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Reducing uncertainty of Methane recovered (R) in greenhouse gases inventories from waste sector and of Adjustement factor (AF) in landfill gas recovery projects under the CDM.

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Brazilian National GHG Emissions Inventory from Waste Sector

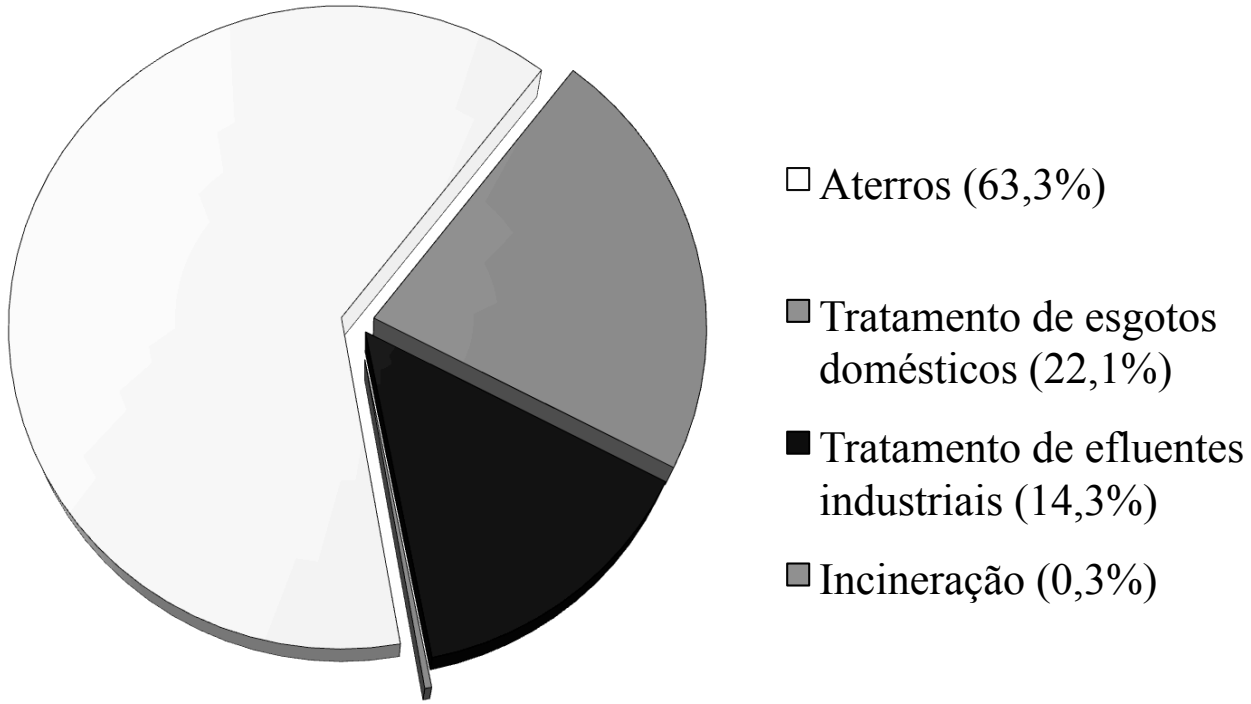
- The amount of methane recovered at Brazilian landfills is estimated by the Brazilian Reference Report on Methane Emissions from Waste Sector to determine the Brazilian net GHG emissions.

- The Reference Report is part of the Brazilian National Communication – one of Brazilian Government commitments with UNFCCC.

- At the 1st Brazilian National GHG Inventory, from 1990 to 1994, the methane recovered was considered as 0 for all landfills. According this document, Brazilian landfills did not destroy methane by flaring.

Brazilian National GHG Emissions Inventory from Waste Sector

- The 2nd Brazilian GHG Inventory, from 1990 to 2005, are now under public consultation, and it only considered the methane recovered by landfill projects under the CDM.



Clean Development Mechanism Projects

- Methane recovered is also estimated to determine the amount of emission reductions of the landfill gas recovery projects under CDM.

- Historically, in Brazilian projects the share of methane recovered in the absence of the project activites was considered as 20% of total generated methane at landfill.

- Following IPCC and UNFCCC methodologies, and data from Brazilian Ministries of Environment and of Science and Technology, the methane recovered was estimated to a sample with 154 Brazilian landfills, in order to reduce the uncertainty.

Objective

The paper aims to:

- Contribute to reduce uncertainty of methane recovered in Brazilian landfills.

- Contribute to reduce uncertainty of the share of methane destroyed at the baseline of Brazilian landfill gas destruction projects.

Methodology

Accordin to two methodologies:

•IPCC – Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000).

• UNFCCC – CDM Methodology “ACM0001 – Consolidated baseline and monitoring methodology for landfill gas project activities”.

IPCC – GPG (2000)

- IPCC-GPG(2000) does not present a equation to estimate the Methane Recovered. However, by inference we deduce the equation to estimate it.

$$R_{(x)} = MD_{BL(x)} \cdot (Q_{(x)} - Q_{i(x)}) + MD_{PR(x)} \cdot Q_{i(x)}$$

Where:

$R_{(x)}$	= *Methane recovered at the year x*	*[tCH_4/year]*
MD_{BL}	= *Methane destroyed at baseline at the year x*	*[dimensionless]*
Q	= *Amount of methane generated at the year x*	*[tCH_4/year]*
MD_{PR}	= *Methane destroyed by LFG recovery projects at year x*	*[dimensionless]*
Q_i	= *Amount of methane generated by LFG recovery projects at year x*	*[tCH_4/year]*
I	= *Projects with recovery and destroy methane*	*[projects]*
x	= *Year*	*[year]*

UNFCCC-ACM0001

UNFCCC – CDM Methodology "ACM0001 – Consolidated baseline and monitoring methodology for landfill gas project activities"

$$AF = MD_{BL} / MD_{PR}$$

Where:

AF	= *Adjustment factor*	$[tCH_4/year]$
MD_{BL}	= *Methane destroyed at baseline of the project*	$[tCH_{4\ destroyed}/tCH_{4\ generated}]$
MD_{PR}	= *Methane destroyed by LFG recovery project*	$[tCH_{4\ destroyed}/tCH_{4\ generated}]$

Methodology

Considering MD_{BL} as

$$MD_{BL} = Ps \,.\, Ca \,.\, Ftc \,.\, CE_{OF}$$

Where:

MD_{BL}	= *Methane destroyed at baseline of the project*	$[tCH_{4\ destroyed}/tCH_{4\ generated}]$
Ps	= *Fraction of LFG vented through the passive system*	$[tCH_{4\ collected}/tCH_{4\ generated}]$
Ca	= *Percentage of chimneys available for flaring*	*[dimensionless]*
Ftc	= *Fraction of time chimneys are actually lit*	*[dimensionless]*
CE_{OF}	= *Combustion efficiency of an open flame*	$[tCH_{4\ destroyed}/tCH_{4\ collected}]$

Methodology

The fraction of LFG vented through passive system (*Ps*) was estimated according the equation,

$$Ps = (W / We) \,.\, CE_{PS}$$

Where:

Ps	= *Fraction of LFG vented through pasive system*	$[tCH_{4\ collected}/tCH_{4\ generated}]$
W	= *Number of wells*	*[wells]*
We	= *Number of wells expected*	*[wells]*
CEPS	= *Collection efficiency of passive system*	$[tCH_{4\ collected}/tCH_{4\ generated}]$

Methodology

And considering MD_{PR} as

$$MD_{PR} = CE_{PR} \,.\, FE$$

Where:

MD_{PR}	= *Methane destroyed by the LFG recovery project*	$[tCH_{4\ destroyed}/tCH_{4\ generated}]$
CE_{PR}	= *Collection efficiency of the project*	$[tCH_{4\ collected}/tCH_{4\ generated}]$
FE	= *Flare efficiency*	$[tCH_{4\ destroyed}/tCH_{4\ collected}]$

Methodology

The formula to estimate AF,

$$AF = MD_{BL} / MD_{PR}$$

can be writen as:

$$AF = (Ps.Ca.Ftc.CE_{OF}) / (CE_{PR}.FE)$$

Data

This study was based on data from:

•Landfill`s specific data collected from landfill managers;

•Brazilian National System of Sanitation Data (SNIS, in portuguese), a Brazilian Environmental Ministry's research.

Data

It would be necessary a field research, in each landfill, to increase the accuracy of data and reduce uncertainty associated.

However, in some cases, it could be not the intention of landfill manager to share the real *status quo* of the landfill. Then, increasing the uncertainty.

Considering that there is no legal obligation to implement active (forced) systems to collect and destroy methane, the efficiency of passive systems are very low.

Data

- Landfill`s specific data collected with landfill managers.

  Data from 35 Brazilian landfills

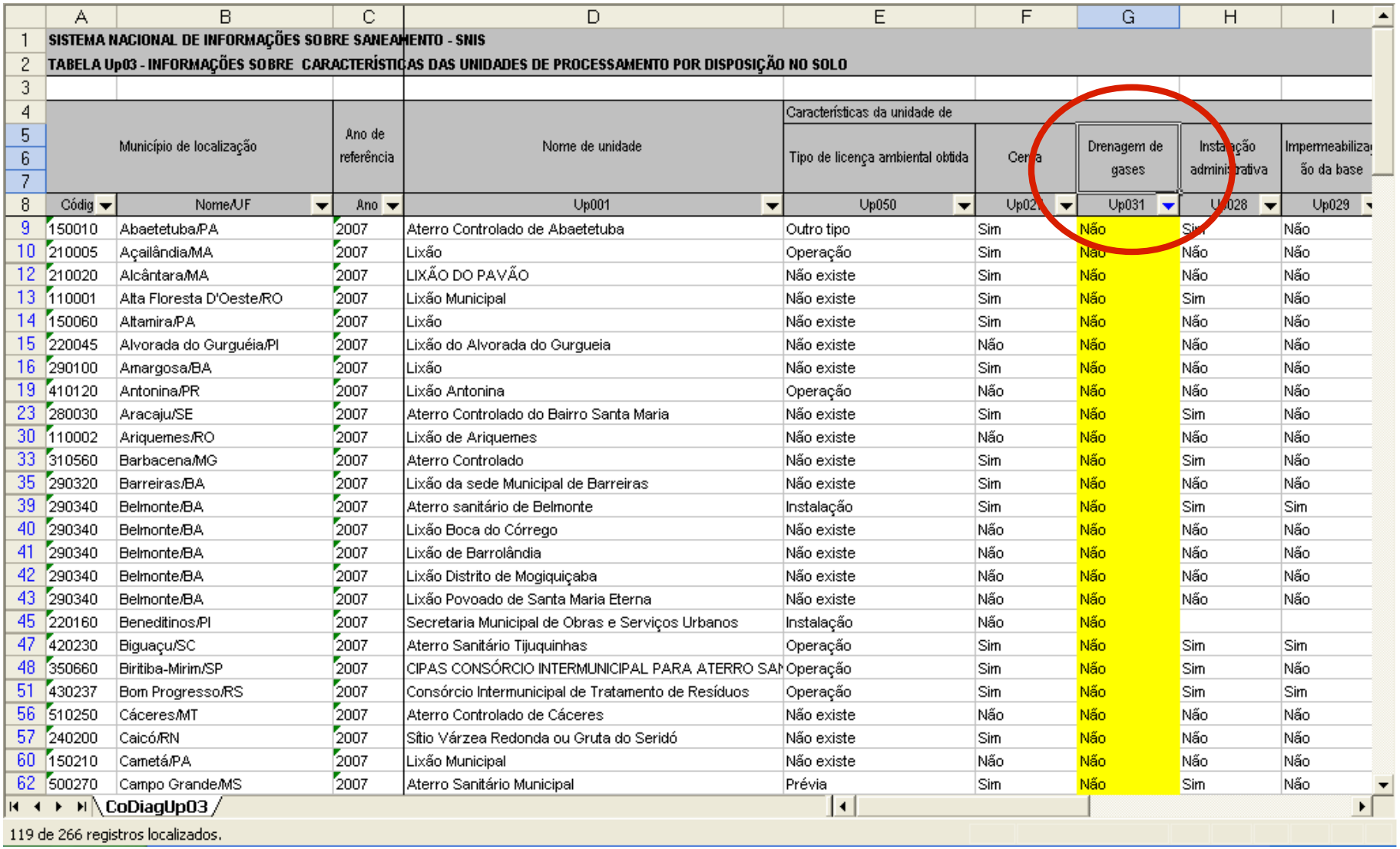
Data

Landfill location	Operation	*A*	*W*	*Wi*	*We*
		[m^2]	[wells]	[m]	[wells]
Americana	Municipal	650,000	20	30	178
Belo Horizonte*	Municipal	59,600	110	30	722
Betim	Municipal	60,000	24	30	66
Blumenau	Municipal	101,400	14	30	67
Caieiras*	Private	95,000	37	30	113
Camaçari	n.a.	106,420	50	30	106
Carapicuíba	Municipal	600,000	0	30	118
Contagem	Municipal	200,000	24	30	667
Cuiabá	Municipal	314,000	13	30	222
Curitiba	Private	45,000	200	30	349
Duque de Caxias*	Private	148,000	49	30	1,556
Embu	Municipal	270,000	4	30	50
Goiânia	Private	100,000	44	30	300
Gravataí	Municipal	240,000	44	30	111
Guarujá	Private	128,000	70	30	267
Itaquaquecetuba*	Private	600,000	30	30	142
Jaboatão dos Guararapes	Municipal	1,000,000	16	30	667
João Pessoa*	Municipal	300,000	6	30	1,111
Joinville	Private	600,000	30	30	333
Natal	Mixed	200,000	5	30	667
Niterói	Municipal	170,000	34	30	222
Osasco	Private	98,000	101	30	189
Palmas	Municipal	705,000	30	30	109
Paulínia*	Private	100,000	59	30	783
Ribeirão das Neves	Municipal	1,400,000	3	30	111
Salvador*	Private	650,000	55	30	164
Santos	Municipal	47,268	19	30	53
São Francisco do Conde	Municipal	35,533	10	30	39
São Leopoldo	Private	40,000	9	30	44
São Paulo – Bandeirantes*	Private	1,500,000	400	30	1,667
São Paulo – São João*	Private	800,000	125	30	889
Serra*	Private	155,025	28	30	172
Valinhos	Private	190,000	50	30	211
Vera Cruz	Municipal	270,000	6	30	300
Vitória*	Private	1,172,000	8	30	1,302

Data

- Data from Brazilian National System of Sanitation Data
  - Latest version available in website of Brazilian Ministry of Cities is of 2007. (hhtp://www.mcidades.gov.br)

Data



	A	B	C	D	E	F	G	H	I
1	SISTEMA NACIONAL DE INFORMAÇÕES SOBRE SANEAMENTO - SNIS								
2	TABELA Up03 - INFORMAÇÕES SOBRE CARACTERÍSTICAS DAS UNIDADES DE PROCESSAMENTO POR DISPOSIÇÃO NO SOLO								
3									
4	Município de localização		Ano de referência	Nome de unidade	Características da unidade de				
5					Tipo de licença ambiental obtida	Cerca	Drenagem de gases	Instalação administrativa	Impermeabilização da base
6									
7									
8	Código	Nome/UF	Ano	Up001	Up050	Up027	Up031	Up028	Up029
9	150010	Abaetetuba/PA	2007	Aterro Controlado de Abaetetuba	Outro tipo	Sim	Não	Sim	Não
10	210005	Açailândia/MA	2007	Lixão	Operação	Sim	Não	Não	Não
12	210020	Alcântara/MA	2007	LIXÃO DO PAVÃO	Não existe	Sim	Não	Não	Não
13	110001	Alta Floresta D'Oeste/RO	2007	Lixão Municipal	Não existe	Sim	Não	Sim	Não
14	150060	Altamira/PA	2007	Lixão	Não existe	Sim	Não	Não	Não
15	220045	Alvorada do Gurguéia/PI	2007	Lixão do Alvorada do Gurgueia	Não existe	Não	Não	Não	Não
16	290100	Amargosa/BA	2007	Lixão	Não existe	Sim	Não	Não	Não
19	410120	Antonina/PR	2007	Lixão Antonina	Operação	Não	Não	Não	Não
23	280030	Aracaju/SE	2007	Aterro Controlado do Bairro Santa Maria	Não existe	Sim	Não	Sim	Não
30	110002	Ariquemes/RO	2007	Lixão de Ariquemes	Não existe	Não	Não	Não	Não
33	310560	Barbacena/MG	2007	Aterro Controlado	Não existe	Sim	Não	Sim	Não
35	290320	Barreiras/BA	2007	Lixão da sede Municipal de Barreiras	Não existe	Sim	Não	Não	Não
39	290340	Belmonte/BA	2007	Aterro sanitário de Belmonte	Instalação	Sim	Não	Sim	Sim
40	290340	Belmonte/BA	2007	Lixão Boca do Córrego	Não existe	Não	Não	Não	Não
41	290340	Belmonte/BA	2007	Lixão de Barrolândia	Não existe	Não	Não	Não	Não
42	290340	Belmonte/BA	2007	Lixão Distrito de Mogiquiçaba	Não existe	Não	Não	Não	Não
43	290340	Belmonte/BA	2007	Lixão Povoado de Santa Maria Eterna	Não existe	Não	Não	Não	Não
45	220160	Beneditinos/PI	2007	Secretaria Municipal de Obras e Serviços Urbanos	Instalação	Não	Não		
47	420230	Biguaçu/SC	2007	Aterro Sanitário Tijuquinhas	Operação	Sim	Não	Sim	Sim
48	350660	Biritiba-Mirim/SP	2007	CIPAS CONSÓRCIO INTERMUNICIPAL PARA ATERRO SAN	Operação	Sim	Não	Sim	Não
51	430237	Bom Progresso/RS	2007	Consórcio Intermunicipal de Tratamento de Resíduos	Operação	Sim	Não	Sim	Sim
56	510250	Cáceres/MT	2007	Aterro Controlado de Cáceres	Não existe	Não	Não	Não	Não
57	240200	Caicó/RN	2007	Sítio Várzea Redonda ou Gruta do Seridó	Não existe	Sim	Não	Não	Não
60	150210	Cametá/PA	2007	Lixão Municipal	Não existe	Não	Não	Não	Não
62	500270	Campo Grande/MS	2007	Aterro Sanitário Municipal	Prévia	Sim	Não	Sim	Não

CoDiagUp03

119 de 266 registros localizados.

Data

SNIS:

•At SNIS, SWDS was categorized as open dumps, controlled landfills or landfills.

•119 Brazilian solid waste disposal sites **without** LFG collection systems (wells, flow pipelines, impermeabilization installed.

Data summary

Data	Value	Unit
CE_{PS}	0.75	*[dimensionless]*
Ca	*0.50*	*[dimensionless]*
Ftc	*0.50*	*[dimensionless]*
CEof	*0.50*	*[dimensionless]*
CE	*0.75*	*[dimensionless]*
FE	*0.75*	*[dimensionless]*

Results

$$Ps = (W / We) \,.\, CE_{PS}$$

City	Ps	City	Ps
Americana	0.0844	Joinville	0.0675
Belo Horizonte	0.1142	Natal	0.0056
Betim	0.2718	Niterói	0.1148
Blumenau	0.1575	Osasco	0.4010
Caieiras	0.2463	Palmas	0.2066
Camaçari	0.3553	Paulínia	0.0565
Carapicuíba	0.0000	Ribeirão das Neves	0.0203
Contagem	0.0270	Salvador	0.2508
Cuiabá	0.0439	Santos	0.2713
Curitiba	0.4299	São Francisco do Conde	0.1900
Duque de Caxias	0.0236	São Leopoldo	0.1519
Embu	0.0600	São Paulo – Bandeirantes	0.1800
Goiânia	0.1100	São Paulo – São João	0.1055
Gravataí	0.2970	Serra	0.1219
Guarujá	0.1969	Valinhos	0.1776
Itaquaquecetuba	0.1582	Vera Cruz	0.0150
Jaboatão dos Guararapes	0.0180	Vitória	0.0046
João Pessoa	0.0041		
Average Ps		0.1411	

Results

City	MD_{BL}	*City*	MD_{BL}
Americana	0.0105	Joinville	0.0084
Belo Horizonte	0.0143	Natal	0.0007
Betim	0.0340	Niterói	0.0143
Blumenau	0.0197	Osasco	0.0501
Caieiras	0.0308	Palmas	0.0258
Camaçari	0.0444	Paulínia	0.0071
Carapicuíba	0.0000	Ribeirão das Neves	0.0025
Contagem	0.0034	Salvador	0.0314
Cuiabá	0.0055	Santos	0.0339
Curitiba	0.0537	São Francisco do Conde	0.0237
Duque de Caxias	0.0030	São Leopoldo	0.0190
Embu	0.0075	São Paulo – Bandeirantes	0.0225
Goiânia	0.0138	São Paulo - São João	0.0132
Gravataí	0.0371	Serra	0.0152
Guarujá	0.0246	Valinhos	0.0222
Itaquaquecetuba	0.0198	Vera Cruz	0.0019
Jaboatão dos Guararapes	0.0023	Vitória	0.0006
João Pessoa	0.0005		
Landfills where $MD_{BL} = 0$	119	Total of landfills	154
Sample average MD_{BL}	0.0176		
Weighted average MD_{BL}	0.0040		

Results

City	MD_{BL}	MD_{PR}	AF	AF_{PR}	City	MD_{BL}	MD_{PR}	AF	AF_{PR}
	a	b	c=a/b			a	b	c=a/b	
Americana	0.0105	0.7425	0.0142	n.p.	Joinville	0.0084	0.7425	0.0114	n.p.
Belo Horizonte	0.0143	0.7425	0.0192	n.p.	Natal	0.0007	0.7425	0.0009	n.p.
Betim	0.0340	0.7425	0.0458	n.p.	Niterói	0.0143	0.7425	0.0193	n.p.
Blumenau	0.0197	0.7425	0.0265	n.p.	Osasco	0.0501	0.7425	0.0675	n.p.
Caieiras	0.0308	0.7425	0.0415	0.20	Palmas	0.0258	0.7425	0.0348	n.p.
Camaçari	0.0444	0.7425	0.0598	n.p.	Paulínia	0.0071	0.7425	0.0095	0.20
Carapicuíba	0.0000	0.7425	0.0000	n.p.	Ribeirão das Neves	0.0025	0.7425	0.0034	n.p.
Contagem	0.0034	0.7425	0.0045	n.p.	Salvador	0.0314	0.7425	0.0422	n.ap.
Cuiabá	0.0055	0.7425	0.0074	n.p.	Santos	0.0339	0.7425	0.0457	0.20
Curitiba	0.0537	0.7425	0.0724	n.p.	São Francisco do Conde	0.0237	0.7425	0.0320	n.p.
Duque de Caxias	0.0030	0.7425	0.0040	0.05	São Leopoldo	0.0190	0.7425	0.0256	n.p.
Embu	0.0075	0.7425	0.0101	n.p.	São Paulo - Bandeirantes	0.0225	0.7425	0.0303	0.20
Goiânia	0.0138	0.7425	0.0185	n.p.	São Paulo - São João	0.0132	0.7425	0.0178	0.20
Gravataí	0.0371	0.7425	0.0500	n.p.	Serra	0.0152	0.7425	0.0205	n.p.
Guarujá	0.0246	0.7425	0.0331	n.p.	Valinhos	0.0222	0.7425	0.0299	n.p.
Itaquaquecetuba	0.0198	0.7425	0.0266	n.p.	Vera Cruz	0.0019	0.7425	0.0025	n.p.
Jaboatão dos Guararapes	0.0023	0.7425	0.0030	n.p.	Vitória	0.0006	0.7425	0.0008	n.p.
João Pessoa	0.0005	0.7425	0.0007	0.10					
Brazilian sample average MD_{BL}, MD_{PR} and AF						**0.0176**	**0.7425**	**0.0238**	
Brazilian weighted average MD_{BL}, MD_{PR} and AF						**0.0040**	**0.7425**	**0.0054**	

Conclusions

National GHG Inventory from Waste Sector

- Brazilian 2nd National Inventory from waste sector, from 1990 to 2005, considers the amount of Methane Recoved as 0 for all landfills, only accountig the emission reductions of CDM projects to this period.

- In fact, the estimative of Average Methane Recovered in Brazilian landfills, results in a value close to 0.0040 (of the total generated methane). If there is no data about share of methane recovered, it is recommended to adopt this value.

- Probably, the developers of Brazilian National Inventory had underestimated this data.

Conclusions

National GHG Inventory from Waste Sector

- Considering the uncertainties to methane emissions from solid waste disposal as 28%, the 2nd Brazilian National GHG Inventory estimated landfill emisisons as 1,053 +/- 294 Gg CH_4 at the year 2005.

- Considering the estimate MDBL = 0.40%, we have an adjust of emissions from 3 – 5 Gg CH_4 at the year 2005.

Source	Greenhouse Gas [Gg.year^{-1}]			
	CH_4	CO_2	N_2O	$CO_{2equivalent}$
MSW disposal at SWDS	1.053	-	-	22.109
Incineration *MSW, HW, CW* e *SS*	-	110	0,007	112
Domestic wastewater management	367	-	-	7.701
Industrial wastewater management	238	-	-	5.775
Total Emissions	**1.658**	**110**	**0**	**35.597**

- This data is now under public consultation and can be adjusted at the final version of the inventory.

Conclusions

CDM Landfill projects

- CDM is one of important initiative to disseminate LFG recovery high efficiency practices at Brazilian landfills. All of landfills with high methane destruction efficiency (active systems) was implemented under the CDM.

- More than 50% of Brazilian Landfill CDM project activities considered the Adjustment Factor (to estimate the amount of methane generated) as 0.20 (20%), and other 25% set AF as 0.10 (10%).

- The Brazilian *Weighted average AF*, estimated to the sample, was 0.0054 (0.54%).

- Probably, Brazilian CDM landfill project designers have adopted an overestimated adopted in these projects.

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