Syria - سورية

Enabiling Activities for Preparation of Syria's
Initial National Communication to UNFCCC

Green House Gases (GHG) Inventory for Waste Sector

July 2009

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Ministry of State for Environment Affairs (MSEA),in collaboration with United Nation Development Programm (UNDP) in Syria, and Global Environmental Facility (GEF).

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Greenhouse Gas (GHG) Inventory for Waste Sector in Syria

(INC-SY_GHG_Waste Inventory-En)

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This report has been approved unanimously by the technical committee, during the Technical Workshop which took place on 23.7.2009, in the Resort of Mount Hermon, Qunitra.

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Executive Summary

The pr;psent report contains an inventory of emissions resulting from waste sector in Syria during the period 1994-2005. These include domestic solid waste and their final disposal sites, wastewater and resulting sludge from wastewater treatment plants, industrial wastewater and resulting sludge from industrial water treatment plants from factories and industrial installations and oil refineries in Syria.

Domestic Solid Waste

Domestic solid waste issue in Syria is one the most important issues of the Ministry of Local Administration and of the local administrative units (cities, municipalities, villages and related groups). In 2004, the national strategy for solid waste management in Syria was released. This strategy is based on converting the inlet organic materials in the domestic solid waste compositions into compost and to be used for soil amendment. The solid waste is first segregated into organic materials for compost and the refusals to be sent to sanitary landfills. This solution of treatment is considered to be the main solution for such waste in the current situation. Therefore, several Governorates have already started executing approved studies either for compost plants, segregation stations or sanitary landfills. However, there are still many disposal sites for domestic solid waste distributed at cities and villages surroundings, which are considered to be the only solution in the mean time to collect wastes generated from such places.

A solid waste treatment factory was constructed by Damascus Governorate late in1990. However, it treats only half of the solid waste generated by Damascus city and the remaining wastes are transferred to neighboring landfills.

The organic materials present in the solid waste is considered the main source of methane gas (CH_4), the ratio of such materials in the waste is around 40-60%. Methane is produced from the leavening of the organic materials in the disposal sites. Methane is the main contributor to the total gas emissions from non-aerobic leavening of wastes at the disposal sites (around 60%)[1].

Methane quantity which was released during the period of 1994-2005 was calculated. It was found (Figure1) that there is a direct relationship between methane volume and solid waste quantity which is related to growth of population and increase in living standards in general, and increase of inhabitants in cities in comparison with countryside. The methodology is based green gases emissions guidelines for 1996 issued by IPCC.

Waste Water

Treatment of wastewater generated from cities and inhabitant complexes is the responsibility of the Ministry of Construction and Housing. Therefore, many administrative units in Syria have started constructing wastewater treatment plants in compliance with the National strategy for treating all wastewaters generated from the cities, towns and villages using best available wastewater treatment plants and according to the plan prepared by the Ministry of Construction and Housing.

[1] National strategy for solid waste management in Syria for the year 2004- French Trivalor Company- Ministry of Local Administration and Environment.

Sludge generated from the wastewater treatment contains mainly organic materials (40-60%) in addition to bacteria. The organic materials is the main source of gas emissions from wastewater and the sludge generated from wastewater treatment plants in cities where wastewater treatment plants were established (Damascus, Aleppo city,…) [2]

Methane Gas

The first wastewater treatment plant was established in 1993 in Salamieh and more wastewater treatment plants have been established in big cities. Methane gas emission from each wastewater plant was calculated for each year during 1994-2005

Nitro Oxide

The rate of nitro oxide (N_2O) emission from wastewater during 1994-2005 was calculated and it was found to be in direct relationship with population increase.

Industrial Wastewater

Directorates of Environment and wastewater companies in each governorate are applying very strict procedures for controlling industrial wastewater to be discharged into the sewage water system in order to separate any dangerous materials. A Syrian Standard No. 2580 of the year 2003 for industrial wastewater specifications to be discharged into the main sewage water system was issued under the title Limitation of Discharged Liquid Wastes of Economic Activities in Sewer Network. For oil sector, the treatment plants operated in Homes and Banias refineries which use oil and precipitation methods in addition to activated sludge for treatment of industrial wastewater . Methane gas quantity (CH_4) emission rate from Homs and Banias refineries was calculated for the period of 1994-2005

Total Emissions from Wastes Sector Equivalent to CO_2

Total emissions from wastes sector has increased due to population increase and migration to cities and increasing the living standards. The total emissions reached 3800 Gg in 2005. This quantity is considered small in comparison with emissions from other energy sectors.

Summary

Methane emission ratio at the disposal sites of domestic solid wastes was found to be about 88%in 2005, while the emissions for wastewater treatment plants was about 11% and about 1% from the industrial wastewater treatment plants. These variations are due to the fact that wastewater treatment plants are new and not sufficient to cover all produced wastewater in the country while the number of industrial wastewater treatment plants is rather small or not in operation. Therefore, the present study was focused only on Homes and Banias treatment plants.

[2] Strategy and National Environmental Work plan in Syria for the Year 2003. Ministry of Local Administration and Environment wastewater.

1. Introduction

The increase in population, increase in living standards and improvements in the cities and countryside in addition to industrial and agricultural development have increased the generation of domestic solid wastes. Many sewage water and industrial water treatment plants have been constructed in cities and small and large communities where proper solutions for safe and environment friendly for waste disposal and wastewater and industrial water have been identified.

Organic materials form the largest ratio of the solid waste in Syria and the largest component of the sludge is produced from wastewater. The organic materials compose about 60% of the domestic solid waste while it is 40-60% in the sludge produced by the wastewater treatment plant in addition to bacteria. These materials are considered the main source of gas emissions from domestic solid wastes due to their composition and leavening at the final disposal sites of domestic solid wastes, and sludge from wastewater and industrial water treatment plants.

2. Waste Sector in Syria

2.1. Solid waste in Syria

The Ministry of Local Administration is responsible for management of solid waste sector through the administrative units (governorate, cities, municipalities). The system is based on collection of all types of solid wastes (mixed system) including domestic, commercial, industrial and agricultural wastes. All municipality units collect their wastes in secondary collection centers in order to transfer the wastes to final disposal sites and sometimes, the waste is directly transferred to the final disposal site.

In Damascus city, there is only one solid waste treatment plant with a capacity of 500 tons/day. The plant converts organic materials included in the solid waste into compost and sold directly to farmers to improve soil fertility. The remaining wastes (unused materials) are sent to landfill constructed close to factory. In other big Syrian governorates such as Aleppo, Homes, Hama, Lattakia, and Tartouse, all wastes are buried as a disposal method where soil is used routinely to cover the wastes or when necessary. Municipalities, especially small ones use unorganized disposal method in uncontrolled sites where health and environmental conditions are not considered.

All disposal sites of the domestic solid waste are distributed at the borders of the cities, villages and other administrative units.

Organic materials present in waste compositions are the main methane gas producer due to leavening of the materials at the disposal sites.

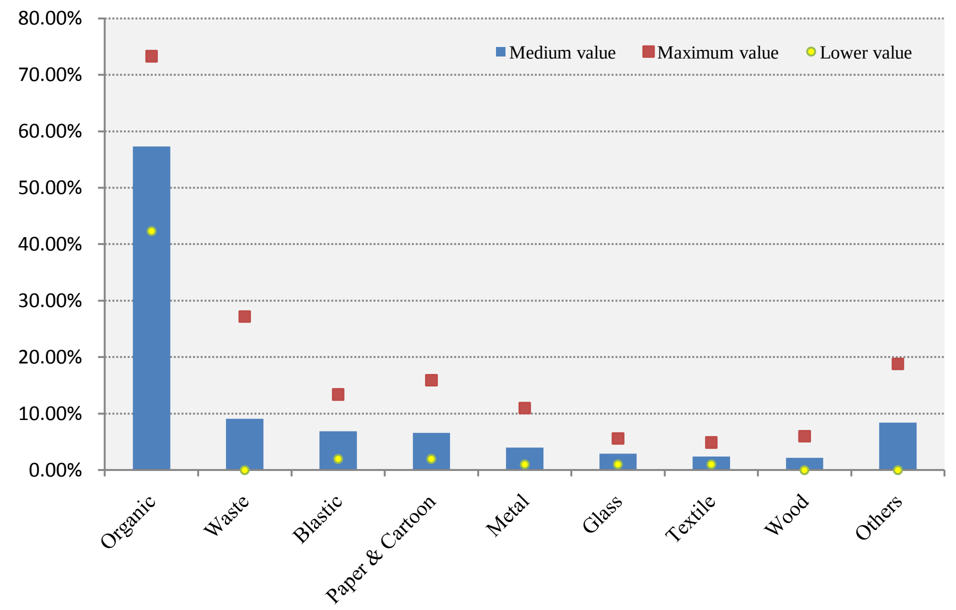

Figure 1. Waste Compositions in Syrian Governorates

Table 1. Waste Quantity produced in each Governorate for the year 2002 According to Trivalor Company which prepared the National Strategy for Solid Waste in Syria.

Governorate Name	Population	Solid Waste With rubbish(T/D) 2002	Kg/per/day	Solid Waste With rubbish(T/D) 2002	Solid Waste Without rubbish (Kg/per/day) 2002	Kg/per/day	Solid Waste Without rubbish(T/D) 2002
Damascus	3,000,000	1200	0.4	438,000	1,200	0.4	438,000
Rural Damascus	2,310,000	1681	0.7	613,446	1546	0.7	564,302
Deraa	850,000	430	0.5	156,768	383	0.5	139,915
Alssoydaa	420,000	221	0.5	80,574	211	0.5	77,082
Aleppo	4,230,000	2169	0.5	791,812	1,964	0.5	716,853
Edleb	1,580,000	883	0.6	322,186	790	0.5	288,275
Homs	1,750,000	1217	0.7	444,369	1,106	0.6	403,709
Hama	1,700,000	985	0.6	359,580	900	0.5	328,368
Latakia	1,070,000	728	0.7	265,647	699	0.7	255,021
Tartous	830,000	525	0.6	191,589	513	0.6	187,118
Deir Alzor	1,300,000	828	0.6	302,111	664	0.5	242,293
AlHassakeh	1,250,000	707	0.6	258,055	637	0.5	232,508
AlRaqa	800,000	616	0.8	224,840	448	0.6	163,684
AlQounytra	76,000	18	0.2	6,570	18	0.2	6,570
Other	340,000	102	0.3	37,230	102	0.3	37,230
Total	21,506,000	12,309	0.6	4.492.774	11,181	0.5	4.080.929

Source *: National strategy for solid waste management in Syria for the year 2004- French Travoler Company- Ministry of Local Administration and Environment*

2.2. Wastewater

Several wastewater treatment plants have been operated in several cities in the country. Damascus and Aleppo treatment plants are the largest plants in Syria. Currently, wastewater drainage systems in small cities and countryside areas are under maintenance and being enlarged. New small treatment plants with low cost are under construction for small communities less than 1000 people. Leavening tanks are currently used in these communities without any need for complete sanitary drainage systems.

Due to the need for purification of wastewater with increasing the request for reuse, there are more solid standards and specifications for their purifications in order to assure the environmental and health safety if the water is to be used or disposed off in the environment. One of the most important standards is related to impurities and solid materials which are removed by the treatment plants and generate sludge. Table 2 shows the approved program by the Ministry of Housing and Construction to construct wastewater treatment plants for some governorate centers.

2.3. Industrial waste water

Directorates of Environmental Affairs and wastewater companies in each governorate are applying very strict procedures for controlling industrial wastewater to be discharged into the sewage water system in order to separate any dangerous materials. A Syrian Standard No. 2580 of the year 2003 was issued for industrial wastewater specifications to be discharged into the main sewage water system under the title Limitation of discharged liquid wastes of economic activities in sewer network. According to the environment law No. 50 of the year 2002 and the executive procedures for environmental impact assessment and environmental audit of all industrial activities, the Directorates of environmental Affairs in the governorates inspect all industrial activities that produce industrial effluents and oblige all of these activities to construct and treat their industrial effluents. Table 2 shows the distribution and capacities of waste water treatment in Syria.

For the oil sector, one treatment plant was constructed in Homes refinery and it has been working since 1979 using the oil separation method, precipitation and the activated sludge. Oil sludge produced by the cleaning activities was supposed be burnt out but it is collected in open pits within the refinery premises. In Banias refinery and in the same time, a treatment plant was also constructed, where the water is treated to separate oil and sludge before discharging into the sea. In addition, there are simple treatment plants in several factories such as the Onion factory in Salamieh, and the industrial waste water treatment plant in the fertilizer factory which was constructed in 1979 to treat effluents. Most of these plants are currently not in operation due to technical problems.

The Sugar factory in Homs discharges all of its waste waters without any treatment into the main sewer system where water is then treated in the treatment plant. The Directorates of Environmental Affairs oblige all owners of the industrial activities to construct water treatment plants according to the environment law No. 50.

Table 2. Wastewater Treatment Plants in Syria

City	NO. of Persons / 1000 People	Treatment Type	Plant Capacity 1000m/^{3}Day	Operation Start Date	Use of Treated Water
Damascus	2500	Activity sludge	485	1997	Irrigation
H.Alawamid	5	W	0.2	worked	Irrigation
Aleppo	1500	Lagoons	383	2002	Irrigation
Homs	517	Activity sludge	130	1999	To River
Latakia	500	Activity sludge	115	2005	To sea
Tartous	131	Activity sludge	42	2005	To sea
Deraa	124	Activity sludge	22	2005	Irrigation
Hama	400	Activity sludge	70	2003	To River
Alssoydaa	155	Filters	19	2004	Irrigation
Edleb	183	Lagoons	30	2004	Irrigation
Ras Alayn	50	Lagoons	6	worked	Irrigation
Salamieh	45	Lagoons	7	1993	Irrigation

***Source** : Strategy and National Environmental Work plan in Syria for the Year 2003. Ministry of Local Administration and Environment wastewater*

3. Primary and Secondary Categories

3.1. Primary Categories

- Methane gas from non aerobic leavening of the organic materials of the solid wastes.
- Methane gas and nitro oxide gas from non aerobic leavening of wastewater.
- Methane gas and nitro oxide resulting from sludge produced by the wastewater.
- Methane gas produced by industrial water and resulting sludge.

3.2. Secondary Categories

- Methane gas from incineration of the solid waste.

4. Calculation Method for Greenhouse Gases Produced by the Waste Sector

4.1. Calculation of Methane Gas from Solid Waste

A methane emission from domestic solid waste was calculated by filling the Tables (6-1s1, 6-1A, 6-1B, 6-1C) (Reference 4) according to the following steps:

Step one

- Enter the population number in column A (*Ref.3*).
- Production rate of each person per day is about 0.5 g/person/day and this is in agreement with the national strategy of solid waste in Syria .(*Ref.2*)
- Multiply column A by column B and multiply the resulting number with a conversion factor of 365 for one year and divide the resulting number by 10^6 to convert to Gg and enter the resulting number in column C.
- Enter factor of the solid waste factor sent to SWDSs number, which is 0.8 in module 6 Waste IPCC 1996).
- Multiply column D * C and place the resulting number in E.
- Enter the results in column A of Table 6-1s1.

MODULE	WASTE				
SUBMODULE	QUANTITY OF MSW DISPOSED OF IN SOLID WASTE DISPOSAL SITES USING COUNTRY DATA				
WORKSHEET	6-1A (SUPPLEMENTAL)				
SHEET	1 OF 1				
	A	B	C	D	E
	Population whose Waste goes to SWDSs (Urban or Total) (persons)	MSW Generation Rate (kg/capita/day)	Annual Amount of MSW Generated (Gg MSW)	Fraction of MSW Disposed to SWDSs (Urban or Total)	Total Annual MSW Disposed to SWDSs (Gg MSW)
	*	**	C=(AxBx365)/1,000,000		E = (C x D)
1994	9091800	0.5	1659.25	0.8	1327.40
1995	9344400	0.5	1705.35	0.8	1364.28
1996	9603600	0.5	1752.66	0.8	1402.13
1997	9870000	0.5	1801.28	0.8	1441.02
1998	10144200	0.5	1851.32	0.8	1481.05
1999	10425600	0.5	1902.67	0.8	1522.14
2000	10714800	0.5	1955.45	0.8	1564.36
2001	11012400	0.5	2009.76	0.8	1607.81
2002	11318400	0.5	2065.61	0.8	1652.49
2003	11632800	0.5	2122.99	0.8	1698.39
2004	11955600	0.5	2181.90	0.8	1745.52
2005	12287400	0.5	2242.45	0.8	1793.96

MODULE	WASTE		
SUBMODULE	DISPOSAL SITES USING DISPOSAL RATE DEFAULT DATA		
WORKSHEET	6-1B (SUPPLEMENTAL)		
SHEET	1 OF 1		
	A	B	C
Year	Population whose Waste goes to SWDSs (Urban or Total) (persons)	MSW Disposal Rate to SWDSs (kg/capita/day)	Total Annual MSW Disposed to SWDSs (Gg MSW)
	*	**	C = (A x B x 365)/1 000 000
1994	9091800	0.5	1659.25
1995	9344400	0.5	1705.35
1996	9603600	0.5	1752.66
1997	9870000	0.5	1801.28
1998	10144200	0.5	1851.32
1999	10425600	0.5	1902.67
2000	10714800	0.5	1955.45
2001	11012400	0.5	2009.76
2002	11318400	0.5	2065.61
2003	11632800	0.5	2122.99
2004	11955600	0.5	2181.90
2005	12287400	0.5	2242.45

Step two

Calculation of mean MCF according to waste disposal method (6-1C)

- Enter the waste percentage by weight for each form of the SWDSs forms according to above Table 1 of the national strategy for solid waste management in Syria.
- Take the correction factor for methane (MCF) (IPCC 1996 Table 6-2) and place in column X.
- Multiply column X by column W and pace the result in column Y.
- Sum the results in column Y and enter the result under column Y so the mean methane correction factor for each form of the SWDSs forms is MCF= 0.74
- Enter the result in column B of Table 6-1s1.

MODULE	WASTE		
SUBMODULE	METHANE CORRECTION FACTOR		
WORKSHEET	6-1C (SUPPLEMENTAL)		
SHEET	1 OF 1		
	W	X	Y
Type of Site	Proportion of Waste (by weight) for Each Type of SWDSs	Methane Correction Factor (MCF)	Weighted Average MCF for Each Type of SWDS
			Y = W x X
Managed	0.38	1.0	0.38
Unmanaged - deep (>=5m waste)	0.29	0.8	0.23
Unmanaged - shallow (< 5m waste)	0.33	0.4	0.13
Total	1	0.6	0.74

Step Three

- Decomposed organic carbon (DOC=0.21) is estimated for wastes of the SWDSs from the closest country which is Egypt since the waste conditions are similar (IPCC1996 Table 6-10 and place it in column C (*Ref.4*).
- Real decomposed organic carbon (DOC=0.77) of the waste is entered in column D(4).
- Enter the emitted carbon as methane (0.5) of the waste SWDSs (IPCC1996 page 6-10) in column E (4).
- Calculate methane quantity rate emitted from waste unit by multiplying column C by column D and E with a conversion 16/12, which is the atomic weight of methane to atomic weight of carbon. And the place the result in column G.
- Calculate methane quantity rate from waste unit by multiplying G column by column B and then enter the result in column H.

Step Four

- Multiply column A by column H to obtain total methane quantity generated and then place the result in column J.
- Enter annual recovered methane quantity which is zero and place in column K.
- Subtract the value in column K from the value in column J and place the result in column L.
- Enter the correction factor of methane oxidation (the value equals to 1) and place the result in column M.
- Multiply column M by column L to obtain the net methane quantity and place in column N.
-

MODULE	WASTE										
SUBMODULE	METHANE EMISSIONS FROM SOLID WASTE DISPOSAL SITES										
WORKSHEET	6-1										
	STEP 1	STEP 2	STEP 3						STEP 4		
	A	B	C	D	E	F	G	H	J	K	L
	Total Annual MSW Disposed to SWDSs	Methane Correction Factor	Fraction of DOC in MSW	Fraction of DOC which Actually Degrades	Fraction of Carbon Released as Methane	Conversion Ratio	Potential Methane Generation Rate per Unit of Waste	Realised (Country-specific) Methane Generation Rate per Unit of Waste	Gross Annual Methane Generation	Recovered Methane per Year	Net Annual Methane Generation
	(Gg MSW)	(MCF)					(Gg CH_4/Gg MSW)	(Gg CH_4 Gg MSW)/	(Gg CH_4)	(Gg CH_4)	(Gg CH_4)
YEAR							G=(CxDxExF)	H= (B x G)	J= (H x A)		L= (J - K)
1994	1327.4028	0.74	0.21	0.77	0.5	16/12	0.11	0.08	105.89	0	105.89
1995	1364.2824	0.74	0.21	0.77	0.5	16/12	0.11	0.08	108.83	0	108.83
1996	1402.1256	0.74	0.21	0.77	0.5	16/12	0.11	0.08	111.85	0	111.85
1997	1441.02	0.74	0.21	0.77	0.5	16/12	0.11	0.08	114.95	0	114.95
1998	1481.0532	0.74	0.21	0.77	0.5	16/12	0.11	0.08	118.15	0	118.15
1999	1522.1376	0.74	0.21	0.77	0.5	16/12	0.11	0.08	121.42	0	121.42
2000	1564.3608	0.74	0.21	0.77	0.5	16/12	0.11	0.08	124.79	0	124.79
2001	1607.8104	0.74	0.21	0.77	0.5	16/12	0.11	0.08	128.26	0	128.26
2002	1652.4864	0.74	0.21	0.77	0.5	16/12	0.11	0.08	131.82	0	131.82
2003	1698.3888	0.74	0.21	0.77	0.5	16/12	0.11	0.08	135.48	0	135.48
2004	1745.5176	0.74	0.21	0.77	0.5	16/12	0.11	0.08	139.24	0	139.24
2005	1793.9604	0.74	0.21	0.77	0.5	16/12	0.11	0.08	143.11	0	143.11

4.2. Calculation of Methane Gas from Wastewater

Emitted methane quantity from wastewater treatment plants was calculate from table (6-2s1, 6-2s2,62s3,62s4) according to the following steps:

Step One

- Enter the city population number that produces wastewater in column B (*Ref.*2).
- Enter the decomposed organic carbon (DOC=14600 kg BOD/1000 person/year) and place in column C and according to IPCC 1996 Table 6-4.
- Enter composted element and removed as sludge (DOC =0.1) and place in column D.
- Calculate total organic carbon in wastewater by multiplying column C with column B and the multiplying the result with 1-D. Enter the result in column E as kg BOD/year.
- Calculate total organic carbon in sludge by multiplying column C by column B and column D and enter the result in column F (kg BOD/year).

MODULE	**WASTE**				
SUBMODULE	**METHANE EMISSIONS FROM DOMESTIC AND COMMERCIAL WASTEWATER AND SLUDGE TREATMENT**				
WORKSHEET	**6-2**				
SHEET	**1 OF 4 ESTIMATION OF ORGANIC WASTEWATER AND SLUDGE**				
STEP 1					
A	B	C	D	E	F
Region or City	Population (1,000 persons)	Degradable Organic Component (kg BOD/1000 persons/yr)	Fraction of Degradable Organic Component Removed as Sludge	Total Domestic/Commercial Organic Wastewater (kg BOD/yr)	Total Domestic/Commercial Organic Sludge (kg BOD/yr)
				E = [B x C x (1-D)]	F = (B x C x D)
Damascus	3093.9	14600	0.1	40,653,591.85	4,517,065.76
Rurral Damascus	5.9	14600	0.1	77,088.22	8,565.36
Aleppo	1624.8	14600	0.1	21,350,003.72	2,372,222.64
Homs	606.6	14600	0.1	7,970,922.19	885,658.02
Latakia	500.0	14600	0.1	6,570,000.00	730,000.00
Tartos	131.0	14600	0.1	1,721,340.00	191,260.00
Dara	124.0	14600	0.1	1,629,360.00	181,040.00
Hhama	421.9	14600	0.1	5,543,655.62	615,961.74
Swida	159.2	14600	0.1	2,091,690.90	232,410.10
Iidleb	187.9	14600	0.1	2,469,544.74	274,393.86
Hasaka	58.7	14600	0.1	770,882.22	85,653.58

Step Two

- Enter the type of treatment in column A (Table 1).
- Enter treated water cut in this plant in column B (Table 1).
- Enter methane correction factor according to treatment system) MCF=0.75) (IPCC 1996 Table 6-4) in column C.
- Multiply column C with column B and place the result in column D.
- Enter maximum methane production factor according to treatment system in column E which is equal to 0.25 kg CH_4/ kg BOD.
- Emission factor (kg CH4 / kg BOD) is calculated by multiplying column D with column E and place the result in column F.

MODULE	**WASTE**				
SUBMODULE	**METHANE EMISSIONS FROM DOMESTIC AND COMMERCIAL WASTEWATER TREATMENT**				
WORKSHEET	**6-2**				
SHEET	**2 OF 4 ESTIMATION OF EMISSION FACTOR FOR WASTEWATER HANDLING SYSTEMS**				
STEP 2					
A	B	C	D	E	F
Wastewater Handling System	Fraction of Wastewater Treated by the Handling	Methane Conversion Factor for the Handling	Product	Maximum Methane Producing Capacity	Emission Factor for Domestic/Commercial Wastewater
	System	System		(kg CH_4/kg BOD)	(kg CH_4/kg BOD)
			D = (B x C)		F = (D x E)
Activity Sludge	0.75	0.7	0.5250	0.25	0.13125
Lagoons	0.25	0.3	0.0750	0.25	0.01875
		Aggregate MCF:	0.6000	0.25	0.150

Step Three

- Enter sludge treatment method in column A from Table 1.
- Enter treated sludge cut in the treatment system in column B (table from the ministry of housing and construction)
- Enter sludge methane conversion factor (MCF=0.75) according to treatment system in column C.
- Multiply column C with column B and enter the result in column D.
- Enter maximum methane production according to treatment system in column E which is equal to 0.25 kg CH_4 / kg BOD.
- Calculate sludge emission factor (kg CH_4 / kg BOD) by multiplying column D with column E and enter the result in column F.

MODULE	WASTE				
SUBMODULE	METHANE EMISSIONS FROM DOMESTIC AND COMMERCIAL WASTEWATER TREATMENT				
WORKSHEET	6-2				
SHEET	3 OF 4 ESTIMATION OF EMISSION FACTOR FOR SLUDGE HANDLING SYSTEMS				
STEP 3					
A	B	C	D	E	F
Sludge Handling System	Fraction of Sludge Treated by the Handling System	Methane Conversion Factor for the Handling System	Product	Maximum Methane Producing Capacity	Emission Factor for Domestic/ Commercial Sludge
				(kg CH_4/kg BOD)	(kg CH_4/kg BOD)
			D = (B x C)		F = (D x E)
Activity Sludge	0.67	0.6	0.402	0.25	0.1005
Lagoons	0.33	0.6	0.198	0.25	0.0495
		Aggregate MCF:	0.60	0.25	0.150

Step Four

- Enter organic materials generated by the treatment plant (kg BOD/year) in column A (first line for wastewater and second line for sludge).
- Enter methane emission factor in column B (kg CH_4 /kg BOD) (first line for wastewater and second line for sludge).
- Calculate methane emissions (without recovered and burnt methane) by multiplying column A with column B and place the result in column C.
- Enter recovered methane quantity in column D.
- Calculate methane emissions (Gg CH_4) by subtracting column D from column C and dividing the result by 10^6 in column E.
- The following table shows the methane quantity emitted from wastewater treatment plants in Syria during the period 1994-2005 as follows:

MODULE	WASTE				
SUBMODULE	METHANE EMISSIONS FROM DOMESTIC AND COMMERCIAL WASTEWATER AND SLUDGE TREATMENT				
WORKSHEET	6-2				
SHEET	4 OF 4 ESTIMATION OF METHANE EMISSIONS FROM DOMESTIC /COMMERCIAL WASTEWATER AND SLUDGE				
COUNTRY	0				
YEAR	0				
STEP 4					
	A	B	C	D	E
	Total Organic Product	Emission Factor	Methane Emissions Without Recovery/Flaring	Methane Recovered and/or Flared	Net Methane Emissions
	(kg BOD/yr)	(kg CH_4/kg BOD)		(kg CH_4)	(Gg CH_4)
	from Worksheet	from Worksheet	C = (A x B)		E = (C-D)/1,000,000
	6-2, Sheet 1	6-2, Sheets 2 and 3			
Wastewater	384,147,900.00	0.150	57,622,185.00	0	57.622
Sludge	42,683,100.00	0.150	6,402,465.00	0	6.4025
				Total:	13.626

4.3. Calculation of Nitrous Oxide Gas from Wastewater

Nitrous oxide quantity resulting from wastewater is calculated from table 6-4s1 and according to the followings:

- Enter the annual protein rate for each person in column A [(2)].
- Enter population in column B [(3)].
- Enter nitrogen in protein (0.16 kg N/kg protein) [(4)] in column C.
- Calculate nitrogen in wastewater (kg N/year) by multiplying column A by column B and B and then enter the result in column D.
- Enter the nitrogen quantity that goes to soil (kg N/year) which is equal to zero and place it in column E.
- To obtain the net nitrogen quantity, subtract column E from column D and place the result in column F.
- Enter emission factor (EF6=0.01 kg N_2O-N/kg sewage) [(4)] and place in column G.
- Calculate the total quantity of N_2O emission by multiplying column F with column G with the factor of 28/44 and then dividing the result by 10^6 and place the result in column H.

▪

MODULE	WASTE							
SUBMODULE	INDIRECT NITROUS OXIDE EMISSIONS FROM HUMAN SEWAGE							
WORKSHEET	6-4							
SHEET	1 OF 1							
	A	B	C	D	E	F	G	H
	Per Capita Protein Consumption	Population	Fraction of Nitrogen in Protein $Frac_{NPR}$	Amount of sewage N produced	Amount of sewage N applied to soils as sewage sludge	Net amount as sewage sludge of sewage N produced	Emission factor	Total Annual N_2O Emissions
	(Protein in kg/person/yr)	(number)	(kg N/kg protein)	(kg N/yr)	(kg N/yr)	(kg N/yr)	EF_6 (kg N_2O-N/kg sewage-N produced)	(Gg N_2O/yr)
				D =AxBxC		F = D - E		H = (F x G)x (44/28)/1,000,000
1994	21.9	45000	0.16	53096112	0	53096112	0.01	0.00
1995	21.9	45000	0.16	54571296	0	54571296	0.01	0.00
1996	21.9	45000	0.16	56085024	0	56085024	0.01	0.00
1997	21.9	2545000	0.16	57640800	0	57640800	0.01	0.14
1998	21.9	2545000	0.16	59242128	0	59242128	0.01	0.14
1999	21.9	3062000	0.16	60885504	0	60885504	0.01	0.17
2000	21.9	3062000	0.16	62574432	0	62574432	0.01	0.17
2001	21.9	3062000	0.16	64312416	0	64312416	0.01	0.17
2002	21.9	4562000	0.16	66099456	0	66099456	0.01	0.25
2003	21.9	4962000	0.16	67935552	0	67935552	0.01	0.27
2004	21.9	5300000	0.16	69820704	0	69820704	0.01	0.29
2005	21.9	6055000	0.16	71758416	0	71758416	0.01	0.33
TOTAL								**1.94**

It can be seen from the above table that there is an increase in N_2O emission from wastewater directly with the increase in population number. This is due to the increased number of constructed wastewater treatment plants in Syria during the period 1995-2005 (Table 2).

4.4. Calculation of Methane Gas from Industrial Wastewater

The quantity of methane resulting from industrial waste water treatment plants in both Homes and Banise refineries has been calculated for the period 1995-2005 from tables (6-3s1, 6-3s2, 3s3, 6-3s4) according to the following steps:

Step one

- Enter the industry wastewater production rate (t/year) for each industry in column A.
- Enter the organic factor of the water (kg COD/m ww) and place in column B [(4)] (Table 6-6).
- Enter water consumption for each tone of production (m^3/ t product) an place it in column C.
- Enter organic content factor of the sludge and place it in column D [(4)].
- To obtain the total organic element for the industrial water (kg COD/year), multiply with A*B*C* (1-D) and place in column E.
- To obtain the total organic element for sludge resulting from industrial wastewater (kg COD/year), multiply A*B*C*D and place in column F.

MODULE	WASTE					
SUBMODULE	METHANE EMISSIONS FROM INDUSTRIAL WASTEWATER AND SLUDGE HANDLING					
WORKSHEET	6-3					
SHEET	1 OF 4 TOTAL ORGANIC WASTEWATER AND SLUDGE					
STEP 1						
	A	B	C	D	E	F
	Total Industrial Output	Degradable Organic Component	Wastewater Produced	Fraction of Degradable Organi Component Removed as Sludge c	Total Organic Wastewater from Industrial Source	Total Organic Sludge from Industrial Source
	(t/yr)	(kg COD/m^3 wastewater)	(m^3/tonne product)		(kg COD/yr)	(kg COD/yr)
					E=[AxBxCx(1-D)]	F=(AxBxCxD)
1994	11800000	1.3	2.4	0.1	33,134,400	3,681,600
1995	11800000	1.3	2.4	0.1	33,134,400	3,681,600
1996	11800000	1.3	2.4	0.1	33,134,400	3,681,600
1997	11800000	1.3	2.4	0.1	33,134,400	3,681,600
1998	11800000	1.3	2.4	0.1	33,134,400	3,681,600
1999	11800000	1.3	2.4	0.1	33,134,400	3,681,600
2000	11800000	1.3	2.4	0.1	33,134,400	3,681,600
2001	11800000	1.3	2.4	0.1	33,134,400	3,681,600
2002	11800000	1.3	2.4	0.1	33,134,400	3,681,600
2003	11800000	1.3	2.4	0.1	33,134,400	3,681,600
2004	11800000	1.3	2.4	0.1	33,134,400	3,681,600
2005	11800000	1.3	2.4	0.1	33,134,400	3,681,600
				Total		44,179,200

Step two

- Enter industrial wastewater treatment method for each industry and place it in column A.
- Enter industrial wastewater treatment factor (0.20) and place it in column B.
- Enter methane conversion factor (0.90) and place it in column C.
- Multiply column B with column C and place it in column D.
- Enter maximum methane production factor (kg CH_4/ kg DC) and place it in column E.
- To obtain the methane emission factor from industrial water (kg CH_4/ kg COD) multiply E*D and place in column F.

Note: all data was taken from module 6 waste IPCC 1996 Table 6-8

MODULE	**WASTE**				
SUBMODULE	**METHANE EMISSIONS FROM INDUSTRIAL WASTEWATER TREATMENT**				
SOURCE					
WORKSHEET	**6-3**				
SHEET	**2 OF 4 ESTIMATION OF EMISSION FACTOR FOR WASTEWATER HANDLING SYSTEMS**				
STEP 2					
A	B	C	D	E	F
Wastewater Handling System	Fraction of Wastewater Treated by the Handling System	Methane Conversion Factor	Product	Maximum Methane Producing Capacity	Emission Factor for Industrial Wastewater Source
		(MCF)		(kg CH_4/kg DC)	(kg CH_4/kg COD)
			D = (B x C)		F = (D x E)
not specified	0.2	0.9	0.18	0.25	
		Aggregate MCF:	0.18	0.25	0.05

Step Three

- Enter treatment method \of the resulting sludge from industrial water and place it in column A.
- Enter sludge treatment factor from industry water (0.20(and place it in column B.
- Enter methane conversion factor (0.90) and place it in column C.
- Multiply column B and column C and place the result in column D.
- Enter maximum methane production factor (kg CH_4/ kg DC) and place it in column E.
- To obtain methane emission factor from sludge (kg CH_4/kg COD), multiply E*D and place ion column F.

SOURCE					
WORKSHEET	**6-3**				
SHEET	**3 OF 4 ESTIMATION OF EMISSION FACTOR FOR SLUDGE HANDLING SYSTEMS**				
STEP 2					
A	B	C	D	E	F
Sludge Handling System	Fraction of Sludge Treated by the Handling System	Methane Conversion Factor	Product	Maximum Methane Producing Capacity	Emission Factor for Industrial Sludge Source
		(MCF)		(kg CH_4/kg COD)	(kg CH_4/kg COD)
			D = (B x C)		F = (D x E)
not specified	0.2	0.9	0.18		
		Aggregate MCF:	0.18	0.25	0.05

Step Four

- Enter organic product quantity (kg COD/year) in column A.
- Enter methane emission factor (kg CH_4/ kg COD) in column B.
- Multiply column B and A and place in column C.
- Enter recovered methane quantity and place it in column D.
- To calculate methane emissions, subtract column D from column C and divide by 10^6 and place in column E.

MODULE	WASTE				
SUBMODULE	**METHANE EMISSIONS FROM INDUSTRIAL WASTEWATER AND SLUDGE TREATMENT**				
WORKSHEET	**6-3**				
SHEET	**4 OF 4 ESTIMATION OF METHANE EMISSIONS FROM INDUSTRIAL WASTEWATER AND SLUDGE**				
STEP 4					
	A	B	C	D	E
	Total Organic Product	Emission Factor	Methane Emissions without Recovery/Flaring	Methane Recovered and/or Flared	Net Methane Emissions
	(kg COD/yr)	(kg CH_4/kg COD)		(kg CH_4)	(Gg CH_4)
	Worksheet 6-3, Sheet 1	Worksheets 6-3, Sheets 2 and 3	C = (AxB)		E = (C-D)/1,000,000
Wastewater	397,612,800.00	0.05	17,892,576.00	0	17.893
Sludge	44,179,200.000	0.050	2,208,960.00	0	2.209
				Total:	20.102

5. Greenhouse Gases Emissions from Waste Sector in Syria

5.1. Emissions from Solid Waste

After following the calculation steps for methane gas emitted from disposal sites from the Tables, Table 4 shows the methane quantity emitted in the period 1994-2005. There is an increase in methane emission rates at the disposal sites of the domestic solid wastes with population increase, which is a fact due to increase in generated solid waste quantity and hence the resulting organic materials that is responsible for methane emissions. This is clear from Figure 3. All data was derived from module 6 waste IPCC 1996.

Table 3. Methane Quantity Emitted in the period 1994-2005

Year	(Gg CH_4) SWDSs
1994	105.89
1995	108.83
1996	111.85
1997	114.95
1998	118.15
1999	121.42
2000	124.79
2001	128.26
2002	131.82
2003	135.48
2004	139.24
2005	143.11

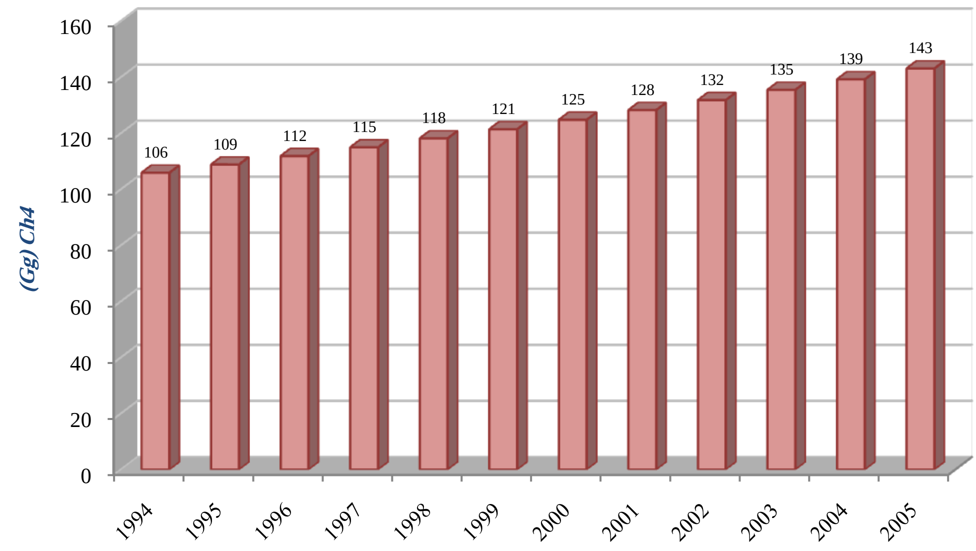

Figure 2. Increase of Methane Emissions from Domestic Solid Waste Sites (1994-2005)

5.2. Emissions from Wastewater

5.2.1. Methane gas emissions

Organic materials present in wastewater compositions of the cities and communities are the main responsible factors for the gas emissions. Methane gas quantity emitted from wastewater treatment plants constructed in Syria has calculated for the period of 1995-2005 and the results are presented in table 5:

Table 4. Methane Production from Waste Water Treatment Plants (1994-2005)

Year	(Gg CH_4) Waste Water
1994	0.12
1995	0.127
1996	0.131
1997	6.8413
1998	7.0259
1999	8.6025
2000	8.9865
2001	9.2233
2002	13.502
2003	14.937
2004	16.25
2005	18.714

5.2.2. Nitro oxide emission

Nitro oxide quantity resulting from sewage water was calculated according to the same procedure mentioned in Table (6.4s1). Table 5 shows the nitro oxide emissions rate from wastewater during the period 1995-2005.

Table 5. Nitro Oxide Quantity Emitted from Wastewater

Year	(Protein in kg/person/yr)	Population	KgN/Kg protein Factor	(kg N/yr)	(kg N/yr) Factor	N_2O Emissions (Gg N_2O/yr)
1994	21.9	45000	0.16	157680	0.01	0.00
1995	21.9	45000	0.16	157680	0.01	0.00
1996	21.9	45000	0.16	157680	0.01	0.00
1997	21.9	2545000	0.16	8917680	0.01	0.14
1998	21.9	2545000	0.16	8917680	0.01	0.14
1999	21.9	3062000	0.16	10729248	0.01	0.17
2000	21.9	3062000	0.16	10729248	0.01	0.17
2001	21.9	3062000	0.16	10729248	0.01	0.17
2002	21.9	4562000	0.16	15985248	0.01	0.25
2003	21.9	4962000	0.16	17386848	0.01	0.27
2004	21.9	5300000	0.16	18571200	0.01	0.29
2005	21.9	6055000	0.16	21216720	0.01	0.33
TOTAL						1.94

There was an increase in nitro oxide emission rate from waste water directly with an increase of population (Table 5 and Figure 3).

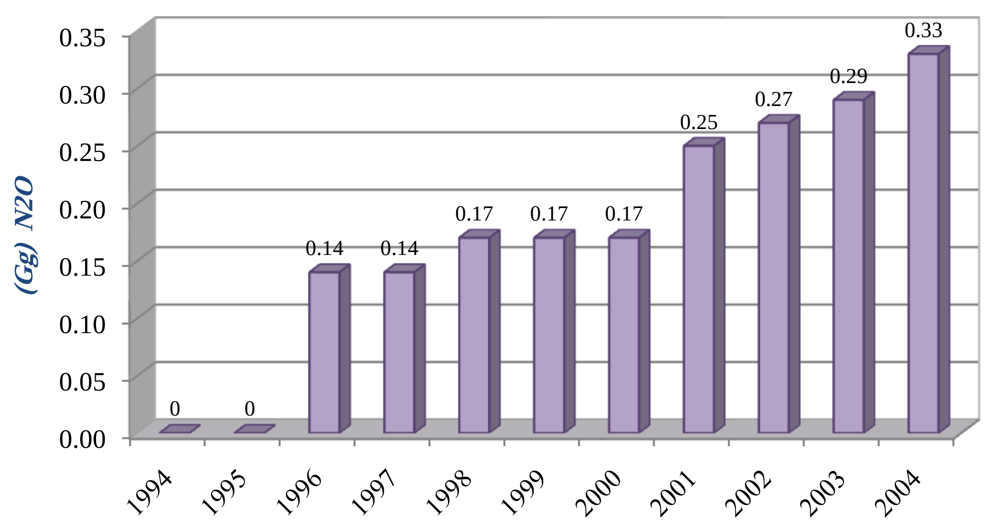

Figure 3. Increase of Nitrous Gas Generated from Wastewater

5.3. Emissions from Industrial Wastewater

5.3.1. Methane gas emission from industrial wastewater

Methane gas quantity emitted from industrial water treatment plants in Homes and Banias refineries have been calculated for the period 1994-2005. A constant quantity of emissions from industrial water treatment plants due to constant industrial water quantity treated was observed during the study years, it had been 1.567 Gg CH4 / year

5.4. Total Emission of Gases and its Equivalent to CO2

5.4.1. Methane and nitrous oxide and the equivalent CO2

Table 6 shows the methane quantities emitted from different waste sectors (solid waste, wastewater and industrial water) and their equivalent CO_2 after converting the quantities with equivalent factor GWP=23. Moreover, Table 6 shows the nitrous oxide quantity generated from wastewater and its equivalent CO_2 quantity after conversion using the factor GWP=296. All quantities were summed and place in the last column which indicates the total equivalent CO2 quantity from all waste sectors in Syria in the period 1995-2005.

Table 6. Methane, Nitrous Oxide and Equivalent Carbon Dioxide Emitted from Waste Sector in Syria (1994-2005).

Year	(Gg CH_4) SWDSs	(Gg CH_4) Waste Water	(Gg CH_4) Industrial Waste Water	Net CH_4	Eq CO_2	N_2O	Eq CO2	Net Eq CO_2
	A	**B**	**C**	**D=A+B+C**	**E=D*23**	**F**	**G=F*269**	**H=E+G**
1994	105.89	0.12	1.567	107.577	2474.27	0	0	2474.27
1995	108.83	0.127	1.567	110.524	2542.05	0	0	2542.05
1996	111.85	0.131	1.567	113.548	2611.6	0	0	2611.6
1997	114.95	6.8413	1.567	123.358	2837.24	0.14	41.44	2878.68
1998	118.15	7.0259	1.567	126.743	2915.09	0.14	41.44	2956.53
1999	121.42	8.6025	1.567	131.59	3026.56	0.17	50.32	3076.88
2000	124.79	8.9865	1.567	135.344	3112.9	0.17	50.32	3163.22
2001	128.26	9.2233	1.567	139.05	3198.16	0.17	50.32	3248.48
2002	131.82	13.502	1.567	146.889	3378.46	0.25	74	3452.46
2003	135.48	14.937	1.567	151.984	3495.64	0.27	79.92	3575.56
2004	139.24	16.25	1.567	157.057	3612.31	0.29	85.84	3698.15
2005	143.11	18.714	1.567	163.391	3758	0.33	97.68	3855.68

The results ARE presented in Figure 4 where total emissions in the waste sector has increased in last years due to an increase in population and migration from countryside to cities and increase in living standards. It reached about 3855 G grams in 2005. This quantity is rather small if it is compared with other emissions from energy sector.

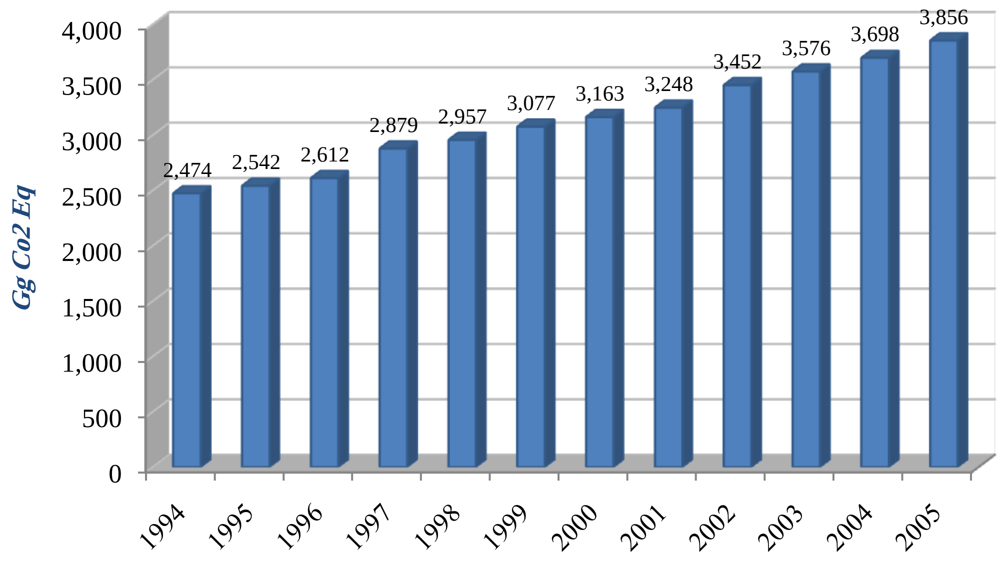

Figure 4. Total GHG Emissions Estimated as CO_2 equivalent from Waste Sector in Syria during the year 1994-2005.

Figure 5 shows the methane gas emitted from waste sector according to source (solid waste, wastewater and industrial water) estimated in G g per year from 1995 to 2005. Most methane gas is emitted from solid waste due to it large quantities followed by wastewater. The quantity generated from the industrial water is rather small and constant during the last years.

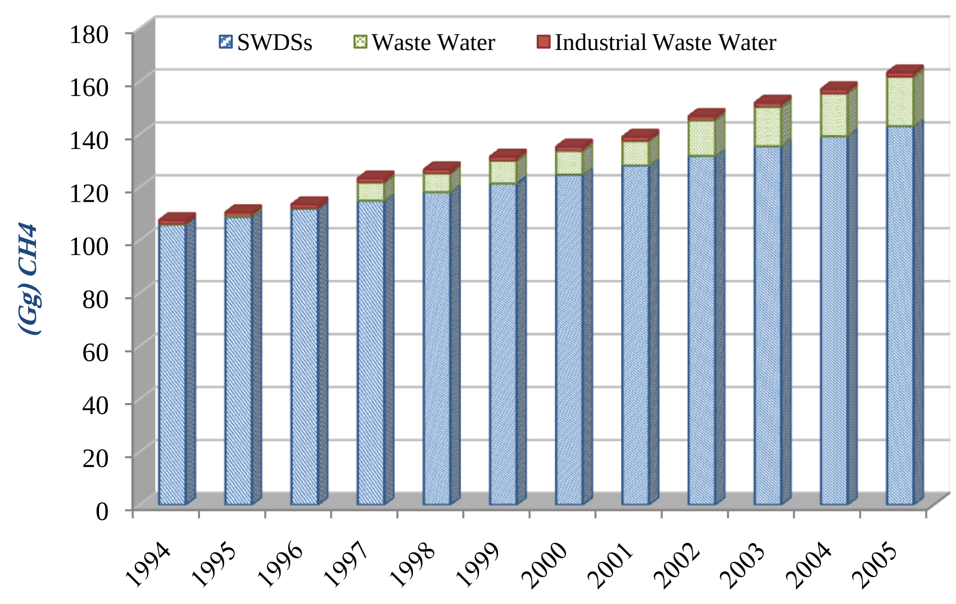

Figure 5. Methane Gas Emitted from Waste Sector According to Source

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