIDEBOOK Low to medium emission level	EMEP GUIDEBOOK Medium to high emission level
TSP	107	102 (50 to 200)	51 (25 to 100)
PM10	33	50 (25 to 100)	25 (13 to 50)
PM2.5	4	5 (2.5 to 10)	3.8 (1.9 to 7.6)

NFR/CRF 2A5 - Emissions from quarrying and mining of minerals other than coal in France

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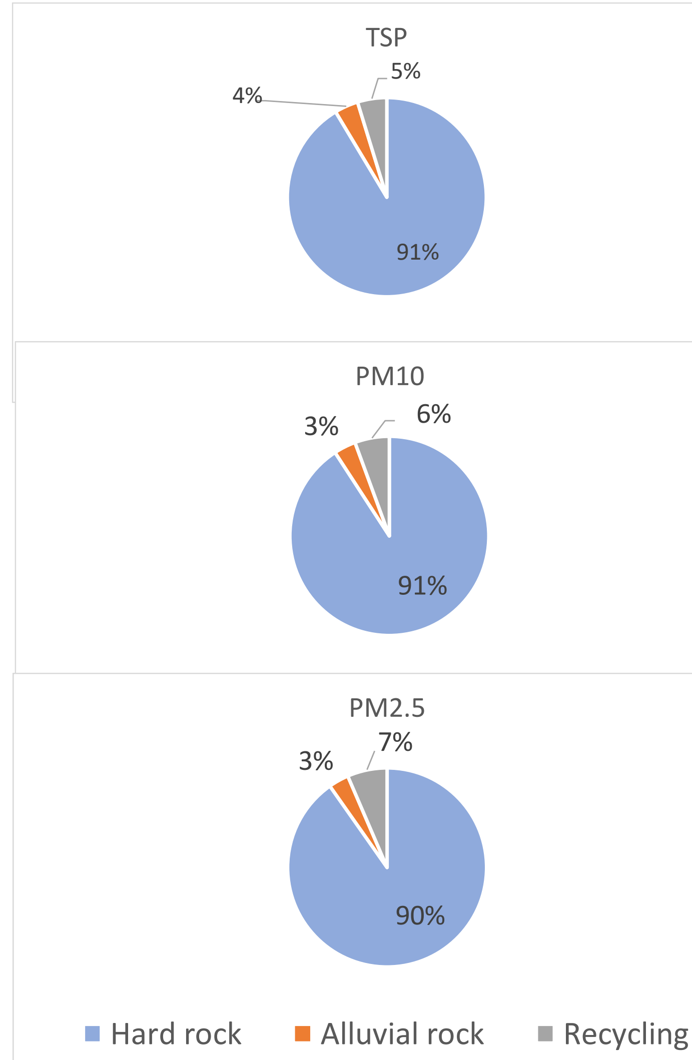
Emissions (Mg)		2016
Hard rock	TSP	21 205
	PM10	6 551
	PM2.5	795
Alluvial rock	TSP	893
	PM10	258
	PM2.5	29
Recycling	TSP	1 104
	PM10	405
	PM2.5	57
Total	*TSP*	*23 202 (2,8% of national emissions)*
	PM10	*7 214 (2,8% of national emissions)*
	PM2.5	*880 (0,5% of national emissions)*



Quarry operators : mandatory emission reporting

Annual reporting from quarries in the **French Registry for air pollutants** (GEREP) (application of E-PRTR regulation) mandatory from the following thresholds:

- *50 000 kg PM10 / year*
- *100 000 kg TSP / year*

✓ An **excel tool and a guidance developed** by CITEPA in cooperation with the French Quarry association (UNICEM) based on US EPA 42 methodology

✓ Objectives : help operators to better estimate and report their dust emissions.

✓ Tool and guidance available on the website GEREP

https://www.declarationpollution.developpement-durable.gouv.fr/gerep/afficherGuideAidePopup.do?methode=lecture

Characteristics of the reporting tool

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Methodology and emission factors from the AP-42 (US EPA) applied

Estimation of PM10 and TSP from the following activities:

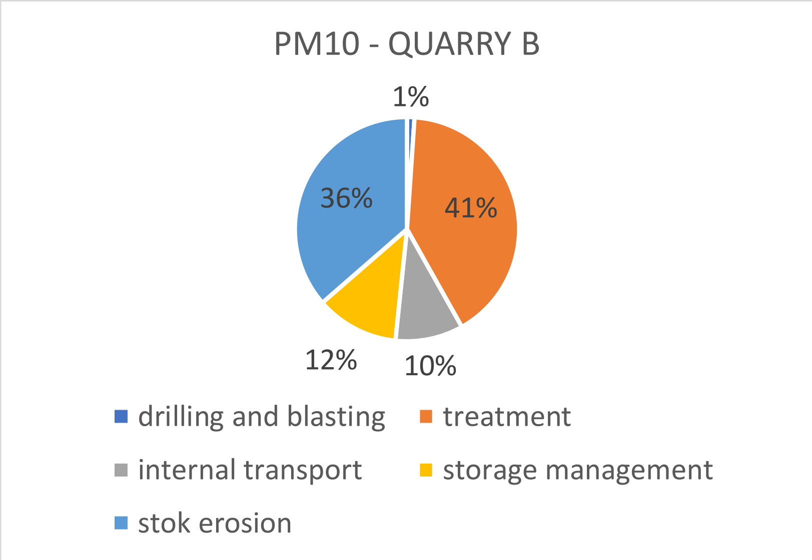
1 - Drilling and Blasting
2- Treatment installation (crushers/screens/transfer points)
3- Internal transport to the quarry (extraction -> treatment and stock -> release career)
4 - Storage management (loading/unloading)
5 - Erosion of stocks

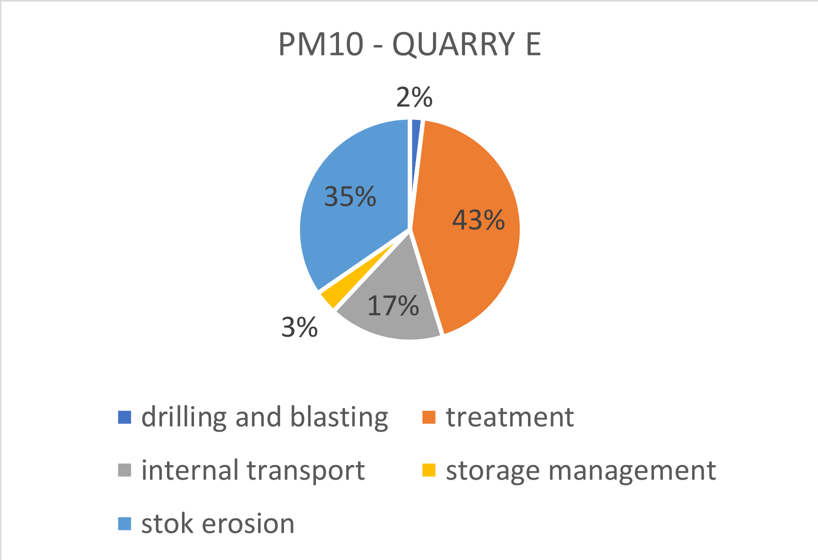
Tool tested under different real cases and adaptable to different configurations

Tool and guidance validated by the French Ministry for an Ecological and Solidary Transition

Specific site TSP and PM10 emissions reported

	TSP EF g/t material	PM10 EF g/t material
SITE A (GNEISS)	162.4	57.4
SITE B (GNEISS)	137	54.4
SITE E (LIMESTONE)	95	34.4
INVENTORY	107	33





Outline

Implementation of the US EPA AP42 method for the french emission inventory and plant emission reporting

CORTEA EMCAIR research project (Impact assessment of quarries on air quality)

CORTEA EMCAIR research project (Emissions from Quarries into the Air)

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Objectives:

- ✓ Improve the knowledge of real-world air emissions from quarrying activities and quantify their impacts in the vicinity of the extraction sites
- ✓ Better assess the driving role of meteorological conditions on ambient PM concentrations and their influence on dispersion processes and deposition (dry/wet) mechanisms
- ✓ Determine a specific chemical fingerprint of dust emitted in order to accurately assess the impact of quarries on PM levels in the surrounding area (receptor sites located within 400 to 2,500m distance from the quarry)

Project partly funded by ADEME, led and coordinated by the Aggregate Industry Trade Union (UNPG/UNICEM) with:

- ✓ 3 French Air Quality Monitoring Associations (ASQAA)
- ✓ Research experts,
- ✓ The French national operator for emission inventories (CITEPA)

ADEME Agence de l'Environnement et de la Maîtrise de l'Energie

En partenariat avec :

UNPG Union Nationale des Producteurs de Granulats

The Cyprus Institute

Atmo Hauts-de-France

CITEPA

air Breizh

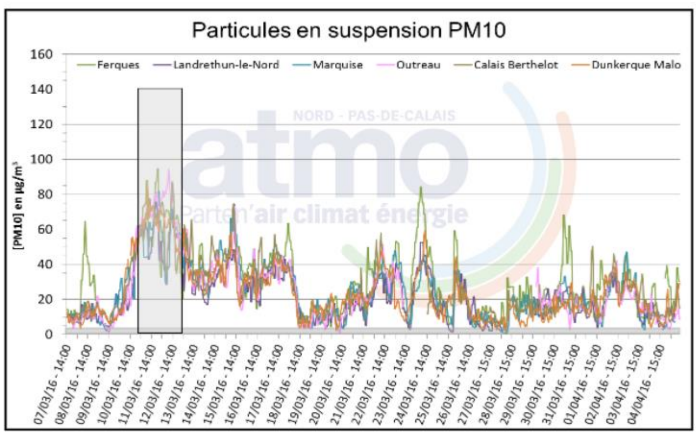
air pays de la loire www.airpl.org

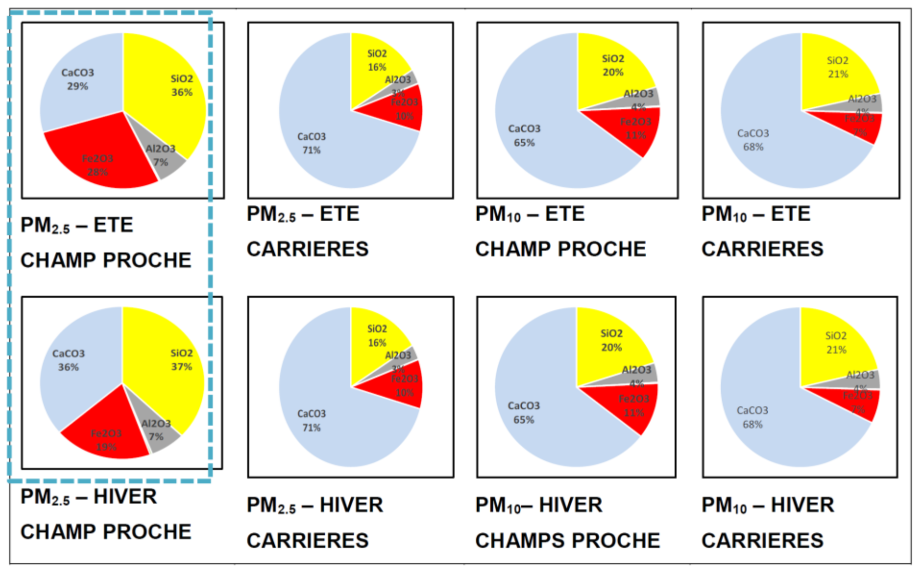
LSCE

CORTEA EMCAIR research project
(Emissions from Quarries into the Air)

Method :

- ✓ 3 representative quarries studied using a similar and well-defined experimental strategy targeting
  - ○ TSP depositions and PM10 and PM2,5 ambient concentration measurements and their chemical characterization
  - ○ Modelling for assessment of air quality
- ✓ Summer and winter intensive (1-month) field campaigns performed for each quarry to better assess the driving role of meteorological conditions on ambient PM concentrations and their influence on dispersion processes and deposition (dry/wet) mechanisms





CORTEA EMCAIR research project - Main results

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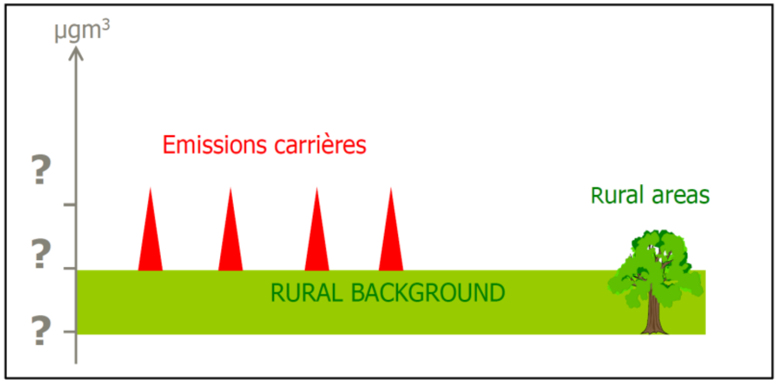
- Highest dust deposition rates observed logically at sampling sites located close to emission sources (inside the quarry))
- Granulometry of deposited dust inside the quarries (measured experimentally) ranges from 0.1 to 250 µm equivalent diameter; a small fraction of which is PM10 and PM2.5 ;
- Chemical fingerprint strongly impacted by the nature of extracted stones (defined from PM chemical analyses (weekly integrated filter sample analyses)),
- Quarry fingerprints and the use of the "Lenschow" methodology made possible to quantify the amount of PM from quarry observed at the receptor sites



CORTEA EMCAIR research project - Main results

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- Sites (upwind/downwind) at distances in the range 400 to 2,500 m from the quarry poorly impacted, with often not detectable atmospheric dust deposition from the quarry, non-detectable PM2.5 concentrations, and detectable PM10 concentrations originating from the quarry for limited time periods.
- More PM10 than PM2.5 in atmospheric emissions of dust from quarries, typical PM2.5/PM10 ratio below 25%

CORTEA EMCAIR research project - Main results

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- A dispersion modelling performed for PM10 emissions from one quarry (ADMS-Urban model) based on PM10 estimated by the GEREP tool (and regional inventory data for emission sources outside the quarry). **The simulation seemed to confirm the relevance of emission factors and methodology proposed by CITEPA, for PM10 emission factors.**

- For TSP, direct measurement tests not totally successful due to the complexity of the quantitative collection of atmospheric aerosols larger than 10 µm diameter; (however, beyond few tens of metres far from the source, quarry dust are mostly PM10)

- **Adjustment of emission factors defined for each quarry operation was not possible from the direct measurements of ambient PM concentrations.** In fact, emission factors linked to a particular operation (Drilling, crushing, storing, transport, etc.) cannot be identified individually from ambient PM concentrations (mainly because the EMCAIR project focused more on the impact of the quarry on air quality than on definition of emissions)

Granulometry of PM from quarries

French inventory based on AP-42 data

	Ratios PM2.5/PM10		Ratios PM2.5/PM10		Ratios PM2.5/PM10
Hard rock	12,1%	Alluvial rock	11,2%	Recycling	14,0%

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- Granulometry of deposited dust at different locations in the quarries (measured experimentally) in a large range from 0.1 to 250 µm equivalent diameter; a small fraction of which is PM10 and PM2.5 with ratios PM2.5/PM10 from 0 to 25%

General conclusions

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- US AP 42 method for quarries can be implemented for emission inventory and plant reporting if enough statistical data are available (types of quarries and materials treated) and influencing parameters determined
- Consultation of quarry experts is essential to implement this methodology and update the parameters from year to year
- PM emissions from quarries ranges from 0.1 to more 250 µm
- In the surrounding zone, the impact of a quarry is rather limited and is represented by PM10

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Thank you for your attention, questions

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Cesbron O. (Air BREIZH), Anquez A., Dufour N., Gimeno R., Vermeesch S. (ATMO Haut de France), Lemaire C. (Air Pays de la Loire), Nicco L., Taïeb N., (CITEPA), Sciare J. (LSCE/The Cyprus Institute), Adam Y., Bio Beri F., Collonge D. (UNICEM) 2018, ÉMISSIONS DES CARRIÈRES DANS L'AIR : études des émissions atmosphériques dans trois régions de France. 276 pages

afaq ISO 9001 Qualité AFNOR CERTIFICATION

EMEP Guidebook - Tier 1 method

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3.2 Tier 1 default approach

3.2.1 Algorithm

The Tier 1 approach uses the general equation:

$$E_{pollutant} = AR_{production} \times EF_{pollutant}$$

Where:

$E_{pollutant}$	=	the emission of the specified pollutant
$AR_{production}$	=	the activity rate for the quarrying/mining
$EF_{pollutant}$	=	the emission factor for this pollutant

The Tier 1 emission factors assume an averaged or typical technology and abatement implementation in the country and integrate all sub-processes.

Table 3.1 Tier 1 emission factors for source category 2.A.5.a Quarrying and mining of minerals other than coal.

Tier 1 default emission factors					
	Code	Name			
NFR source category	2.A.5.a	Quarrying and mining of minerals other than coal			
Fuel	NA				
Not applicable	NO_x, CO, NMVOC, SO_x, NH_3, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, HCH, PCBs, PCDD/F, Benzo(a)pyrene, Benzo(a)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated					
Pollutant	Value	Unit	95 % confidence interval		Reference
			Lower	Upper	
TSP	102	g/Mg mineral	50	200	Visschedijk et al. (2004)
PM_{10}	50	g/Mg mineral	25	100	Visschedijk et al. (2004)
$PM_{2.5}$	5.0	g/Mg mineral	2.5	10	Visschedijk et al. (2004)

EMEP Guidebook - Tier 2 method

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3.3 Tier 2 technology-specific approach

3.3.1 Algorithm

The Tier 2 approach uses the general equation:

$$E_{pollutant} = AR_{production} \times EF_{pollutant} \quad (1)$$

Where:

$E_{pollutant}$ = the emission of the specified pollutant

$AR_{production}$ = the activity rate for the quarrying/mining

$EF_{pollutant}$ = the emission factor for this pollutant

The Tier 2 emission factors assume either a low to medium emission level, or a medium-high to high emission level assuming a typical technology and abatement implementation in a country and integrate all sub-processes.

Table 3.2 Tier 2 emission factors for source category 2.A.5.a Quarrying and mining of minerals other than coal; low to medium emission level.

Tier 2 default emission factors						
	Code	Name				
NFR source category	2.A.5.a	Quarrying and mining of minerals other than coal				
Fuel	NA					
SNAP (if applicable)						
Technologies/Practices	Low to medium emission level					
Region or regional conditions						
Abatement technologies						
Not applicable	NO_x, CO, NMVOC, SO_x, NH_3, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, HCH, PCBs, PCDD/F, Benzo(a)pyrene, Benzo(a)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB					
Not estimated						
Pollutant	Value	Unit	95 % confidence interval		Reference	
			Lower	Upper		
TSP	*51*	*g/Mg mineral*	*25*	*100*	*Visschedijk et al. (2004)*	
PM_{10}	*25*	*g/Mg mineral*	*13*	*50*	*Visschedijk et al. (2004)*	
$PM_{2.5}$	*3.8*	*g/Mg mineral*	*1.9*	*7.6*	*Visschedijk et al. (2004)*	

Table 3.3 Tier 2 emission factors for source category 2.A.5.a Quarrying and mining of minerals other than coal; medium to high emission level.

Tier 2 default emission factors						
	Code	Name				
NFR source category	2.A.5.a	Quarrying and mining of minerals other than coal				
Fuel	NA					
SNAP (if applicable)						
Technologies/Practices	Medium high to high emission level					
Region or regional conditions						
Abatement technologies						
Not applicable	NO_x, CO, NMVOC, SO_x, NH_3, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, HCH, PCBs, PCDD/F, Benzo(a)pyrene, Benzo(a)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB					
Not estimated						
Pollutant	Value	Unit	95 % confidence interval		Reference	
			Lower	Upper		
TSP	*102*	*g/Mg mineral*	*50*	*200*	*Visschedijk et al. (2004)*	
PM_{10}	*50*	*g/Mg mineral*	*25*	*100*	*Visschedijk et al. (2004)*	
$PM_{2.5}$	*5.0*	*g/Mg mineral*	*2.5*	*10*	*Visschedijk et al. (2004)*	

Treatment installation

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$$E_{TSP} = P \times \left(\sum_{conc} FE_{TSP_{conc}} \times Débit_{conc} \times (1 - ER_{conc}) + \sum_{crib} FE_{TSP_{crib}} \times Débit_{crib} \times (1 - ER_{crib}) + \sum_{tran} FE_{TSP_{crib}} \times Débit_{tran} \times (1 - ER_{tran}) \right)$$

- E_{TSP} : emissions of TSP (in kg)
- P: production (in Mg)
- Débit: material throughput in the different treatment process
- FE: emission factor (common for all type of materials treated)
- ER abatment factor (in %), depending on the reduction technology implemented

Stage of the process	Flow (% of the production treated)		
	Primary	Secondary	Tertiary
Crushing	100	50	30
Screening	100	120	170

Stage of the process	FE : Emission Factor (kg/t)	
	Dry Uncontrolled	Wet
Crushing	0,0027	0,0006
Screening	0,0125	0,0011
Transfer points	0,0015	0,00007

Stage of process		ER (abatement factor)
Crushing	Partial enclosure	85%
	Full enclosure	90%
	Water spray	75%
	Filter (electrostastic or bag)	95%
Screening	Full enclosure	50%
	Water spray	75%
Transfer points	Water spray	95%
-	No control	0%

Internal transport

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$$E_{TSP} = 1,381 \times \left(\frac{s}{12}\right)^{0,7} \times \left(\frac{P_{véhicule}}{2,72}\right)^{0,45} \times d_{non\ revêtue} \times (1 - ER) + 0,076 \times d_{revêtue}$$

- E_{TSP}: TSP emissions (in kg)
- $d_{non\ revêtue}$: total distance traveled by vehicles on unpaved roads (in km),
- $d_{revêtue}$: total distance traveled by vehicles on paved roads (in km),
- $P_{véhicule}$: average vehicle weight (in t)
- s: the fines (< 63 µm) content of the surfacing material (in %), this default value is 1.6% for hard rock and 0.8% for the alluvial rock
- ER: abatment factor (in %), changing according to the reduction technology implemented

Reduction technology	ER (abatement factor)
Percentage of rainy days during the year	Percentage of rainy days per year %
Water spray twice daily	55%
Water spray more twice daily	70%
No control	0%

Storage management

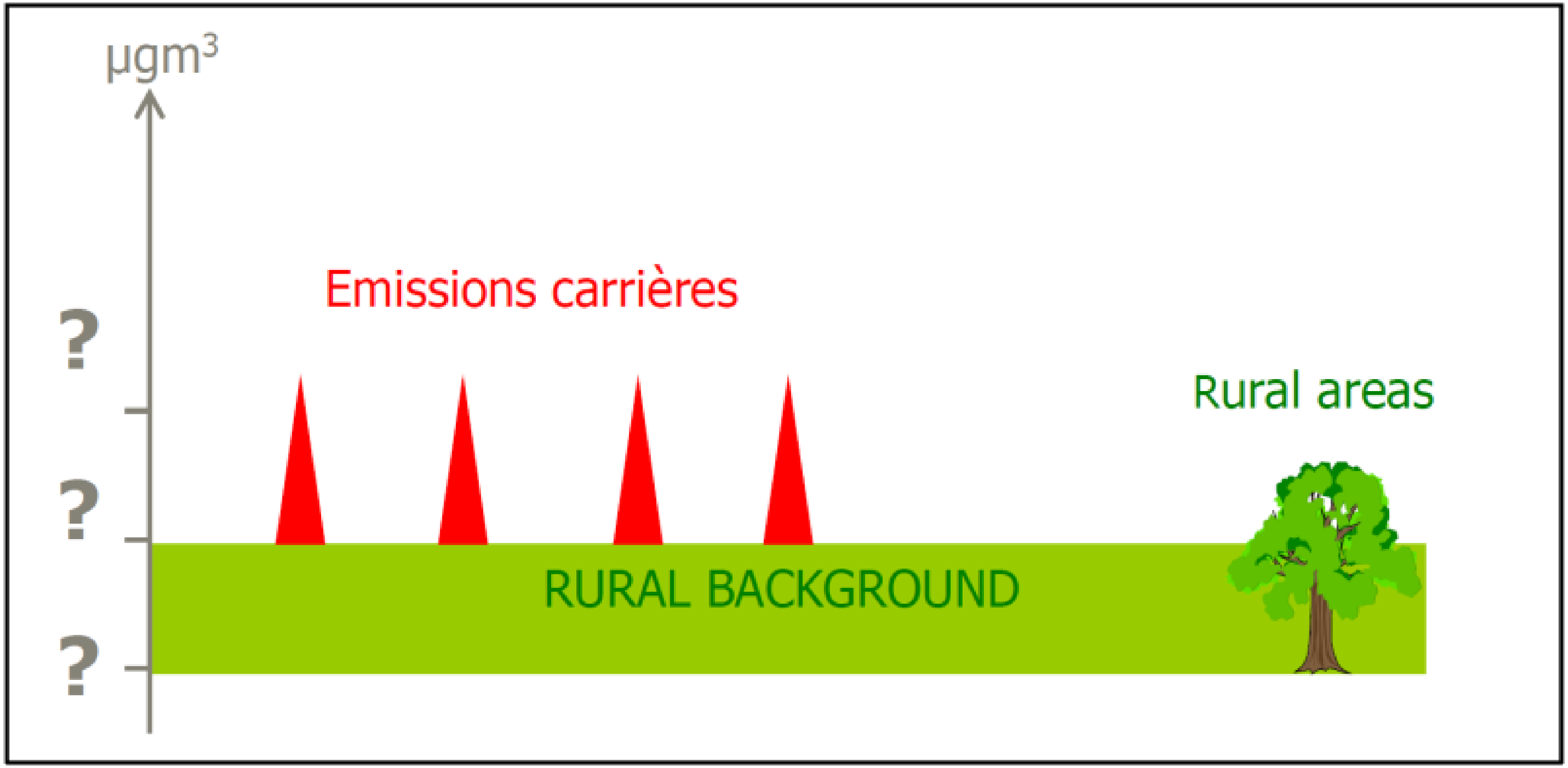
$$E_{TSP} = 0,74 \times 0,0016 \times \frac{\left(\frac{U}{2,2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1,4}} \times Q_{matériau\ manipulé}$$

- E_{TSP} : emissions of TSP (in kg)
- U: average wind speed (in m/s)
- M: moisture content of the material (in %), default loose rock 6% and other 2%
- Q matériau manipulé: material handled (in t), assumptiums each stock manipulated twice.

Erosion of stocks

$$E_{TSP} = 1,12.10^{-4} \times 1,7 \times \left(\frac{s}{1,5}\right) \times \left[365 \times \frac{(365 - P)}{235}\right] \times \left(\frac{I}{15}\right) \times \pi \times R \times \sqrt{(R^2 \times H^2)}$$

- E_{TSP}: emissions of TSP (in kg),
- P: number of rainy days per year,
- I: percentage of day with a wind speed larger than 19.3 km/h,
- S: average content of fine (<63µm) of the storage pile (in %)


µgm3
Emissions carrières
Rural areas
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RURAL BACKGROUND