Estimate of United States GHG Emissions from Wastewater

- Elizabeth A. Scheehle, US EPA, Office of Air and Radiation, Climate Protection Partnerships Division, Washington DC, United States
- Michiel R.J. Doorn, ARCADIS, Research Triangle Park, North Carolina, United States

Outline

- Methane from Domestic Wastewater
  - GP factor
  - septic tanks
- Methane from Industrial Wastewater
  - meat and poultry, pulp and paper, fruits, vegetables, and juices
- N_2O from wastewater
  - additional nitrogen loading
  - direct emissions

Methane from Domestic Wastewater

CH_4 = Population * BOD/capita * MCF * EF

- BOD = organic content in terms of Biological organic demand
- MCF = Percent of BOD_5 that is anaerobically digested

Methane from Domestic Wastewater

- Revised IPCC Emission Factor
- Revised Country specific MCF: 16.5%
  - inclusion of septic tanks:
    - 25% of US population
    - 50% treated anaerobically
  - revision of WWTP TA:
    - 75% of population
    - 5% treated anaerobically

Industrial wastewater treatment

- Current nitrogen measurements = negligible
- Potential for cost-effective mitigation for methane

Treatment :

Organic matter (BOD/COD)

- Soluble / insoluble
- Aerobic / anaerobic conditions
- Accidentally / deliberately managed under anaerobic conditions

Methane

Industrial wastewater: Methodology

For each evaluated industry:

CH_4 emissions = P ´ O ´ D ´ TA ´ EF (grams/yr)

Where:

P = production (tons of product/yr);

O = outflow (m^3/ton);

D = average organic loading (grams organic COD/m^3);

TA = factor to express which part of organic COD is prone to organic degradation;

EF = emission factor (0.25 gram CH_4/ gram COD).

TA

- often expert judgment.
- TA = 1.0 for anaerobic lagoons and
- TA = 0.0 for most other (aerobic, chemical, and physical) processes.

Settling ponds may have anaerobic zones or pockets,
Sludge may be anaerobic

Top Industry Sources

Step 1: Evaluate the industry sectors in the country that are believed to produce large volumes of organic wastewater.

- Meat and poultry: anaerobic lagoons;
- Pulp and paper industry: lagoons
- Vegetables, fruits and juices industry: lagoons

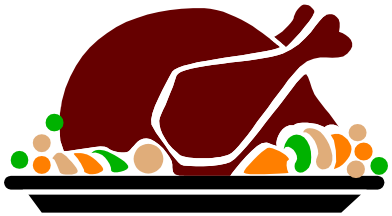
Organic chemicals, plastics and resins, starch production, alcohol refining, dairy products, and textiles: unlikely sources.

Petroleum refining wastewater included elsewhere.

Meat and poultry processing

Wastewater treatment:

- screening, fat traps and dissolved air flotation,
- anaerobic lagoons



Assumed that 77% for TA

- Note: Will be reviewed upon completion of surveys

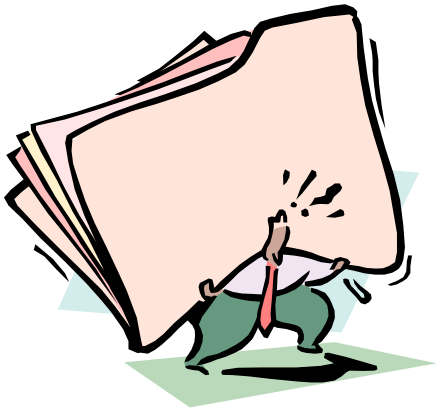
COD and wastewater flow based on actual measurements.

Pulp and paper manufacturing

565 pulp and paper manufacturing facilities in the US

Wastewater treatment:

- Pre-treatment, solids removal,
- lagoons for storage, settling, and
- lagoons for biological treatment



Based on survey data:

- 42% of organics to secondary treatment and
- 25% of organics in secondary treatment lagoons are treated anaerobically
- BOD used because more reliable data

Fruits, vegetables, and juices Processing

Wastewater treatment:

- screening, coagulation/settling and
- biological treatment (lagooning),
- effluent to municipal sewer

Assumed that 5% of wastewater organics degrades anaerobically.

Parameters used and CH_4 emissions

Parameters	Units	Meat & poultry	Pulp & paper	Fruits, juices, vegetables
Annual production	Tons x 1000	38,000	144,367	37,900
WW Generation	(m^3/ton)	13	85	5.6
BOD	(g/l)		0.4	
COD	(g/l)	4.1	5	5
TA	(%)	77	10.3	5
CH_4 Emissions	Gg/yr	390	303	13.3

Nitrous Oxide from wastewater

- IPCC default methodology
  - human sewage only
  - effluent emissions only
- EPA revised methodology:
  - additional domestic nitrogen
  - co-discharged industrial nitrogen
  - direct emissions from treatment

Additional Domestic Nitrogen Loading

Table 2. Estimate of the components of total (dissolved and suspended) solids in wastewater[1]

	Dry weight (lb/capita.day		
Component	**Range**	**Typical**	**Percentage**
Domestic wastes:			
Feces (solids, 23 percent)	0.07–0.15	0.09	9
Urine (solids, 3.7 percent)	0.09–0.15	0.11	11
Total Feces and urine		*0.20*	*20*
Ground food wastes	0.07–0.18	0.10	10
Sinks, baths, laundry, other wash waters	0.13–0.22	0.18	19
Toilet (incl. paper)	0.03–0.06	0.04	4
Total from domestic wastes[2]	0.41–0.80	0.52	54
Industrial wastes:	0.33–0.88	0.44	46

[1] adapted from Metcalf and Eddy (1991), Table 5-3

[2] excluding water softeners

Additional Domestic Nitrogen Loading

- All domestic nitrogen loading = 1.4 times human sewage nitrogen only
  - data not available for every year so 1.4 factor used
- Industrial co-discharge
  - Average amounts: industrial = 1.25 times human sewage nitrogen only
  - data not available every year
- Overall 1.75 times human sewage methodology

Direct emissions from WWTPs

- Current IPCC default method only for effluent
- Direct estimates from treatment plants
  - emission factor (4 g N_2O/person.year)
    - based on secondary treatment measurements (Czepiel, 1995)
    - does not include N_2O emissions from sewers and primary treatment.
- Small part of wastewater inventory:
  - 1-2 Gg/year, human sewage = 26 Gg in 1999

Conclusions and Uncertainties

- Best data found through surveys for effluent rule making
- % of national CH_4 estimates.
- Methane emissions from the fruits, vegetables, and juices category are insignificant.

Uncertainties

- heterogeneous nature of wastewater treatment
- degree to which anaerobic degradation occurs