Waste Sector Emission Estimates

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Objectives and Scope

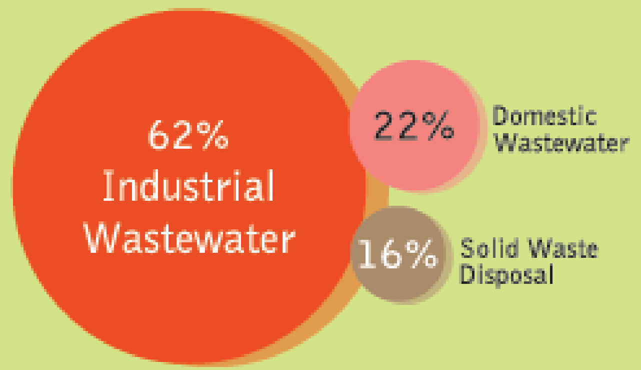
- To create a sufficiently **detailed, transparent and publicly available estimates and analysis of India's current and historical annual GHG emission for Waste Sector**
- To **complement existing efforts of the Government of India** (GoI) by addressing existing **data gaps and accessibility** and **informing policy dialogue through increased analytics**

- Follows 2006 IPCC Guidelines and in line with Government of India's 2007 inventory (NATCOM-II), includes sub-sectors
  - Industrial Wastewater Treatment and Discharge
  - Municipal Solid Waste (Urban)
  - Domestic Wastewater Treatment and Discharge (Urban)
- Tier I (IPCC defaults)+ Tier II (country specific emission factors & coefficients where available)

- **Phase I: National level emission estimates from 2007-2012**
- **Phase II (ongoing):**
  - Extend and strengthen National level emission estimates and prepare State level estimates from 2005-2014

Overall Results for Waste Sector

Sub-sector	GHG Emissions (Megatonnes of CO_2 equivalent)						Avg. Annual Growth Rate (%)
	2007	2008	2009	2010	2011	2012	
Solid Waste Disposal	10.76	11.47	12.16	12.85	13.52	14.18	5.28%
Domestic Wastewater Treatment and Discharge	16.86	17.18	17.43	17.75	18.24	18.60	1.72%
Industrial Wastewater Treatment and Discharge	32.51	36.02	49.52	48.76	58.96	54.02	11.03%
OVERALL WASTE SECTOR	**60.13**	**64.67**	**79.11**	**79.36**	**90.72**	**86.80**	**7.39%**



Sub-sector Contribution to the Waste Sector in 2012

i. Industrial Wastewater: Methodology

- 12 Industry sectors generating substantial organic wastewater considered

Iron and Steel	Production of Pig Iron, Sponge Iron and Finished steel (alloy & Non-alloy)
Fertilizer	Production of Nitrogenous and Phosphatic Fertilizers
Beer	Production of all types of Beer (alcoholic)
Meat	Finished Meat production from all the registered Slaughterhouses
Sugar	Finished Sugar production from cane
Coffee	Production of all types of coffee (Arabica, Robusta and varieties of these)
Soft Drink	Production of non-alcoholic soft drinks
Pulp & Paper	Production of paper from all pulp and paper industries
Petroleum	Refining and production of Petroleum, Oil and Lubricants
Rubber	Production of Finished Natural and Synthetic Rubber
Dairy	Production of milk in the Dairy Sector
Tannery	Production of Raw Bovine, Sheep, lamb, Goat and kid skins and hides

i. Industrial Wastewater: Methodology

- Emission estimation for each industry sector based on following parameters
  - Industrial production in tonnes
  - Wastewater generated per tonne of product
  - Organic concentration (i.e. characteristic of wastewater)
  - MCF based on broad treatment technology used by sector
  - Methane recovery (if any)

- ***Industrial production***

  Data sources:
  - Indian Bureau of Mines
  - National Dairy Development Board
  - Rubber Board
  - Fertilizers Association of India
  - Department of Industrial Policy & Promotion (Handbook of Industrial Policy & Statistics)

Data reliability and availability issues:
- **Aerated soft drinks** has not been included under Soft Drinks Sector
- Reliability issues in production data available for **Beer sector**

i. Industrial Wastewater: Methodology

❑ ***Wastewater generated per tonne of product***

- Based on NATCOM-II, related NEERI studies, 2006 IPCC Guidelines (in this order)

Industry	Wastewater generation (m3/tonne of product)	Reference
Iron & Steel	**60**	GOI's NATCOM-II
Fertilizer	**8**	GOI's NATCOM-II
Beer	**9**	GOI's NATCOM-II
Sugar	**1**	GOI's NATCOM-II
Coffee	**5**	GOI's NATCOM-II
Soft Drink	**3.7**	GOI's NATCOM-II
Petroleum	**0.7**	GOI's NATCOM-II
Dairy	**3**	GOI's NATCOM-II
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Pulp & Paper	**162**	2006 IPCC guidelines for National GHG Inventories
Rubber	**26.3**	GOI's NATCOM-II
Tannery	**32**	NEERI (2010): Inventorisation of CH4 Emissions from Domestic & Key Industries Wastewater

i. Industrial Wastewater: Methodology

❑ *Methane Correction Factor (MCF)*

- Based on wastewater treatment technology largely used by sector
- Signifies degree to which the wastewater treatment system is anaerobic and thereby generates GHG emission

Type of treatment and discharge pathway or system	Remarks/Details	MCF
Untreated		
Sea, river and lake discharge	-	0.1
Treated		
Aerobic treatment plant	Well managed	0
Aerobic treatment plant	Not well managed. Overloaded	0.3
Anaerobic digester for sludge	CH4 recovery not considered	0.8
Anaerobic reactor (e.g., UASB, Fixed Film Reactor)	CH4 recovery not considered	0.8
Anaerobic shallow lagoon	Depth less than 2 metres	0.2
Anaerobic deep lagoon	Depth more than 2 metres	0.8

Source: 2006 IPCC Guidelines

i. Industrial Wastewater: Methodology

MCF values used based on NATCOM-II, 2006 IPCC Guidelines and sector-specific documents/studies (in this order)

Industry	Prevalent Treatment Technology	MCF	Corresponding Emission Factor	Reference for Treatment Technology used in the Sector
Iron & Steel	**Aerobic treatment- well managed**	**0**	0	International publication on Wastewater treatment technologies in Major Steel Industries of India
Fertilizer	**Anaerobic shallow lagoon**	**0.2**	0.05	GOI's NATCOM-II
Beer	**Anaerobic digester/reactor**	**0.8**	0.2	2006 IPCC Guidelines
Sugar		**0.8**	0.2	GOI's NATCOM-II; CDM project database
Coffee		**0.8**	0.2	2006 IPCC Guidelines
Soft Drink		**0.8**	0.2	2006 IPCC Guidelines
Petroleum	**Aerobic treatment- well managed**	**0**	0	MoEF: EIA Guidance manual for refineries
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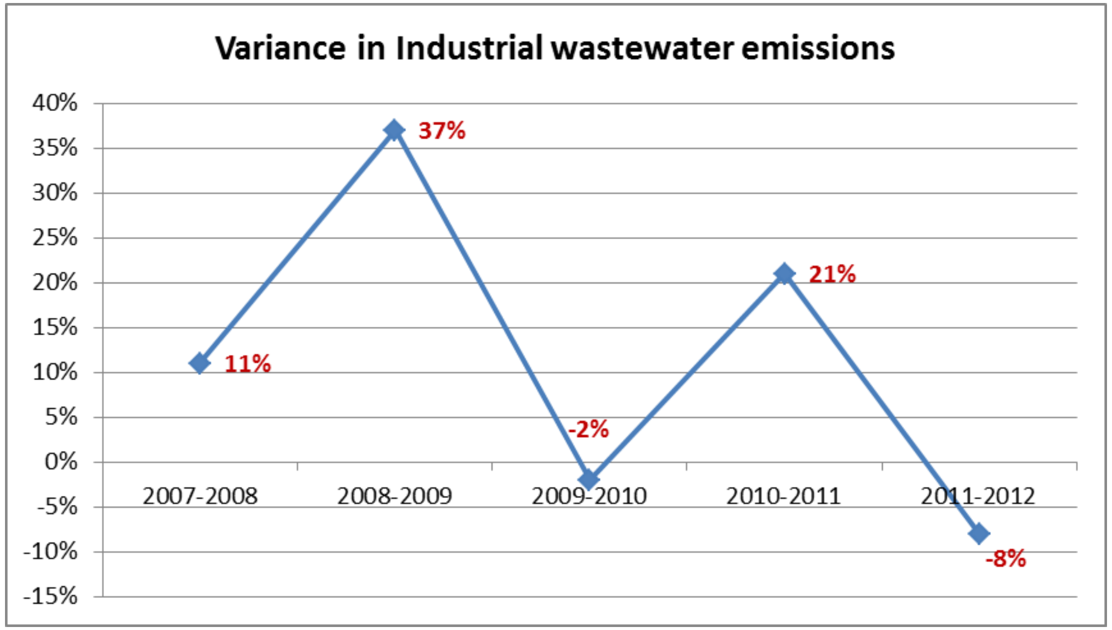
Tannery	**Anaerobic shallow lagoon**	**0.2**	0.05	NEERI (2010): Inventorisation of CH4 Emissions from Domestic & Key Industries Wastewater

i. Industrial Wastewater: Key Findings

- High variance observed year on year in industrial wastewater emission estimates
- Pulp & paper, Coffee, Soft drink, Meat and Tannery are critical sectors



Industry Type	GHG emission in kg CO_2e per tonne of product	GHG emission in kg CO_2e per cu. m of wastewater generated
Coffee	189.0	37.8
Soft drink	139.9	37.8
Pulp & Paper	4,014.4	24.8
Meat	201.5	17.2
Tannery	104.2	3.3
Fertilizers	25.2	3.1
Sugar	3.1	3.1
Beer	27.4	3.0
Dairy	7.1	2.4
Petroleum	-	-
Iron & Steel	-	-
Rubber	-	-

Note:
Emissions from Iron & Steel, Petroleum and Rubber sectors are zero since aerobic treatment systems used are assumed to be well managed, having zero MCF and thereby resulting in no CH4 emission for these sectors in the assessment

ii. Domestic Wastewater: Methodology

CH_4 emissions from Domestic Wastewater

❑Key parameters for emission estimation

- Fraction of Urban population in High Income & Low Income group
- Degree of Utilization of each treatment type (i.e. proportion of resident population using different wastewater treatment/discharge systems)
- Biochemical oxygen demand (BOD) (i.e. organic content in wastewater)
- MCF based on treatment technology used
- Collected/Uncollected fractions of Wastewater
- Methane recovery (if any)

ii. Domestic Wastewater: Methodology

CH_4 emissions from Domestic Wastewater

❑ ***Fraction of population by income group***

- As per 2006 IPCC Guidelines, Urban wastewater categorized into two income groups
  - ➢ Urban high income
  - ➢ Urban low income

❑ ***Degree of utilization***

- relates to the proportion of resident population using different wastewater treatment/discharge pathways or systems

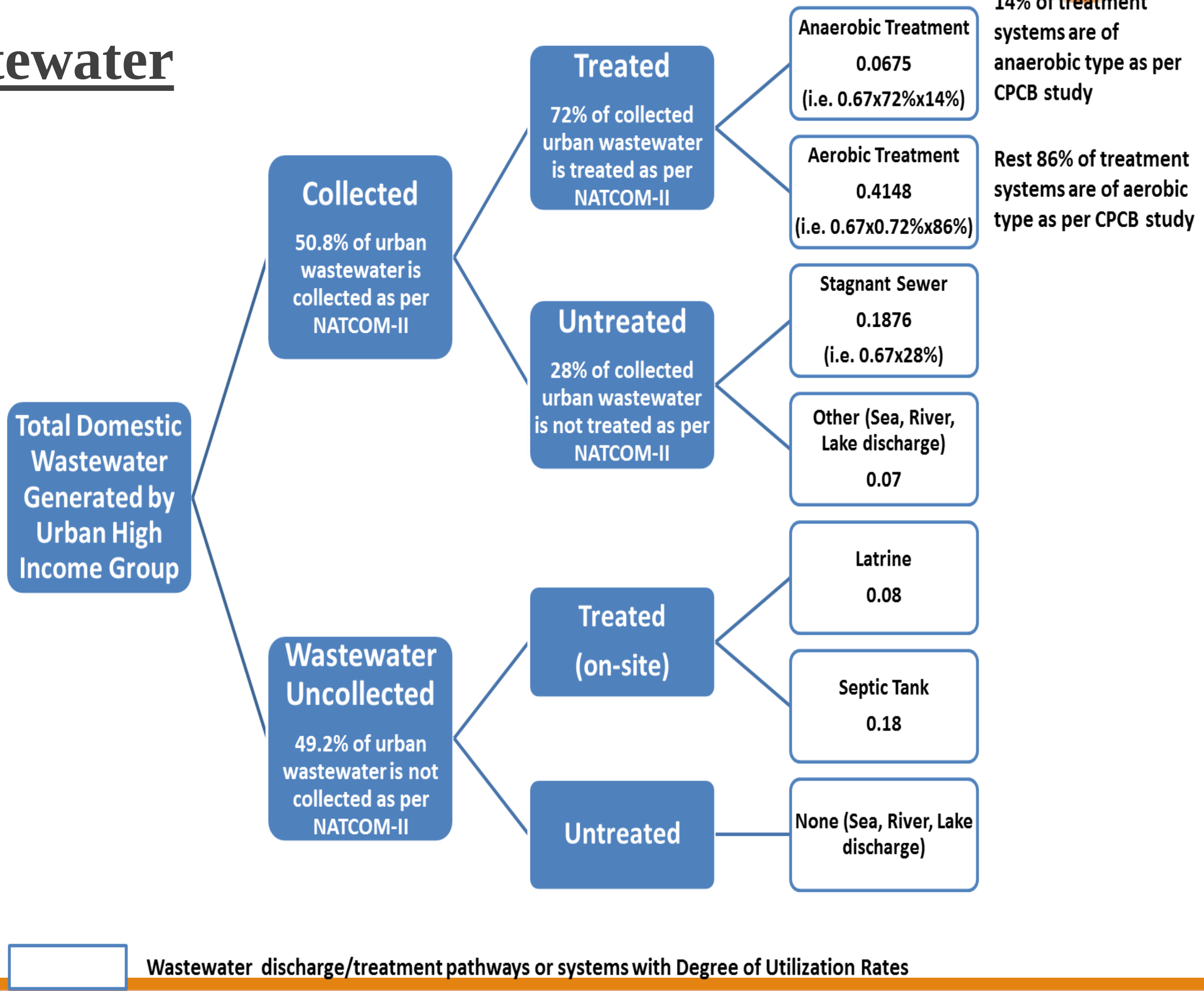
Income Group	IPCC Default Degree of Utilization Rates for Discharge/Treatment Type				
	Septic Tank	Latrine	Other	Sewer	None
Urban High	18%	8%	7%	67%	0%
Urban Low	14%	10%	3%	53%	20%

ii. Domestic Wastewater: Methodology

CH_4 emissions from Domestic Wastewater

❑ ***Degree of Utilization***

- Rates worked out further for Sewer systems for India's Urban High and Low Income population based on
  - ➢ **49.2% of the wastewater generated** from the urban centers is **not collected** (NATCOM-II)
  - ➢ **treatment is provided to only 72% of wastewater collected** (NATCOM – II)
  - ➢ **14% of collected wastewater is treated anaerobically** and **86% is treated aerobically** based on CPCB studies on STPs in India for 2007 and 2014



ii. Domestic Wastewater: Methodology

CH_4 emissions from Domestic Wastewater

- ***Methane Correction Factor (MCF)***
  - values for applicable treatment types for India based on IPCC and NATCOM-II

Specific Treatment/Discharge pathway or system	MCF values as per IPCC
Septic Tank	0.5
Latrine (Dry climate, ground water table lower than latrine, small family (3-5 persons))	0.1
Other (i.e. Sea, river and lake discharge)	0.1
Stagnant sewer	0.5
Anaerobic Reactor/Anaerobic digester for sludge	0.8
Centralized, aerobic treatment plant (not well managed)	0.3
None (i.e. Sea, river and lake discharge)	0.1

ii. Domestic Wastewater: Methodology

N_2O emissions from Domestic Wastewater

- Key parameters for emission estimation
  - Country population
  - Average annual per capita protein consumption (kg/person/yr): NSSO surveys
  - Other default coefficients from IPCC

Years	Daily per capita protein consumption (gm/capita/day)	Source
2007 and 2008	57.0	Nutritional Intake in India 2004-05, NSSO Report
2009 and 2010	56.15*	Nutritional Intake in India 2009-10, NSSO Report
2011 and 2012	58	Nutritional Intake in India 2011-12, NSSO Report

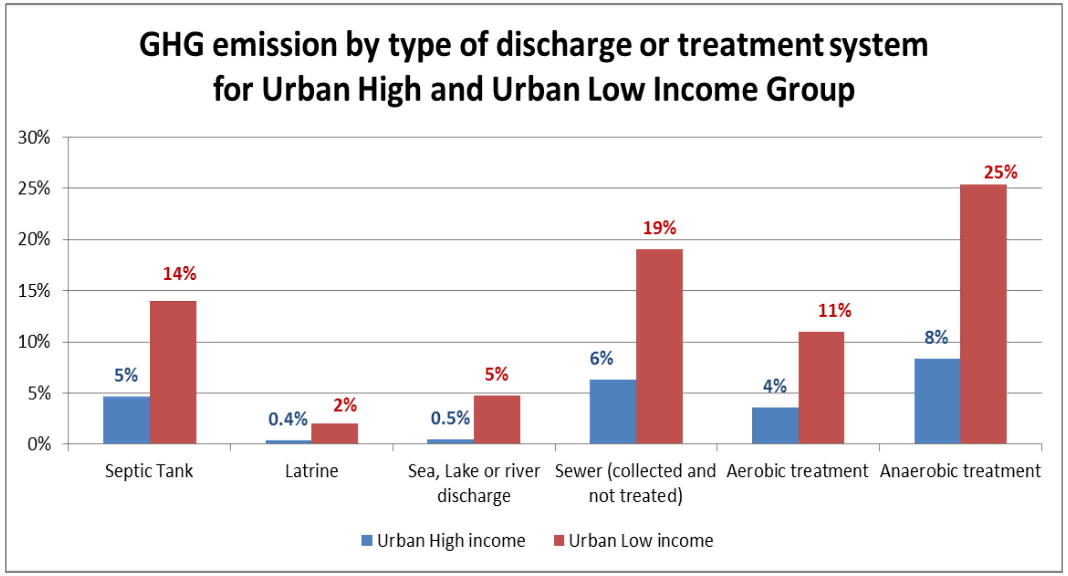
*The NSSO survey was conducted over two rounds (or schedules). Values used are average values based on findings across the two rounds.

ii. Domestic Wastewater: Key Findings

- **Per capita emissions** from domestic wastewater are **20% higher for urban high income population than for the urban low income population**

Per capita GHG emissions for domestic wastewater	kg of CO_2e (2012)
Urban High Income	42
Urban Low Income	35

- About **30 percent of CH_4 generated** in anaerobic treatments systems is **lost as dissolved gas** in the treated effluent
- **Adopting CH_4 capture and recovery technologies** (biogas/electricity generation/thermal energy) **in anaerobic wastewater treatment systems** (largely serving high income population group) is a relatively **quick-win mitigation solution**



iii. Municipal Solid Waste: Methodology

❑Key parameters for emission estimation:

- Urban population
- Per capita solid waste generation (kg/day)
- Proportion of solid waste going to landfill Site (%)
- Degradable Organic Carbon (DOC) – based on waste composition

❑First Order Decay (FOD) method used as per 2006 IPCC guidelines and NATCOM-II

- emissions from decomposition of solid waste over a period of 50 years prior to 2007 i.e. from 1956-2006

iii. Municipal Solid Waste: Methodology

❑ *Per capita solid waste generation*

- Waste generation based on population and per capita waste generation

Year	Daily Per capita Waste generation (gm/day)	Annual Growth rate
1951	305	1.1%
1961	340	1.0%
1971	375	1.5%
1981	430	0.7%
1991	460	1.2%
2007	550	1.2%

Source: TERI

❑ *Proportion of waste going to landfill*

- 70% of waste generated assumed to be going to landfill as per NATCOM-II

iii. Municipal Solid Waste: Methodology

GHG Platform INDIA

❑ *Degradable Organic Carbon (DOC)*

- Depends on the waste composition
- Changing lifestyles have led to changes in waste composition over the years

Component	Waste Composition (%)		
	1971	1995	2005
Paper	4.14	5.78	8.13
Plastics	0.69	3.9	-
Rubber	-	-	9.2
Metals	0.5	1.9	0.5
Glass	0.4	2.1	1.01
Rags	3.83	3.5	4.4
Compostable Matter	41.2	41.8	47.4
Inert	49.2	40.3	25.2

Source: CPCB and NEERI

iii. Municipal Solid Waste: Methodology

GHG Platform INDIA

Degradable Organic Carbon (DOC)

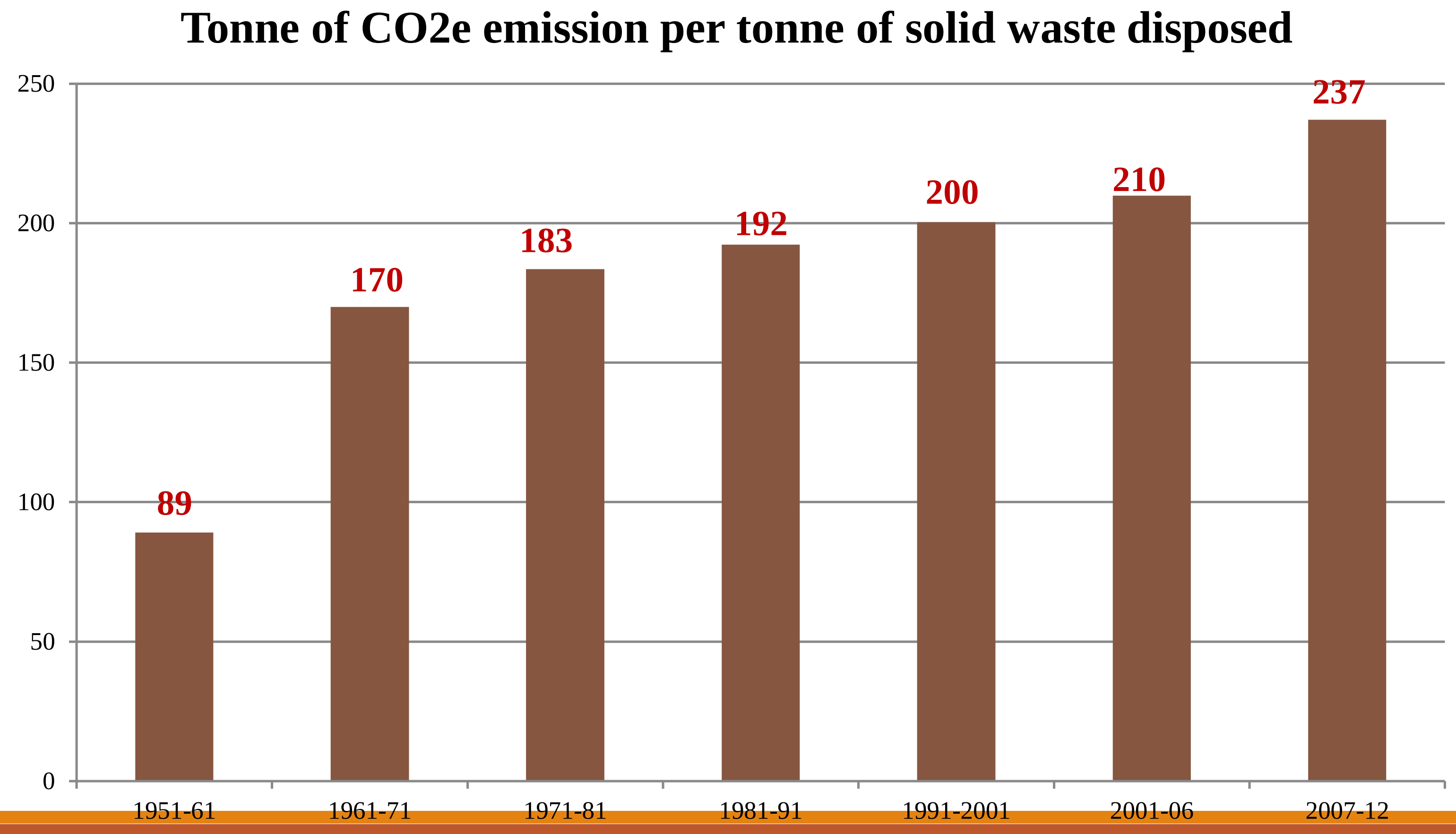
- **NATCOM-II** uses aggregate DOC value of 0.11
- **In our emission estimates, DOC value for each of the constituent degradable fractions of waste has been calculated** using the default DOC content from 2006 IPCC Guidelines
- **Changing waste composition has been factored in to estimate varying DOC values** over the years

Component	Waste Composition			Default DOC Content values in % (2006 IPCC Guidelines)
	1971	1995	2005	
Paper	4.14%	5.78%	8.13%	40%
Rags	3.83%	3.5%	4.4%	24%
Compostable Matter	41.24%	41.8%	47.4%	15%
DOC Estimated for overall waste (in fraction)	0.088	0.094	0.114	
Applicable time period considered for estimated DOC value	1956-1994	1995-2004	2005-2012	-

Source: CPCB and NEERI, CPHEEO

iii. Municipal Solid Waste: Key Findings

- Changing lifestyles impacting waste composition and GHG emission
- GHG emissions from a unit amount of solid waste disposed are increasing over time



Comparison with GoI estimates for 2007 & 2010

Sub-sector	GHG Emissions (Megatonnes of CO_2e)						Possible reasons for divergence
	2007			2010			
	GHG Platform India Estimates	NATCOM-II (2007)	Deviation wrt Official Estimate (%)	GHG Platform India Estimates	Biennial Update Report (2010)	Deviation wrt Official Estimate (%)	
Solid Waste disposal	10.76	12.69	-15.21%	12.85	13.96	-7.95%	• Varying per capita waste generation rates • Varying DOC values over time periods • Possible variation in Population estimates
Domestic Wastewater	16.86	22.98	-26.63%	17.75	29.38	-39.58%	• Share of aerobic and anaerobic treatments based on CPCB analysis • Ambiguity on degree of utilization rates, assumptions in NATCOM & BUR
Industrial Wastewater	32.51	22.05	47.44%	48.76	21.71	124.60%	• Multiple data sources used for industrial production • Ambiguity on data sources and values used for different sectors in NATCOM & BUR for industrial production, wastewater generation, COD and MCF values

Challenges

Limited clarity and ambiguity in National Communication documents	• Activity data and data sources • Approach and assumptions • Emission factors & sector specific parameters/coefficients
Limited updated information available on values for country specific parameters in National Communication documents and secondary sources	• Coefficients for organic characteristics of solid waste and wastewater • Emission factors for treatment technologies in use on-ground • Degree of utilization rates for domestic wastewater discharge/treatment
Non availability of updated year-wise activity data	• Solid waste composition and per capita waste generation rates • Industrial production and industrial wastewater generation • Prevalent wastewater treatment systems
Lack of centralized datasets with usable information for development of GHG emission	• Limitations in official datasets with regards to usability of activity data • Lack of a centralized information repository, particularly for industrial sector
Reliability of Information	• Inconsistencies in official datasets/statistical records • Variation in information in NATCOM reports & IPCC default values and on-ground surveys/studies of government agencies Eg: Extent of Anaerobic and aerobic treatment, industrial production

Recommendations

- Need for **periodic reporting** on
  - Changes in **solid waste characteristics and generation rates** with changing lifestyles
  - **Treatment technologies and performance of STPs** by Central and State Pollution Control Boards
  - Status and impacts of **on-ground developments and improvements in treatment technologies**
- **Use existing data management processes** to capture information required and identify relevant entities
  - *E.g. Annual reports from States on solid waste management collected by State Pollution Control Boards*
  - *Industrial information collected under the Annual Survey of Industries (ASI)*
- **Transparent and robust data management systems** can improve accuracy and capture emission reduction from policy and programme initiatives

Thank You

Discussions

❑Industrial Wastewater

- Wastewater generation per tonne of industrial product for industry sectors. Changes in Industrial Wastewater generation due to technological improvements...
- Prevalent Industrial Wastewater treatment technologies for industry sectors – especially for Iron & Steel, Rubber and Petroleum...
- In the absence of state level industrial production data, economic indicators/proxies to apportion national level Industrial Wastewater emission estimates to the state level...

❑Domestic Wastewater

- Proportion of resident population using different Domestic Wastewater treatment/discharge pathways – *sewer, latrine*, *septic tanks*, *none*, *others*. Information availability at the state level...

❑Municipal Solid Waste

- Updated data on composition of solid waste at the state level...
- Proportion of solid waste going to landfill site for the states. Factoring in waste processing plants which are not operational...

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- ***Wastewater generated per tonne of product***
  - Based on NATCOM-II, related NEERI studies, 2006 IPCC Guidelines (in this order)

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