# Sector: Waste

## Sub Sector: Domestic Wastewater

***Prepared by: ICLEI, South Asia***

| | |
|---|---|
| Usage Policy | Any re-production or re-distribution of the material(s) and information displayed and published on this Website/GHG Platform India/Portal shall be accompanied by a due acknowledgment and credit to the GHG Platform India for such material(s) and information.<br>You must give appropriate credit, provide a link, and indicate if changes were made. You may do so in any reasonable manner, but not in any way that suggests the GHG Platform India endorses you or your use. This paper may be revised or updated from time to time. The latest version of each this paper will be posted on the website. To keep abreast of these changes, please email us at info@ghgplatform-india.org so that we may inform you when this paper has been updated. |
| Citation | Chaturvedula, S., Kolsepatil, N., Sangem, P., (2016). Waste Emissions. Version 1.0 dated July 15, 2016, from GHG platform India: GHG platform India-2007-2012 National Estimates - 2016 Series: http://ghgplatform-india.org/data-and-emissions/waste. html<br>In instances where this sheet is used along with any other sector sheet on this website, the suggested citation is "GHG platform India 2007-2012 National Estimates - 2016 Series" |
| Disclaimer | The data used for arriving at the results of this study is from published, secondary sources, or wholly or in part from official sources that have been duly acknowledged. The veracity of the data has been corroborated to the maximum extent possible. However, the GHG Platform India shall not be held liable and responsible to establish the veracity of or corroborate such content or data and shall not be responsible or liable for any consequences that arise from and / or any harm or loss caused by way of placing reliance on the material(s) and information displayed and published on the website or by further use and analysis of the results of this study. |

## Introduction

Methane ($CH_4$) is emitted from waste water when it is treated or disposed anaerobically. Waste water originates from a variety of domestic, commercial, and industrial sources, and may be treated on site, sewered to a centralized treatment plant or disposed of untreated in nearby areas or via an outfall. Nitrous oxide ($N_2O$) emission occurs from domestic wastewater after the disposal of effluent into waterways, lakes or sea.

This exercise provides a detailed estimation of the Green House Gas (GHG) emissions (in terms of $CO_2$ equivalent) from Domestic Wastewater Treatment and Discharge (IPCC code: 4D1) in the Waste sector in India.

The objective is to contribute towards establishment of the 'India GHG platform' – which aims to complement the national reporting process, as well as to drive an informed policy dialogue within the country on the industrial carbon emissions estimation and the possibility to reduce emissions in the decades ahead.

This document provides details on the adopted methodology, data sources, information gaps, and the GHG emission estimations for the time period from 2007 to 2012.

## Scope of Assessment, Applicability and Boundary limitations:

The characteristics of domestic waste water and consequently the associated GHG emissions vary from place to place depending on factors such as economic status, community food intake, water supply status, treatment systems and climatic conditions of the area. Moreover, centralized wastewater treatment systems are being provided in urban areas while rural areas are largely lacking in such wastewater handling and treatment systems. This leads to rural wastewater being decomposed under aerobic conditions and not contributing to any significant $CH_4$ emissions. Moreover, given the lack of wastewater treatment systems, quantification of the waste water generated, collected, and treated becomes difficult. In line with India's Second National Communication for 2007 and in consideration of rural wastewater not contributing significantly to GHG emissions, domestic wastewater generated in rural areas is not included in the assessment.

Thus, this assessment is applicable for GHG emissions ($CH_4$ and $N_2O$) associated with the treatment and discharge of urban domestic wastewater within India. The reporting period considered is from the year 2007 to 2012.

To account for the factors indicated above and estimate $CH_4$ emissions, domestic wastewater is categorized on the basis of income group for urban areas across India as follows (in line with the 2006 IPCC guidelines on National GHG Inventories for Wastewater sector)

- Urban high income
- Urban low income

$N_2O$ emissions occurring as direct emissions from treatment plants or from indirect emissions from wastewater after disposal of effluent into waterways, lakes or the sea are also considered.

## $CH_4$ Emissions from Domestic Wastewater

## Methodology

Calculation of $CH_4$ emission from treatment of domestic wastewater is largely based on the country population, degree of utilization of treatment system or discharge pathways relevant to urban high and low income residents respectively. The total organics in waste water determine the quantum of methane emissions.

As per the 2006 IPCC Guidelines and India's Second National Communication, the following equation is used to estimate $CH_4$ emissions from domestic wastewater treatment and discharge

$$\boldsymbol{CH4\ Emissions} = \sum_{i,j} [(\boldsymbol{U_i} * \boldsymbol{Ti_{,j}} * \boldsymbol{EFj})](\boldsymbol{TOW} - \boldsymbol{S}) - \boldsymbol{R}$$

Where,

$CH_4$ Emissions = Methane emissions in inventory year, kg CH4/yr
TOW = total organics in wastewater in inventory year, kg BOD/yr
S = organic component removed as sludge in inventory year, kg BOD/yr (default value of 0[1])
Ui = fraction of population in income group i in inventory year
Ti,j = degree of utilization of treatment/discharge pathway or system, j, for each income group
Fraction i in inventory year
i = income group: rural, urban high income and urban low income
j = each treatment/discharge pathway or system
EFj = emission factor, kg CH4 / kg BOD
R = amount of CH4 recovered in inventory year, kg CH4/yr (default value of 0[2])

The emission factor $EF_j$ is applicable for the various type treatment system or discharge pathways listed in Table 1. It is a function of the maximum $CH_4$ producing potential (Bo) and the methane correction factor (MCF) for the waste water treatment and discharge system. The MCF indicates the extent to which the $CH_4$ producing capacity (Bo) is realized in each type of treatment and discharge pathway and system.

$$\boldsymbol{CH4\ Emission\ Factor\ EF_j} = \boldsymbol{B_o} * \boldsymbol{MCFj}$$

Where,

EFj = emission factor, kg CH4/kg BOD
j = each treatment/discharge pathway or system
Bo = maximum CH4 producing capacity, kg CH4/kg BOD (Default value 0.6[2])
MCFj = methane correction factor (fraction)

[1] As per 2006 IPCC Guidelines, Chapter 6: Wastewater Treatment and Discharge. Available at http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf

[2] As per 2006 IPCC Guidelines, Chapter 6: Wastewater Treatment and Discharge and NEERI document on Inventorisation of Methane Emissions from Domestic & Key Industries Wastewater – Indian Network for Climate Change Assessment, 2010. Available at: http://www.moef.nic.in/sites/default/files/M%20Karthik.pdf

The default MCF values for different types of domestic wastewater treatment and discharge pathways as available in the 2006 IPCC guidelines for Wastewater are given in Table 1.

**Table 1: Default MCF values for Domestic Wastewater by treatment type and discharge pathway**

| Type of treatment and discharge pathway or system | Description | MCF |
|---|---|---|
| **Untreated system** | | |
| Sea, river and lake discharge | Rivers with high organic loadings can turn anaerobic | 0.1 |
| Stagnant sewer | Open and warm | 0.5 |
| Flowing sewer (open or closed) | Fast moving, clean. (Insignificant amounts of $CH_4$ from pump stations, etc) | 0 |
| **Treated system** | | |
| Centralized, aerobic treatment plant | Must be well managed. Some $CH_4$ can be emitted from settling basins and other pockets. | 0 |
| Centralized, aerobic treatment plant | Not well managed. Overloaded. | 0.3 |
| Anaerobic digester for sludge | $CH_4$ recovery is not considered here. | 0.8 |
| Anaerobic reactor | $CH_4$ recovery is not considered here. | 0.8 |
| Anaerobic shallow lagoon | Depth less than 2 metres, use expert judgment | 0.2 |
| Anaerobic deep lagoon | Depth more than 2 metres | 0.8 |
| Septic system | Half of BOD settles in anaerobic tank | 0.5 |
| Latrine | Dry climate, ground water table lower than latrine, small family (3-5 persons) | 0.1 |
| Latrine | Dry climate, ground water table lower than latrine, communal (many users) | 0.5 |
| Latrine | Wet climate/flush water use, ground water table higher than latrine | 0.7 |
| Latrine | Regular sediment removal for fertilizer | 0.1 |

***(Source: 2006 IPCC Guidelines, Chapter 6 - Wastewater treatment and discharge)***

A key parameter for this source category is the total amount of organically degradable material in the wastewater (TOW). This parameter is a function of human population and Biological Oxygen Demand (BOD)[3] content of waste water generated per person. It is expressed in terms of biochemical oxygen demand (kg BOD/year).

The equation for TOW in domestic wastewater is:

$$TOW = P * BOD * 0.001 * I * 365$$

Where,

TOW = total organics in wastewater in inventory year, kg BOD/yr
P = country population in inventory year, (person)
BOD = country-specific per capita BOD in inventory year, g/person/day,
0.001 = conversion from grams BOD to kg BOD

[3] The principal factor in determining the $CH_4$ generation potential of domestic wastewater is the amount of degradable organic material in the wastewater i.e. BOD content. Wastewater with higher BOD concentrations will generally yield more $CH_4$ than wastewater with lower BOD concentrations. Both the type of wastewater and the type of bacteria present in the wastewater influence the BOD concentration of the wastewater.

I = correction factor for additional industrial BOD discharged into sewers

## Data Sources and Assumptions

### 1. Fraction of Population in income group i ($U_i$)

This parameter defines the breakup of population into each income group (Urban high income and urban low income). As per the 2006 IPCC Guidelines on Wastewater, the default country values for India for fraction of population in Urban high income group is 0.06 and the fraction of population in Urban low income group is 0.23 of the total country population. The same values are used in the Second National Communication for India. Thus, these values are considered in calculations in this assessment.

### 2. Degree of Utilization of treatment/discharge pathway or system j, for each income group fraction I ($T_{i,j}$)

**The degree of utilization expresses the contribution or share (in terms of a fraction) of each discharge system in the treatment of all the wastewater generated by each income group. This is a key parameter since this relates to the proportion of the resident population using different wastewater treatment/discharge pathways or systems.** For example, the degree of utilization rates listed for Urban High Income group in Table 2 implies that of the total urban high income population, 18% use on-site septic tanks, 8% use on-site latrines, 67% are served by sewer systems and 7% use systems other than these to discharge and treat their domestic wastewater.

Each of treatment/discharge pathways or systems will have different $CH_4$ emission factors and MCF values (see Methodology section for $CH_4$ emissions and Table 1); thereby having a varying contribution to the GHG emissions. The default values of degree of utilization rates for India as specified in the 2006 IPCC Guidelines and used in India's Second National Communication for Urban High Income are given in Table 2. The Treatment/Discharge pathways or systems are broadly classified by the 2006 IPCC Guidelines into Collected systems (i.e. wherein wastewater is conveyed using a sewer network) and Uncollected systems (wastewater not conveyed using a sewer network).

**Table 2: Default India specific Degree of Utilization Rates for Domestic Wastewater Treatment/Discharge Pathways or Systems**

| Income Group | Treatment/discharge type used as per 2006 IPCC Guidelines | Classification of the system as per 2006 IPCC Guidelines (Collected/ Uncollected and Treatment) | Degree of utilization of treatment/ Discharge pathway or system j, for each income group fraction i (Ti,j) |
|---|---|---|---|
| **Urban High** | Septic Tank | Uncollected (Treatment on-site) | 0.18 |
| | Latrine | Uncollected (Treatment on-site) | 0.08 |
| | Other | Collected (No Treatment) | 0.07 |

| Income Group | Treatment/discharge type used as per 2006 IPCC Guidelines | Classification of the system as per 2006 IPCC Guidelines (Collected/ Uncollected and Treatment) | Degree of utilization of treatment/ Discharge pathway or system j, for each income group fraction i (Ti,j) |
|---|---|---|---|
| **Income** | Sewer | Collected (Treatment/No Treatment) | 0.67 |
| | None | Uncollected (No Treatment) | 0 |
| **Urban Low Income** | Septic Tank | Uncollected (Treatment on-site) | 0.14 |
| | Latrine | Uncollected (Treatment on-site) | 0.10 |
| | Other | Collected (No Treatment) | 0.03 |
| | Sewer | Collected (Treatment/No Treatment) | 0.53 |
| | None | Uncollected (No Treatment) | 0.20 |

***(Source: 2006 IPCC Guidelines, Chapter 6 - Wastewater treatment and discharge; India's Second National Communication to UNFCCC)***

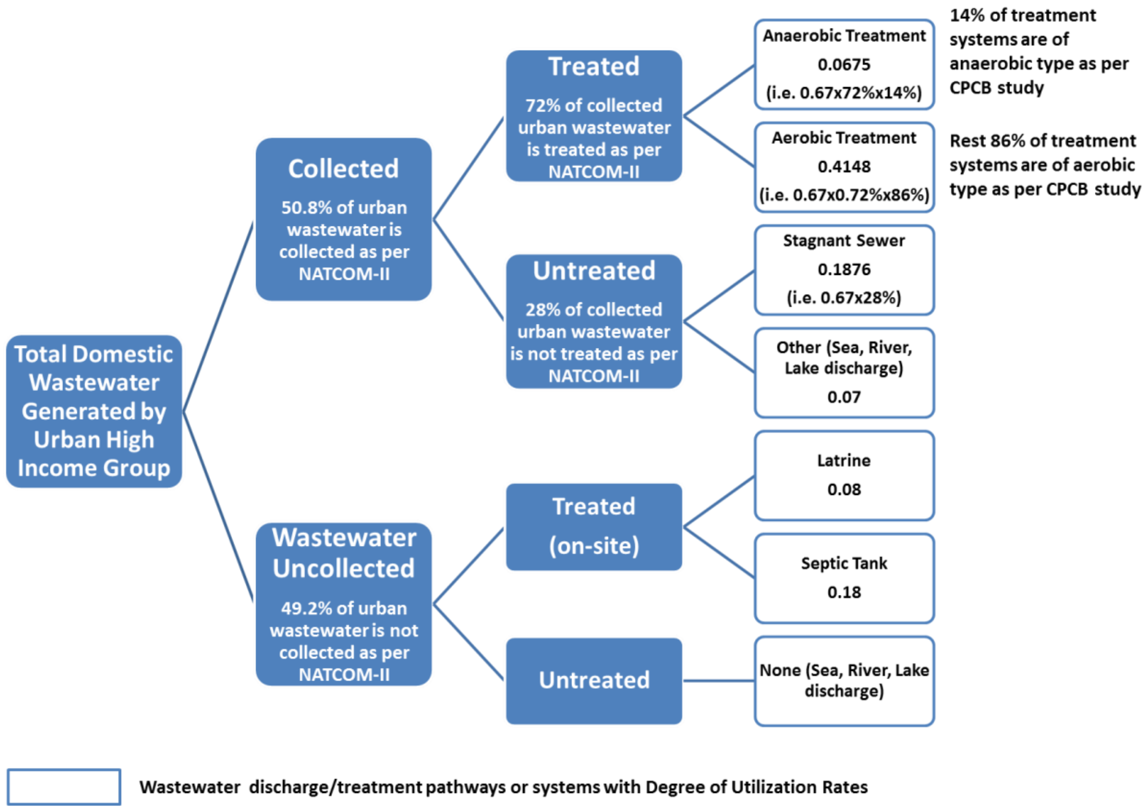
As per India's Second National Communication report, about 49.2% of the domestic wastewater generated from the urban centers is not collected. Further, treatment is provided to only **72%** of the wastewater that is collected (see Figure 1).

While the Second National Communication report further indicates that anaerobic treatment systems are used for about 25% of wastewater that is collected and treated; no specific reference documents are indicated in the National Communication report for this information. However, a 2007 Central Pollution Control Board (CPCB) study on "Inventorization of Sewage Treatment Plants[4]" in which 84 Sewage Treatment Plants (STPs) (spread across 9 states and 30 cities) out of a total of 175 STPs in urban areas in the country were assessed, indicates that only 14% of treatment capacity installed is using anaerobic systems and the remaining 86% of the treatment capacity is using aerobic systems. A similar CPCB study conducted in 2014-15 in which 601 existing STPs were assessed (in class-I and class-II cities spread across 35 states and Union Territories) indicates that 16% of the treatment capacity installed is using anaerobic systems and the remaining 84% of the treatment capacity is using aerobic systems. The 2014-15 CPCB study, although conducted post the period of this GHG emission estimation assessment i.e. year 2012, substantiates the findings of the 2007 CPCB study which indicates that the fraction of anaerobic treatment for collected wastewater is 14% as compared to 25% mentioned in the Second National Communication report. Therefore it is assumed that for the wastewater which is collected and treated, 14% is treated by anaerobic systems and 86% is treated by aerobic systems and this is considered to rework the fractions for degree of utilization given in Table 2.

Based on this data on extent of collection and treatment in India, the fractions for degree of utilization have been further split up and calculated for sewer systems (see Figure 1 and Table 3).

[4] CPCB (2007): Inventorization of Sewage Treatment Plants in India. Available at http://www.cpcb.nic.in/upload/NewItems/NewItem_99_NewItem_99_5.pdf

**Figure 3: Classification of Wastewater Treatment Systems and Estimated Degree of Utilization for Urban High Income Group in India**




For example, for Urban High Income group the degree of utilization as per 2006 IPCC guidelines for sewer system is 0.67 (i.e. 67%). As per India's Second National Communication, only 72% of the collected wastewater is treated and thereby 28% is untreated. Thus 0.67 x 0.28 i.e. 0.1876 (or 18.76%) of the total domestic wastewater generated from Urban High Income group is untreated. Based on data from the 2007 CPCB study on STPs, 14% of wastewater that is collected is treated anaerobically while the rest 86% undergoes aerobic treatment. Thus, 0.67 x 0.72 x 0.14 i.e. 0.0675 (or 6.75%) of the total domestic wastewater generated from Urban High Income group undergoes anaerobic treatment and similarly 0.4148 (or 41.48%) of total domestic wastewater generated from Urban High Income group undergoes aerobic treatment. Fractions have been calculated for Urban Low income groups similarly in Table 3.

**Table 4: Estimated Fractions for Degree of utilization of Sewer based systems for each income group**

| Income Group (i) | Treatment/ discharge pathway or system (j) | Specific Treatment/Discharge pathway or system (j) selected from Table 1[5] | Degree of utilization of treatment/ Discharge pathway or system j, for each income group fraction i (Ti,j)[6] | Remarks |
|---|---|---|---|---|
| Urban - High | Septic Tank (uncollected) | Septic Tank (uncollected) | 0.18 | |
| | Latrine (uncollected) | Latrine (uncollected) (Dry climate, ground water table lower than latrine, small family (3-5 persons) | 0.08 | |
| | Other (collected and not treated) | Sea, river and lake discharge | 0.07 | |
| | Sewer (collected and not treated) | Stagnant Sewer (collected and not treated) | 0.67x0.28 = 0.1876 | 28% of collected wastewater is not treated as per Second National Communication |
| | Sewer (collected and anaerobic treatment) | Anaerobic Reactor/ Anaerobic digester for sludge (collected and anaerobic treatment) | 0.67x0.72x0.14 = 0.0675 | Remaining 72% of collected wastewater is treated; of which 14% is treated anaerobically as per 2007 CPCB study on STPs in India[4] |
| | Sewer (collected and other treatment) | Centralized, aerobic treatment plant (not well managed) (collected and aerobic treatment) | 0.67x0.72x0.86 = 0.4148 | Remaining 72% of collected wastewater is treated; of which rest of the 86% is treated aerobically as per 2007 CPCB study on STPs in India[4] |
| | None | Sea, river and lake discharge | 0 | |
| Urban - low | Septic Tank (uncollected) | Septic Tank (uncollected) | 0.14 | |
| | Latrine (uncollected) | Latrine (uncollected) (Dry climate, ground water table lower than latrine, small family (3-5 persons) | 0.1 | |
| | Other (collected) | Sea, river and lake discharge | 0.03 | |
| | Sewer (collected and not treated) | Stagnant Sewer (collected and not | 0.53x0.28 =0.148 | 28% of collected wastewater is not treated |

[5] Based on India's Second National Communication

[6] Values for wastewater conveyed through sewer system worked out based on values in Table 2 and 2007 CPCB Report on Evaluation of Operation and Maintenance of Sewage Treatment Plants in India and information given in India's Second National Communication to UNFCCC

| Income Group (i) | Treatment/ discharge pathway or system (j) | Specific Treatment/Discharge pathway or system (j) selected from Table 1[5] | Degree of utilization of treatment/ Discharge pathway or system j, for each income group fraction i (Ti,j)[6] | Remarks |
|---|---|---|---|---|
| | | treated) | | as per Second National Communication |
| | Sewer (collected and anaerobic treatment) | Anaerobic Reactor/ Anaerobic digester for sludge (collected and anaerobic treatment) | 0.53x0.72x0.14 =0.053 | Remaining 72% of collected wastewater is treated; of which 14% is treated anaerobically as per 2007 CPCB study on STP in India[4] |
| | Sewer (collected and other treatment) | Centralized, aerobic treatment plant (not well managed) (collected and aerobic treatment) | 0.53x0.72x0.86 =0.3281 | Remaining 72% of collected wastewater is treated; of which rest of the 86% is treated aerobically as per 2007 CPCB study on STPs in India[4] |
| | None | Sea, river and lake discharge | 0.2 | |

## 3. Methane Correction Factor ($MCF_j$)

Methane Correction Factor which is an indication of the degree to which the wastewater treatment system is anaerobic (and thereby generating GHG emission), varies with the type of treatment or discharge pathway.

Based on India's Second National Communication, specific treatment/discharge pathways or systems have been selected in Table 3 and default MCF values given in IPCC guidelines in Table 1 have been used as applicable.

**Table 5: MCF values considered for various treatment types**

| Treatment/ discharge pathway or system (j) | Classification of the system (Collected/ Uncollected and Treatment) | Specific Treatment/Discharge pathway or system (j) selected from Table 1[7] | MCF |
|---|---|---|---|
| Septic Tank | Uncollected (Treatment on-site) | Septic Tank | 0.5 |
| Latrine | Uncollected (Treatment on-site) | Latrine (Dry climate, ground water table lower than latrine, small family (3-5 persons)) | 0.1 |
| Other | Collected (No Treatment) | Sea, river and lake discharge | 0.1 |
| Sewer | Collected (No Treatment) | Stagnant sewer | 0.5 |
| Sewer | Collected (Anaerobic treatment) | Anaerobic Reactor/Anaerobic digester for sludge | 0.8 |

[7] Based on India's Second National Communication

| Treatment/ discharge pathway or system (j) | Classification of the system (Collected/ Uncollected and Treatment) | Specific Treatment/Discharge pathway or system (j) selected from Table 1[7] | MCF |
|---|---|---|---|
| Sewer | Collected (Aerobic treatment) | Centralized, aerobic treatment plant (not well managed) | 0.3 |
| None | Uncollected (No Treatment) | Sea, river and lake discharge | 0.1 |

***(Source: 2006 IPCC Guidelines, Chapter 6 - Wastewater treatment and discharge; India's Second National Communication to UNFCCC)***

## 4. **Country population (P)**

The country population for all the years (2007-12) is estimated on the basis of population data and decadal population growth trends as per the National Census 2001 and 2011.

## 5. **Biochemical oxygen demand (BOD)**

The primary factor in determining the $CH_4$ generation potential of wastewater is the amount of degradable organic material in the wastewater. BOD is a common parameter used to measure the organic component of domestic wastewater. Under the same ambient conditions, wastewater with higher BOD concentration will generally yield more $CH_4$ than wastewater with lower BOD concentration.
The BOD concentration indicates only the amount of carbon that is aerobically biodegradable.

According to the 2006 IPCC guidelines for Wastewater, the default value of BOD generated per person for India is about 34 gm/person/day. However, an average value for BOD of 40.5 gm/person/day is used in the Second National Communication[8] and to maintain consistency, this updated country specific value of 40.5 gm/person/day is used in this analysis.

## 6. **Correction factor for additional Industrial BOD discharged into sewers (I)**

Effluent from industries and establishments is often co-discharged in sewers and mixes with domestic wastewater. As indicated previously the total organics in wastewater (TOW) is directly proportional to BOD value and BOD is the principal factor determining the CH4 generation potential of domestic wastewater. Wastewater with higher BOD concentrations will generally yield more $CH_4$ than wastewater with lower BOD concentrations. Both the type of wastewater and the type of bacteria present in the wastewater influence the BOD concentration of the wastewater.

This correction factor I accounts for additional BOD from mixing of such industrial and commercial effluent with domestic wastewater. Based on the Second National Communication for India and the 2006 IPCC Guidelines for Wastewater, the default values of 1.25 for I for collected wastewater and 1 for uncollected wastewater as given in IPCC guidelines are used in this assessment.

[8] Inventorisation of Methane Emissions from Domestic & Key Industries Wastewater – Indian Network for Climate Change Assessment, NEERI, 2010. Available at: http://www.moef.nic.in/sites/default/files/M%20Karthik.pdf

## $N_2O$ Emissions from Domestic Wastewater

### Methodology

$N_2O$ emissions can occur as direct emissions from treatment plants or from indirect emissions from wastewater after disposal of effluent into waterways, lakes or the sea.

As per the 2006 IPCC Guidelines and India's National Communication, the following equation is used to estimate $N_2O$ emissions from domestic wastewater treatment and discharge

$$N_2O\ Emissions = N_{EFFLUENT} * EF_{EFFLUENT} * 44/28$$

Where,

$N_2O$ emissions = $N_2O$ emissions in inventory year, kg $N_2O$/yr
$N_{EFFLUENT}$ = nitrogen in the effluent discharged to aquatic environments, kg N/yr
$EF_{EFFLUENT}$ = emission factor for $N_2O$ emissions from discharged to wastewater, kg $N_2O$-N/kg N
The factor 44/28 is used for conversion of kg $N_2O$-N into kg $N_2O$.

The activity data that is needed for estimating $N_2O$ emissions is nitrogen content in the wastewater effluent, Country population and average annual per capita protein consumption (kg/person/yr).

The total nitrogen in the effluent is estimated as follows:

$$N_{EFFLUENT} = P * Protein * F_{NPR} * F_{NON-CON} * F_{IND-COM}) - N_{SLUDGE}$$

Where,

$N_{EFFLUENT}$ = total annual amount of nitrogen in the wastewater effluent, kg N/yr
P = human population
Protein = annual per capita protein consumption, kg/person/yr
$F_{NPR}$ = fraction of nitrogen in protein, kg N/kg protein (default value of 1.1 used as per 2006 IPCC guidelines for wastewater)
$F_{NON-CON}$ = factor for non-consumed protein added to the wastewater (default value of 1.1 used as per 2006 IPCC guidelines for wastewater)
$F_{IND-COM}$ = factor for industrial and commercial co-discharged protein into the sewer system, (default value of 1.25 used as per 2006 IPCC guidelines for wastewater)
$N_{SLUDGE}$ = nitrogen removed with sludge, kg N/yr (default value of 0 used as per 2006 IPCC guidelines for wastewater)

### Data Sources and Assumptions

1. **Human Population**

   The country population for all the years (2007-12) is estimated on the basis of population data and decadal population growth trends as per the National Census 2001 and 2011.

## 2. **Annual per capita protein consumption (Protein)**

As per National Sample Survey Organization (NSSO), Ministry of Statistics & Programme Implementation Report on Nutritional Intake 2004-05, the protein consumption in urban India is about 57 gm/capita/day. This value is considered in the Second National Communication and in this assessment. Based on NSSO surveys conducted subsequently, the per capita protein consumption values used in this assessment have been updated as shown in Table 5.

**Table 6: Values of Daily Per Capita Protein Consumption considered for urban Population**

| Years | Daily per capita protein consumption (gm/capita/day) | Source |
|---|---|---|
| 2007 and 2008 | 57.0 | Nutritional Intake in India 2004-05, NSSO Report[9] |
| 2009 and 2010 | 56.15[10] | Nutritional Intake in India 2009-10, NSSO Report[11] |
| 2011 and 2012 | 58[10] | Nutritional Intake in India 2011-12, NSSO Report[12] |

Based on the daily protein consumption, annual protein consumption values have been calculated and used in the equation to estimate $N_2O$ emissions.

## Results and Comparison with National Inventory

The GHG emission estimates for the time period 2007-2012 along with a comparison with official national reporting (for years 2007 and 2010) are given in Table 5. The overall GHG emission estimates from domestic wastewater for 2007 and 2010 show an under estimation as compared to the National reporting estimates, with a deviation of 28.7% and 41.3%. $CH_4$ emissions are underestimated by 36.1% and 24% for the year 2007 and 2010 respectively as compared to official National reporting estimates. $N_2O$ emissions are underestimated by 1.3% for the year 2007 and by 62% for the year 2010.

**Table 7: Results of GHG emission Estimation and Comparison with National Inventory Reporting**

| GHG Emissions from Domestic Wastewater | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| **$CH_4$ Emissions (Megatonnes of $CO_2$e)** | | | | | | |
| India GHG Platform Estimates | 12.027 | 12.219 | 12.412 | 12.604 | 12.797 | 13.023 |
| As per Second National Communication (2007) and Biennial Update Report (2010) | 18.081 | - | - | 15.840 | - | - |
| Deviation as compared to official | -33% | - | - | -20% | - | - |

[9] Available at http://mospi.nic.in/rept%20_%20pubn/513_final.pdf

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

[11] Available at http://www.indiaenvironmentportal.org.in/files/file/nutrition%20intake%20in%20india.pdf

[12] Available at http://mospi.nic.in/mospi_new/upload/nss_report_560_19dec14.pdf

| GHG Emissions from Domestic Wastewater | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| estimates (%) | | | | | | |
| **$N_2O$ Emissions (Megatonnes of $CO_2$e)** | | | | | | |
| India GHG Platform Estimates | 4.834 | 4.963 | 5.016 | 5.144 | 5.444 | 5.576 |
| As per Second National Communication (2007) and Biennial Updated Report (2010) | 4.898 | - | - | 13.538 | - | - |
| Deviation as compared to official estimates (%) | -1.3% | - | - | -62% | - | - |
| **Cumulative GHG Emissions (Megatonnes of $CO_2$e)** | | | | | | |
| India GHG Platform Estimates | 16.8617 | 17.1832 | 17.4287 | 17.7482 | 18.2414 | 18.5991 |
| As per Second National Communication (2007) and the Biennial Update Report (2010) | 22.979 | - | - | 29.378 | - | - |
| Deviation as compared to official estimates (%) | -27% | - | - | -40% | - | - |

The possible reasons for the deviation from official estimates are discussed below:

- To estimate $CH_4$ emissions, the extent of wastewater treated aerobically, anaerobically or not treated at all and the type of treatment system considered for collected wastewater streams is critical since this impacts the degree of utilization of the wastewater treatment system and the respective emission factor; which subsequently impacts the associated GHG emission. Limited clarity and details are provided in the Second National Communication Reports and the Biennial Update Report on the breakup of degree of utilization, assumptions and specific data sources used- specifically for the portion of the domestic wastewater that is collected and conveyed through sewer networks.
- The country population used to calculate the $CH_4$ and $N_2O$ emissions is estimated for the time period between 2007 to 2012 based on National Census data for 2001 and 2011 and decadal growth rates therein. The Second National Communication and the Biennial Update Report do not provide details of the country population that is used for the estimations. Possible variation in the methods used to arrive at country population can be a likely source of deviation.
- The Second National Communication report indicates that anaerobic treatment systems are used for about 25% of the domestic wastewater that is collected and treated in India. The official emission estimates are subsequently based on this data which is used to assess the extent of utilization for anaerobic treatment systems to treat wastewater collected through sewer systems. However, no specific reference documents are indicated in the National Communication report for this information. In this assessment, based on the CPCB study conducted in 2007 on STPs in India, it is assumed that 14% of collected wastewater undergoes anaerobic treatment. This proportion is further substantiated by a similar CPCB study conducted in 2014-15 (see Table 3 and Section on Assumptions and Data Sources for ‘Degree of Utilization of treatment/discharge pathway or system j’ for $CH_4$ emissions). The difference in this underlying assumption has contributed to deviation in the two estimates.

- $CH_4$ emission estimates done by assuming that 25% of collected domestic wastewater is treated using anaerobic treatment systems (as per the Second National Communication) results in $CH_4$ emission of 12.891 Megatonnes of $CO_2$e and 13.509 Megatonnes of $CO_2$e for year 2007 and 2010 respectively, which is relatively closer to the official emission estimates as per Second National Communication and the Biennial Update Report. The variation of this estimate with respect to the final estimates prepared under our assessment (by considering 14% of collected domestic wastewater is treated by anaerobic systems) is 7% and 4% respectively. However, for the reasons indicated above our assessment uses the results of the CPCB study and assumes that anaerobic treatment plants constitute 14% of the treatment capacity as a basis to calculate the degree of utilization for anaerobic and aerobic treatment systems in India.
- For the estimation of $N_2O$ emissions in 2007, the protein consumption in urban India is assumed to be 57 gm/capita/day as per the NSSO survey in 2004-05 on nutritional Intake in India 2004-05. The same value is used in the Second National Communication for 2007. For the year 2010, this assessment has used a value of 56.15 gm/capita/day for the protein consumption in urban areas based on the NSSO survey in 2009-10. The Biennial Update Report does not indicate the value considered for the per capita protein consumption. Deviation in the official estimates of $N_2O$ emissions for 2010 and estimates of this study is higher as compared to 2007, possibly due to the variation in the values of per capita protein intake and country population.

## Remarks

Limited clarity and information is provided in the National Communication Reports and the Biennial Update Report on values, assumptions and data sources for parameters such as degree of utilization, type of treatment system in the preparation of the 2007 and 2010 national inventories. Details of the assumptions and disaggregated results of GHG emission for different treatment/discharge pathways or systems for domestic wastewater are not available in these documents as well.

Limited updated information on country specific values for parameters such as degree of utilization rates by income group, methane recovery rates, BOD values, wastewater generation and treatment in rural areas exists in the IPCC guideline documents and also in other secondary sources to enable an accurate and updated estimation of GHG emissions from domestic wastewater.

Improved transparency with regards to availability of the underlying datasets and assumptions used for the official National GHG emission estimates in the public domain will greatly help in improving the accuracy of this assessment, enable better comparability, and help identify and address any limitations in the estimates done under this assessment as well as official emission estimates.