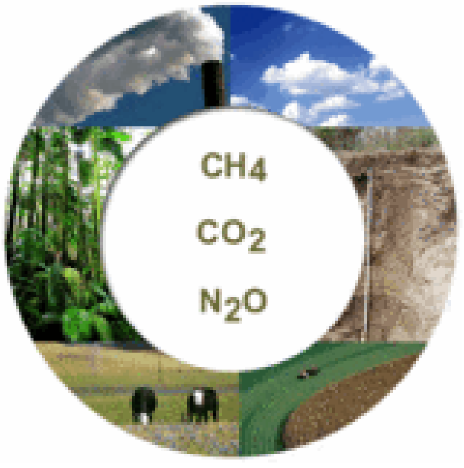
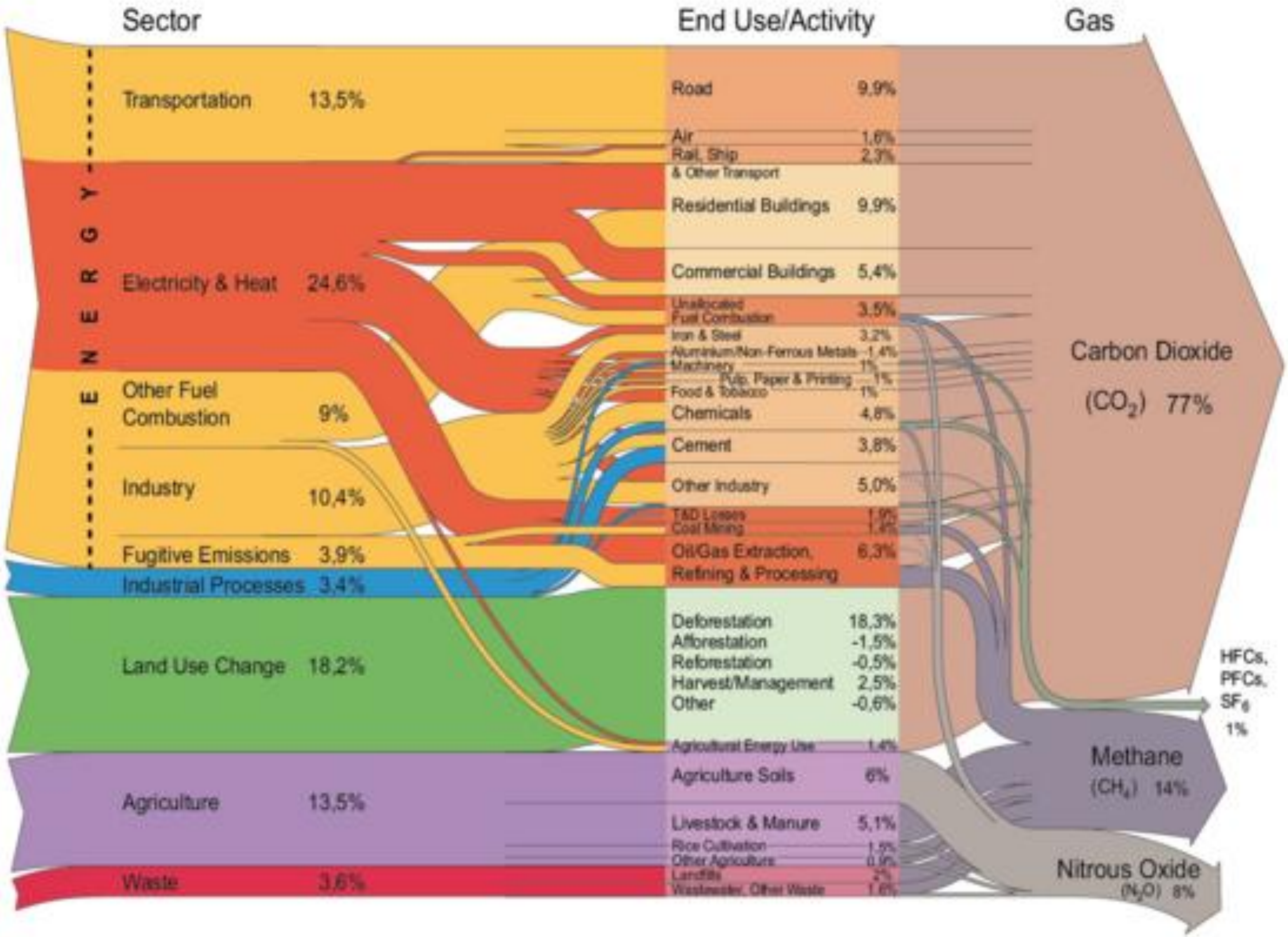
Philippines GHG Emissions : Waste Sector



Teresita R. Perez, Ph.D.
Ateneo de Manila University

World Greenhouse gas emissions by sector



All data is for 2000. All calculations are based on CO_2 equivalents, using 100-year global warming potentials from the IPCC (1996), based on a total global estimate of 41 755 $MtCO_2$ equivalent. Land use change includes both emissions and absorptions. Dotted lines represent flows of less than 0.1% percent of total GHG emissions.

Source: World Resources Institute, Climate Analysis Indicator Tool (CAIT), Navigating the Numbers: Greenhouse Gas Data and International Climate Policy, December 2005; Intergovernmental Panel on Climate Change, 1996 (data for 2000).

Rapid urbanization is positively correlated with the increase in the consumption and production of goods

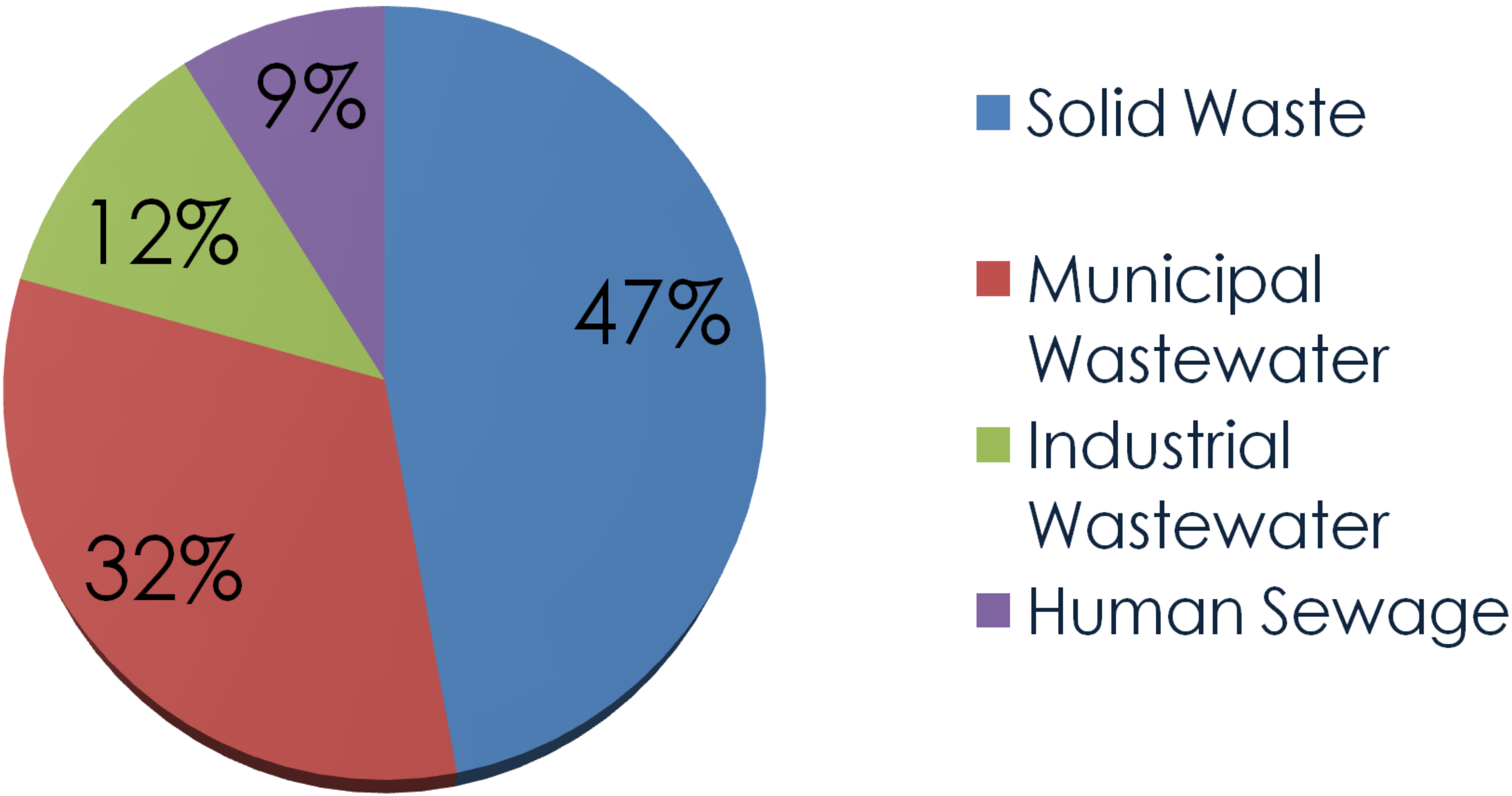
Leads to an increase in the volume of waste generated by the commercial, domestic, and industrial sectors

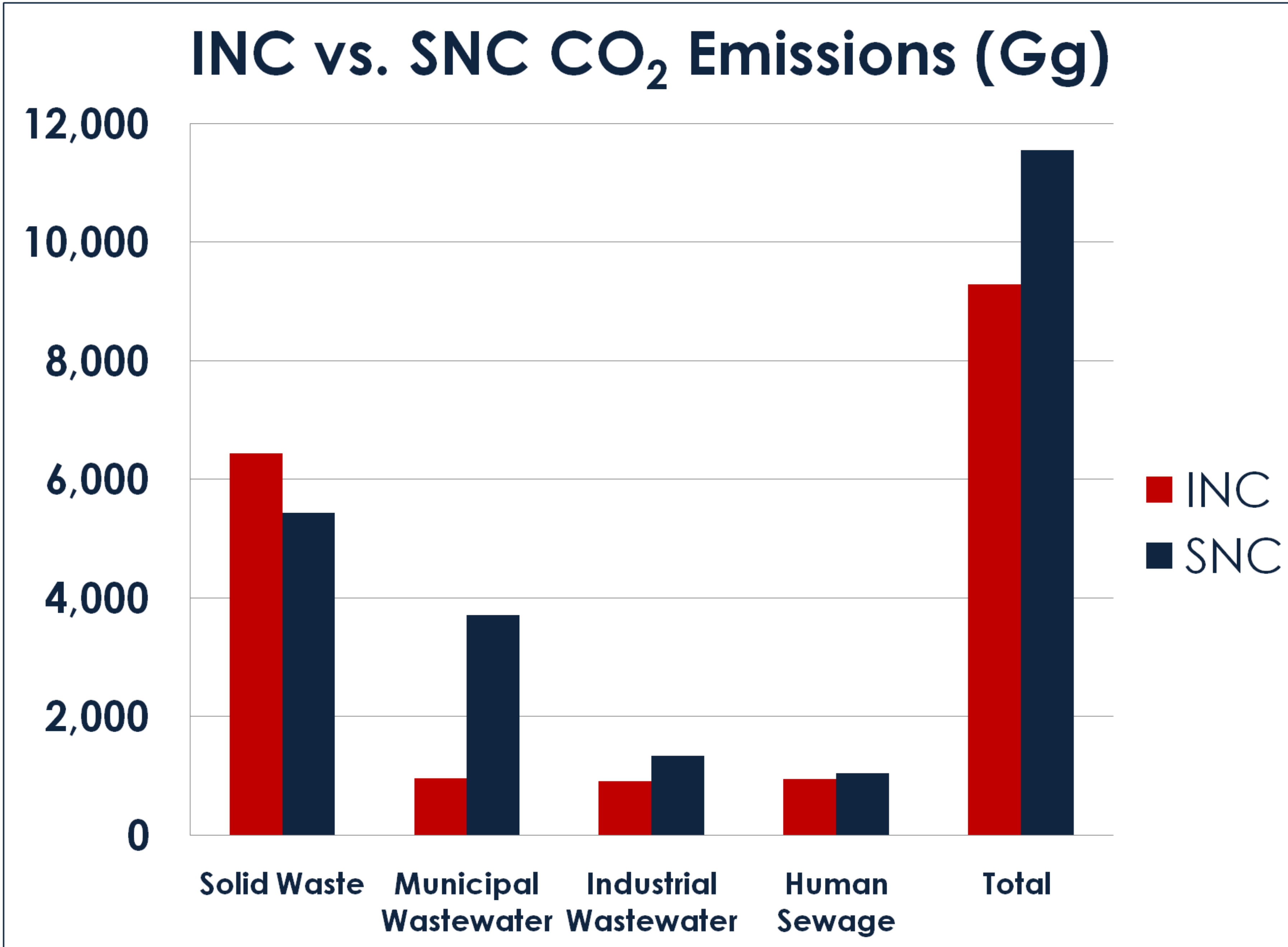
Releases greenhouse gases in the atmosphere that could interfere with our climate systems → methane, carbon dioxide and nitrous oxide

Solid wastes, industrial and domestic wastewater, and human sewage are the sources of greenhouse gas emissions for the waste sector. For the year 2000, the waste sector released 11,556 Gg of CO_2 to the atmosphere. Approximately 47% of the total emissions come from solid waste which generated 259 Gg of CH_4 or 5,439 Gg CO_2.

Waste Sector

Subsectoral Contributions




INC vs. SNC CO_2 Emissions (Gg)
12,000
10,000
8,000
6,000
4,000
2,000
0
Solid Waste
Municipal Wastewater
Industrial Wastewater
Human Sewage
Total
INC
SNC

SOLID WASTE

- Increase in the production of solid waste is generally proportional with the population
- The daily generation of waste by a Filipino ranges from 0.3 to 0.7 kilos of garbage depending on his economic status
- Households produced 10 million tons of solid waste in year 2000 (Philippines Environment Monitor, 2001)

SOLID WASTE DISPOSAL

- Treatment and disposal of solid waste produces significant amounts of methane (CH_4)
- CH_4 produced at solid waste disposal sites (SWDS) contributes 3-4% to the annual global anthropogenic greenhouse gas emissions (IPCC, 2001)
- SWDS also produce biogenic carbon dioxide (CO_2), non-methane volatile organic compounds (NMVOCs), nitrous oxide (N_2O) nitrogen oxides (NO_x), carbon monoxide (CO) although CH_4 is the primary greenhouse gas in SWDS

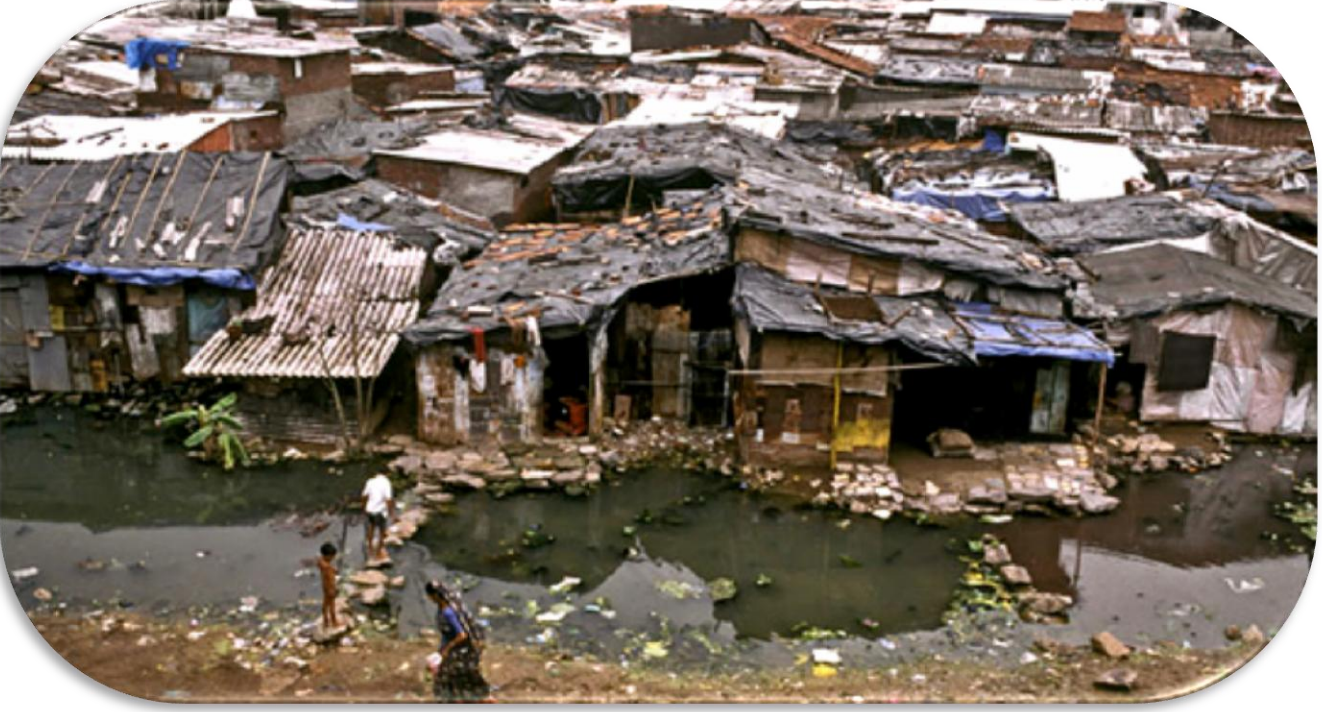
SOLID WASTE DISPOSAL

- Conversion of degradable material in waste to methane and carbon dioxide is complex
- The series of equations below is a simplified version of the DOC transformation to CO_2 and CH_4 (methanogenesis):

Organic matter $\rightarrow$ H_2, CO_2, & carboxylic acids

$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$

$CH_3COOH \rightarrow CH_4 + CO_2$



Solid Waste

Most of the calculations were based on the 1994 inventory process, the JICA- sponsored research on urban waste management, and the ADB-sponsored Metro Manila Solid Waste Management Project

SOLID WASTE DISPOSAL

In many countries waste management has changed much over the last decade :

- waste minimization and recycling/reuse,
- policies to reduce the amount of waste generated
- alternative waste management practices
- landfill gas recovery
- Implementation of R.A. 9003 (January 2001)

Methodology

- Three levels to estimate the CH4 emissions (highly dependent on the data available):
  - Tier 1: uses default activity data and default parameters
  - Tier 2: uses some default parameters, and good quality country-specific data on current and historical waste disposal at SWDS

Methodology

- Three levels to estimate the CH4 emissions (highly dependent on the data available):
  - Tier 3: uses country-specific activity data, and nationally developed key parameters :
    - Half-life
    - Methane Generation Potential
    - Degradable organic content (DOC) in the waste
    - Fraction of DOC that decomposes

CH_4 Estimation Models

- Two models to estimate CH_4 emissions from SWDS:
  1. Mass Balance Approach
  2. First Order Decay (FOD) Method

CH_4 Estimation Models

- Mass Balance Approach
  - Used in the 1994 Philippine inventory
  - Does not distinguish between various types of disposal sites (e.g. open dump or sanitary landfill)
  - Strongly discouraged because it produces inaccurate estimates of annual emissions (IPCC, 2006)

CH_4 Estimation Models

- First Order Decay Model
  - Degradable organic component (DOC) decays slowly throughout a few decades
  - Requires historical waste disposal data over a time period of 3-5 half lives
    - Half lives vary from a few years to several decades
    - Good practice to use disposal data for at least 50 years (1950 – 2000)

CH_4 Estimation Models

Pertinent Equations

1. DDOC*m* Accumulated in the SWDS

$$DDOCma_T = DDOCmd_T + (DDOCma_{T-1} \bullet e^{-k})$$

Where:

$DDOCma_T$ = DDOC accumulated at the end of the year T

$DDOCma_{T-1}$ = DDOC accumulated in the previous year

$DDOCmd_T$ = DDOC deposited in the year T

CH_4 Estimation Models

Pertinent Equations

2. DDOCm Decomposed at the end of the year

$$DDOC\mathit{m\ decomp}_T = DDOC\mathit{ma}_{T-1} \bullet (1-e^{-k})$$

Where:

$DDOC\mathit{ma}_{T-1}$ = DDOC accumulated in the previous year

$DDOC\mathit{m\ decomp}_T$ = DDOC decomposed at the end of the year

k =reaction constant

CH_4 Estimation Models

Pertinent Equations

3. CH_4 generated from DDOCm

$$CH_4\ generated_T = DDOCm\ decomp_T \bullet F \bullet 16/12$$

Where:

$CH4\ generated_T$ = amount of CH_4 generated from decomposable material

$DDOCm\ decomp_T$ = DDOC decomposed in year T

F = fraction of CH_4 in generated landfill gas

16/12 = molecular weight ratio CH_4/C

Using the IPCC Waste Model

- Incorporates the FOD Model
- Based on equations 1-3
- Data from 1950-2000 must be supplied

Using the IPCC Waste Model

- Requires the following data:
  - Urban Population
  - Waste per capita generation rate(kg/cap/year)
  - Percentage of waste that goes to different disposal sites
  - Percent composition of wastes that goes to the disposal sites
  - Industrial waste generation rate (Gg/$M GDP/yr),
  - Percent of industrial solid waste that goes to solid waste disposal sites
  - Amount of methane recovered

Results

Year	Methane (Gg)	Carbon Dioxide (Gg)
1994 (Mass Balance)	302.73	6,357.3
1994 (FOD)	307	6,447
2000 (FOD)	287	6,027

Solid Waste Subsector

GHG Inventory from Waste (Wastewater)

- Domestic/commercial and industrial sources
- Treatment: on site, centralized or directly disposed
  - Anaerobic treatment produces methane
  - May also be a source of CO_2 and N_2O
  - Differs between countries, between rural and urban areas

Factors affecting methane production

Wastewater Characteristics

- Methane generation potential: degradable organic material present
  - Parameters used
    - BOD (Biochemical Oxygen Demand)
    - COD (Chemical Oxygen Demand)
    - Higher BOD or COD means more methane generated

Factors affecting methane production

Temperature

- Methane production at 15° C and higher
  - Increase in temperature means rate of methane production increases
  - Below 15° C: Fermentation and thus CH_4 production is negligible and lagoon serves as a sedimentation tank

Factors affecting methane production

BOD vs. COD

- BOD (Biochemical Oxygen Demand) concentration indicates only the amount of carbon that is aerobically biodegradable
  - less appropriate for determining the organic components in anaerobic environments
- COD (Chemical Oxygen Demand) measures the total material available for oxidation (both biodegradable and non-biodegradable)
- Reported COD/BOD ratios can be used to determine the COD if the BOD is known

Domestic Wastewater

- The greenhouse gas (GHG) generation potential of the wastewater is driven by the organic content of the wastewater stream (BOD) and the volume of wastewater.

Domestic Wastewater

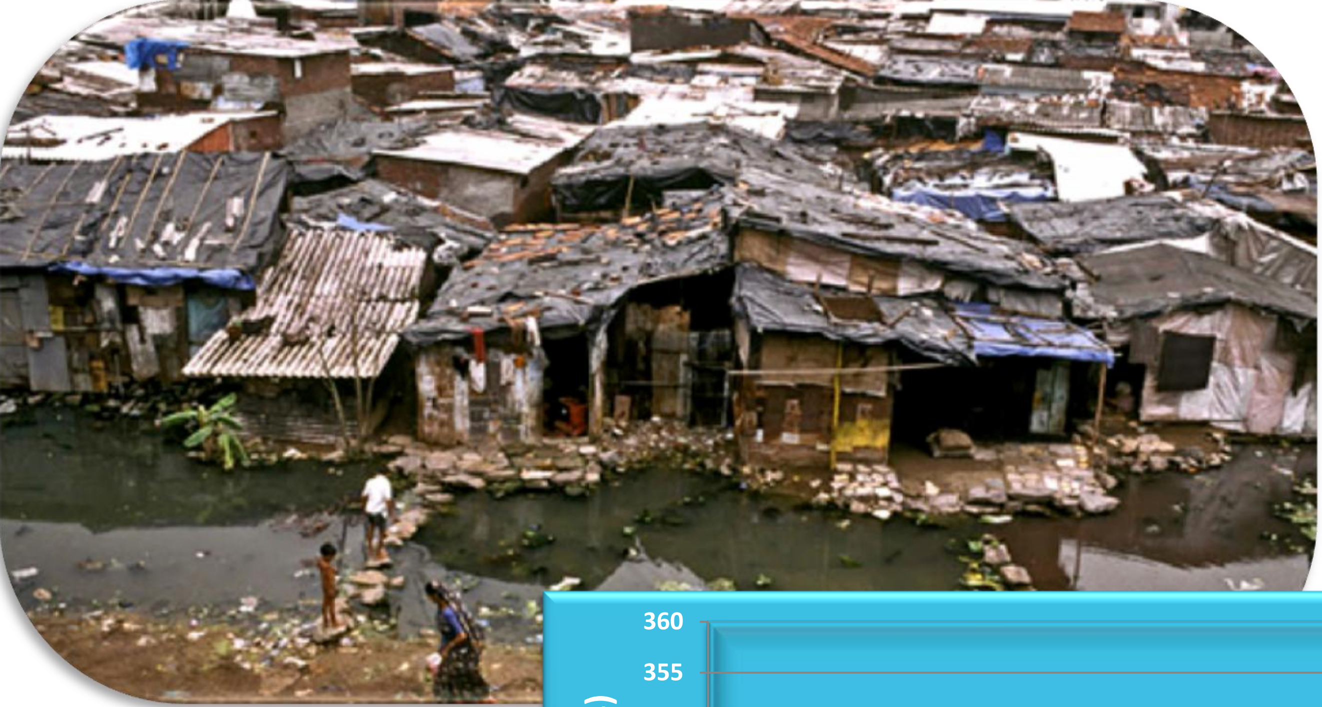
Data needed:

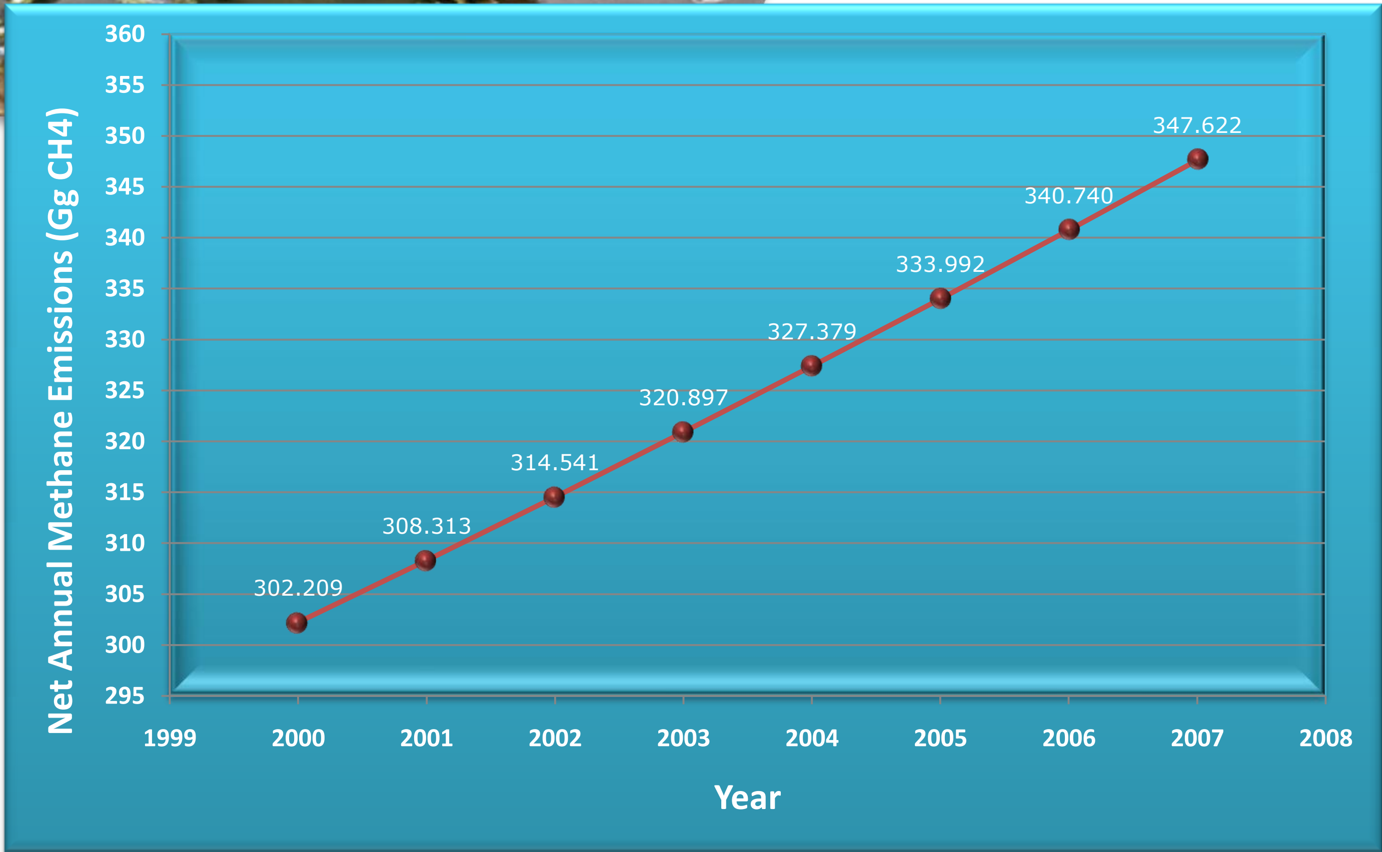
1. Degradable organic component (DC) indicator in kg DC per 1000 persons per year. For domestic wastewater and sludge, BOD is the recommended DC indicator.
2. Country population in thousands
3. Fraction of BOD removed as sludge.

Results

Year	Methane (Gg)	Carbon Dioxide (Gg)
1994		
Domestic	46.02	966.47
Industrial	43.83	920.5
2000		
Domestic	307.43	6,456.03
Industrial	64.20	1,348.2

Domestic Wastewater Subsector





Human Sewage Subsector

Data Requirements

- Per capita protein consumption
- National Population
- Amount of sewage applied to soils as sewage sludge

- National Statistical Information Center (NSIC)
- Department of Science and Technology- Food and Nutrition Research Institute (DOST- FNRI)
- Manila Water Co.

Nitrous Oxide Emissions from Human Sewage

Worksheet 6-4 Human Sewage, Sheet 1 of 1

1. Enter the per capita protein consumption in terms of kg/person/year in column A.

2. Enter the national population in column B.

3. Enter the fraction of nitrogen in protein in column C. The default value is 0.16 kg N per kg protein (IPCC, 1996).

Nitrous Oxide Emissions from Human Sewage

Worksheet 6-4 Human Sewage, Sheet 1 of 1

- 4. In column D, the amount of sewage N produced (in kg N/yr) is calculated automatically by multiplying values in columns A, B and C.

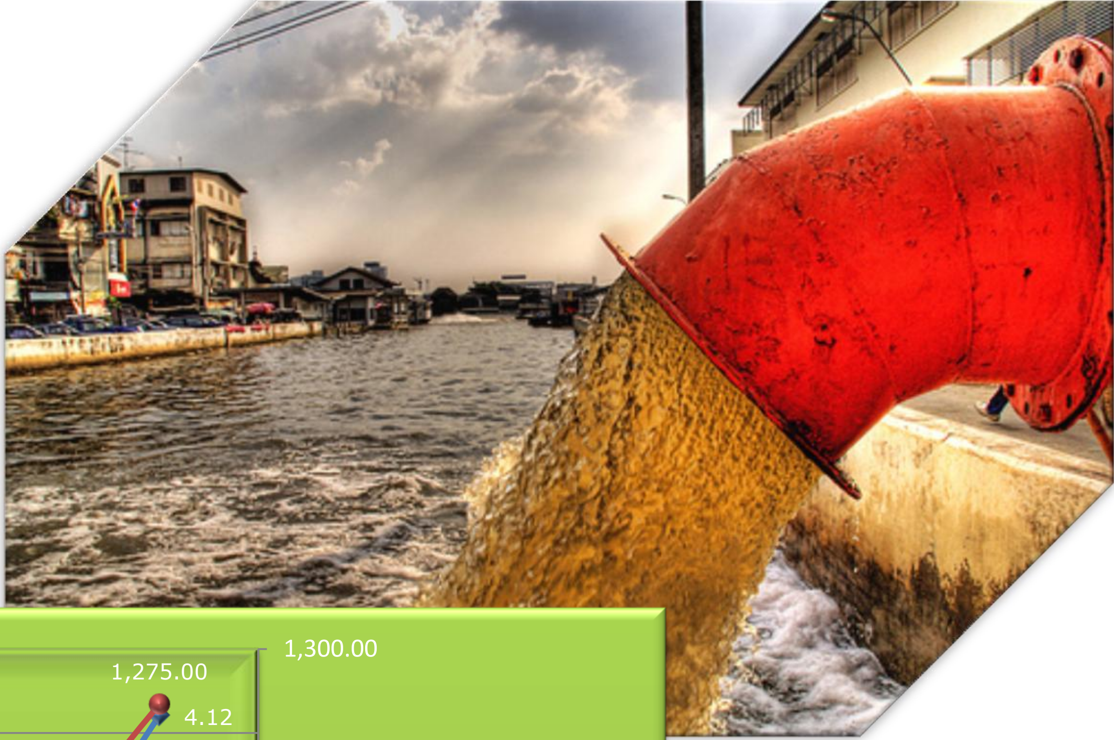
5. Enter the amount of sewage N applied to soils as sewage sludge (in kg N/yr) in column E.
6. In column F, the net amount of sewage produced (in kg N/yr) is calculated by subtracting value in column D with v value in column E (D - E).

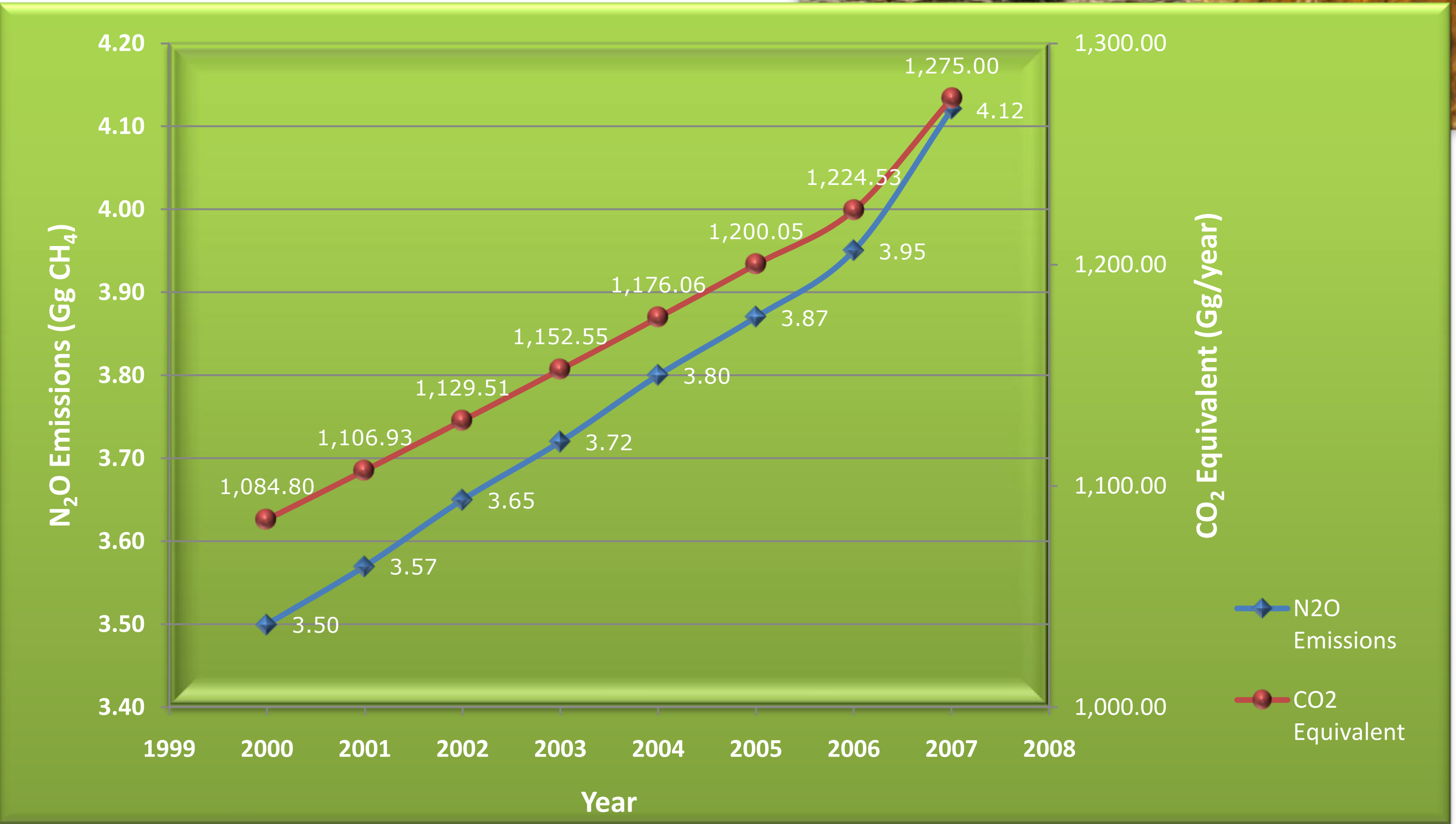
Nitrous Oxide Emissions from Human Sewage

Worksheet 6-4 Human Sewage, Sheet 1 of 1

7. Enter the emission factor EF in column G. The default value is 0.01 kg N2O per kg sewage–N produced (IPCC, 1996)
8. In column H, multiply together the values in columns F and G and the molecular conversion ratio, 44/28. Then convert this to Gg. This yields the total annual N2O emissions from human sewage (in Gg N2O).

Human Sewage Subsector





Conclusions

- In 2000, the emissions rose to 11,556 Gg CO_2e, a 63% increase compared to the 1994 emissions.
- The increase in industrial waste subsector is attributed to the increase in production industries and inclusion of untreated wastewater in the calculations.
- The increase in N_2O from human sewage could be attributed to the population growth.
- GHG emissions from municipal wastewater is due to the use of a new value for methane producing capacity constant (from 0.25 kg CH4/kg BOD to 0.6 kg CH4/kg BOD
- The decrease in emissions for the solid waste is due to the change in estimation model from mass balance approach to FOD.

Sources of Data

Published Articles:

Department of Environment and Natural Resources and Asian Development Bank (2003). Metro Manila Solid Waste Management Project (TA 3848-PHI): *Waste Analysis and Characterization Study*.

IPCC, 1996. *Guidelines for National Greenhouse Gas Inventories* (Workbook and Reference Manual)

IPCC, 2006. *Guidelines for National Greenhouse Gas Inventories* (Workbook and Reference Manual)

JICA-MMDA, 1998. *The Study on Solid Waste Management for Metro Manila in the Republic of the Philippines*. Master Plan Report, Pacific Consultants International, Kokusai Kogyo Co., Ltd

Metropolitan Manila Development Authority (MMDA), Metropolitan Solid Waste Management Office (2008). *Ang Basura ng Metro Manila*. Leaflet

Naz, A.C. and Naz, M.T. (2005). *Modeling Choices for Ecological Solid Waste Management in Sub-Urban Municipalities: User Fees in Tuba, Philippines (A Research Report).* Economy and Environment Program for Southeast Asia, 2005-RR10

National Solid Waste Management Commission, Office of the Secretariat (2000). *List of Controlled Disposal Facilities in the Philippines*

•

Sources of Data

National Solid Waste Management Commission, Office of the Secretariat (2000). *List of Open Dumpsites in the Philippines*

National Solid Waste Management Commission, Office of the Secretariat (2000). *List of Sanitary Landfills in the Philippines*

National Statistical Coordination Board (2003). *Balance Sheet of the Philippines*

National Statistics Office (2007). *Population and Annual Growth Rates by Region, Province, and Highly Urbanized City: Population Censuses 1995, 2000, and 2007*

Senate Planning Economic Office (2005). *Philippine Evnironment Quality: At a Glance*

Villarin, J.T., Narisma, G.T., Reyes, M.S., Macatangay, S.M., and Ang, M.T. (1999). *Tracking Greenhouse Gases: A Guide for Country Inventories*

World Bank, 2003. *Philippines Environment Monitor: Water Quality*

Sources of Data (Website)

International Monetary Fund (2006). World Economic Outlook Database. Obtained from: http://www.imf.org/external/pubs/ft/weo/2006/01/data/dbcoutm.cfm?SD=1980&ED=2007&R1=1&R2=1&CS=3&SS=2&OS=C&DD=0&OUT=1&C=566&S=NGDP_RPCH-NGDP-NGDPD-NGDPPC-NGDPDPC-PPPWGT-PPPSH-PPPEX&CMP=0&x=85&y=17 Accessed: 04 April 2009

National Statistics Office (2008). *Monthly Integrated Survey of Selected Industries (MISSI).* Obtained from: http://www.bsp.gov.ph/Statistics/spei/tab40.htm Accessed: 08 May 2009

National Statistics Office (2008). Value of Production Index, Annual and Monthly Growth for Manufacturing by Industry Major Group: January 1998 – May 2001 (Press Release). Obtained from: http://www.census.gov.ph/data/sectordata/2001/sk010501r.htm Accessed: 08 May 2009