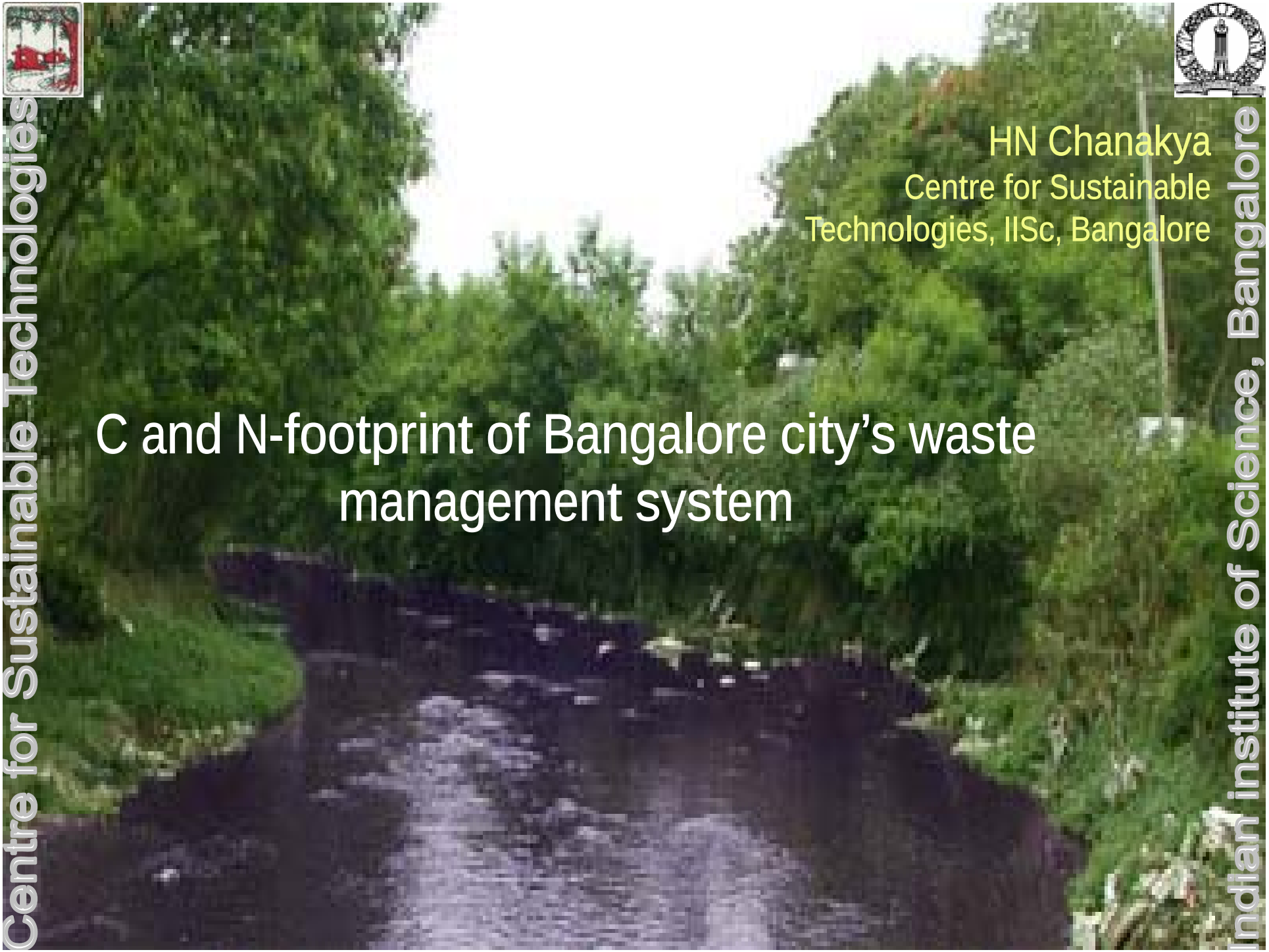

C and N-footprint of Bangalore city's waste management system

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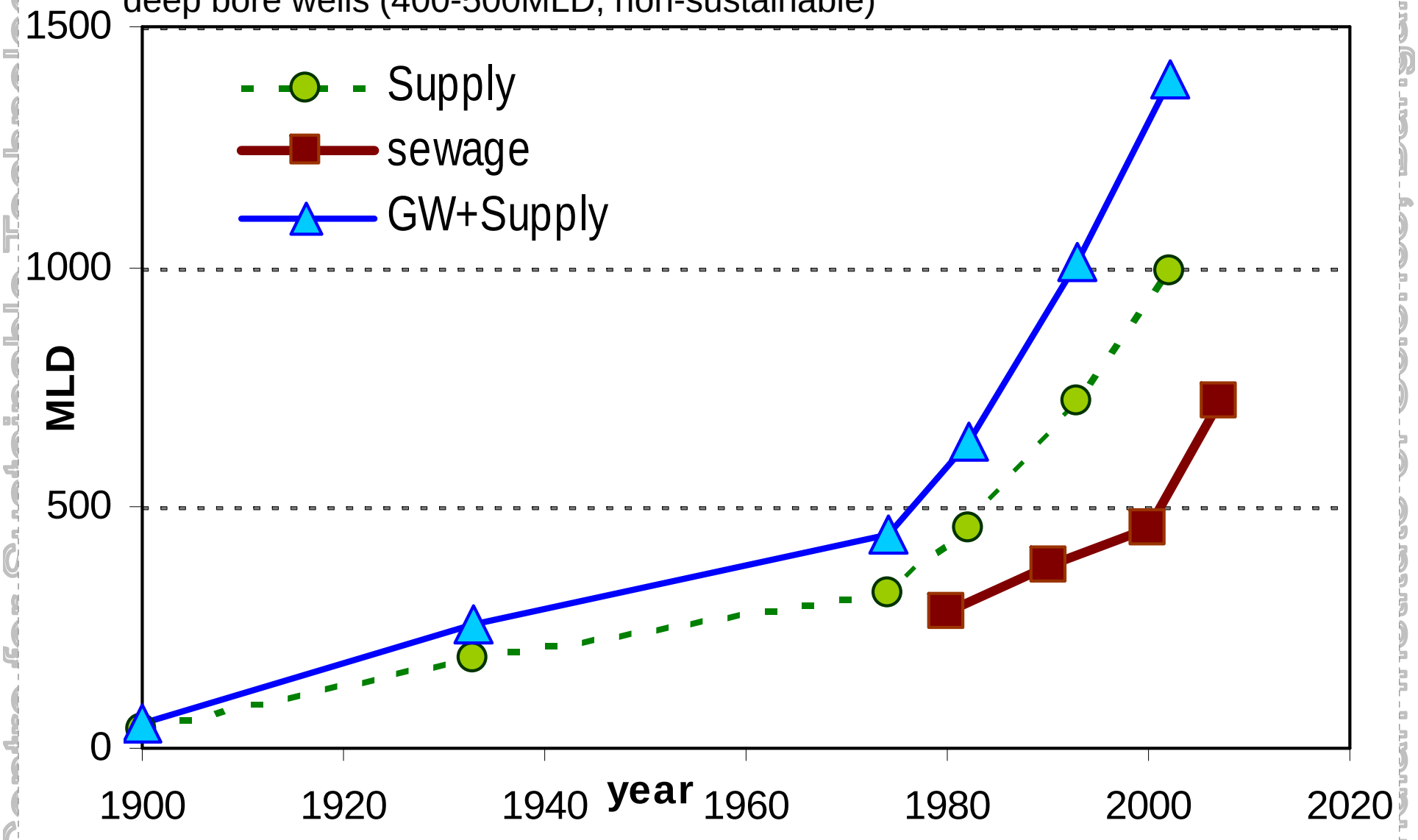
Inadequacy and threats from septic tank /soak pits – Sewage treatment capacity is about 50% of the total water supplied (adding water recovered from bore wells). The BWSSB estimates wastewater = 80% of water supply – this does not account for nearly 40-50% of supplies from deep bore wells (400-500MLD, non-sustainable)



Wastes and waste related activities implicated in GHG production

1.Human and animal wastes undergoing decomposition

2.Urban solid wastes undergoing decomposition (during collection & at dumpsite)

3.Garden wastes /USW being burnt

GHGs emission processes

Organic material in human /animal wastes → → → methane + CO_2

(total absence of dissolved oxygen such as in black sewage)

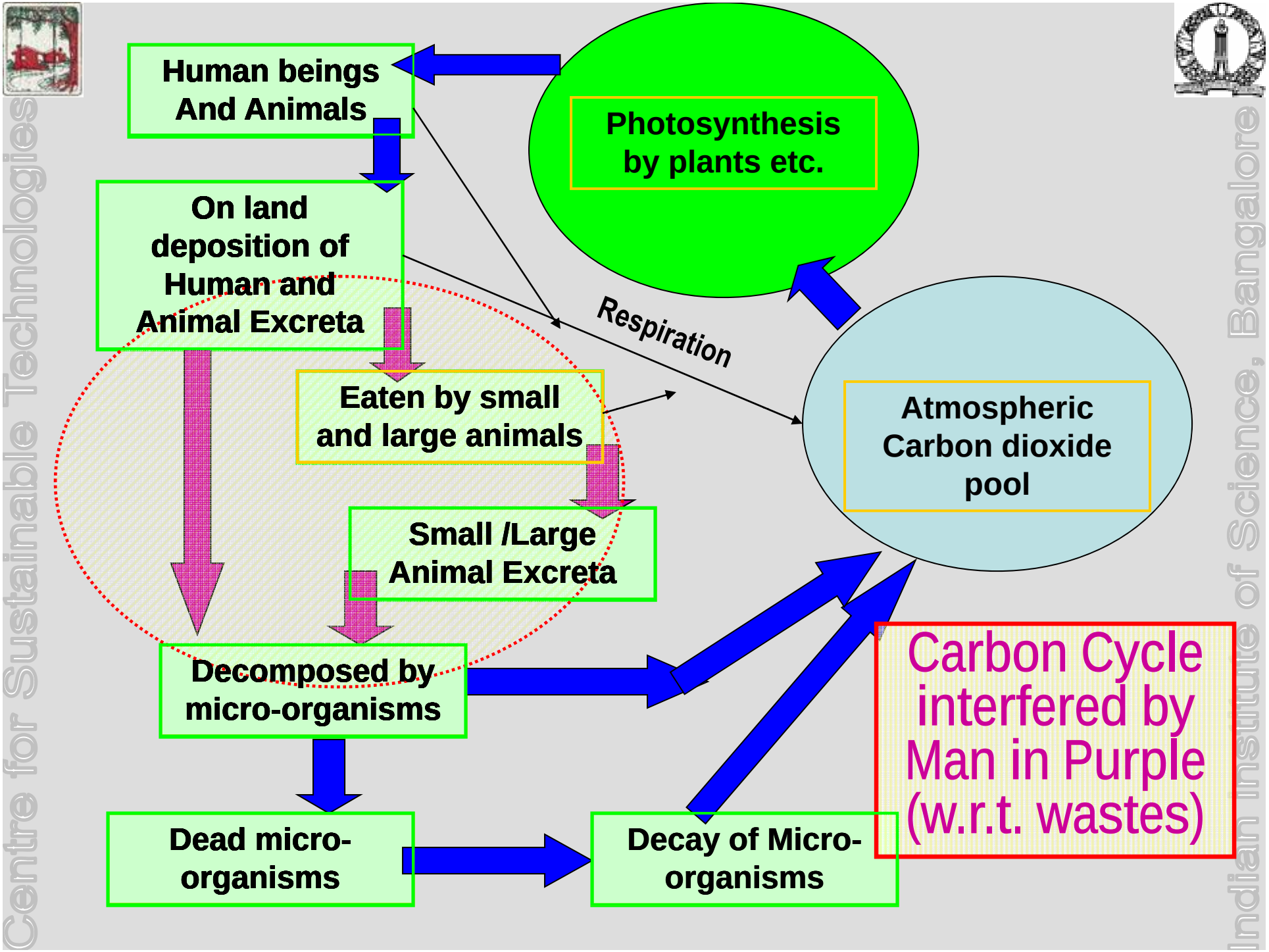
Proteins in wastes suffering anaerobic decomposition → **Ammonia (NH_4)**

(Some ammonia escapes from dissolved form into atmosphere ➔ quantum to be determined)

Ammonia in wastewater being oxidised to **NO_2** → **Nitrous oxide (N_2O, 1%)**

(Nitrification process has a few mistakes, about 0.5-1% converted to N_2O instead of NO_2)

All organic material when decomposed lead finally to **Carbon dioxide (CO_2)**



Human Excreta (and animal excreta)

60% → **UGD sewage treated by anaerobic + aerobic routes (usual)**

Anaerobic and aerobic stages = some CH_4 (30-50%)+ CO_2(50-70%)
This proportion to be derived

30% → **Treated by soak-pits**

100% anaerobic= 66%CH_4 + 33% CO_2

1% → **Transported and Composted**

Methane in early stages only
This proportion to be derived

? → **Fossil fuels in transport/treatment etc.** (not estimated)

Needs to be estimated

9% → **Deposited on land dried rapidly and consumed by small and large animals**

Anaerobic stage for 2-5d, experimental evidence needed

Source	No.	Fraction dried CH4			Sewage CH4		compost CH4		Gross	CO_2
			BMP	t CH4		t CH4		t CH4	t CH4	'000t
Human (residents)	5200000	0.1	0.220	5	0.9	41	0	5	50	384.2
Human (floating popn.)	2000000	0.2	0.220	2	0.8	7	0	2	11	81.3
Cattle	185087	0.3	0.180	11	0.3	11	0.4	11	33	255.6
Buffaloes	27429	0.3	0.180	2	0.3	2	0.4	2	7	57.0
Sheep	108317	0.3	0.220	1	0.2	0	0.6	1	2	12.1
Goats	41392	0.3	0.220	0	0.2	0	0.6	0	1	4.6
Horses	500	0.1	0.220	0	0.1	0	0.8	0	0	0.3
Dogs	80000	0.5	0.220	0	0.4	0	0.1	0	1	6.3
Cats*	50000	0.7	0.220	0	0.2	0	0.2	0	1	4.4
Pigs*	100	0.1	0.220	0	0.8	0	0.1	0	0	0.1
Poultry*	500000	0.2	0.250	1	0.1	1	0.7	1	3	19.3
Ducks	500	0.1	0.250	0	0.1	0	0.8	0	0	0.0
other birds			0.250	0		0		0	0	0.0
fish			0.005	0		0		0	0	0.0
aquatics			0.005	0		0		0	0	0.0
Total			0	22		62.9		22.4	108	825.4

Methane emissions from various sources of human and animal wastes assuming a 100% conversion to methane in the overall processing system. Note decimals are not shown and this is the "Worst Case Scenario"

Source	No.	dried *in situ*		Sewage		Soak Pit		composted		Gross	CO2
		%	t CH4	%	t CH4	%	t CH4	%	t CH4	t CH4	'000t
Human (residents)	5200000	0.1	1	0.6	18	0.3	14	0	2	35	265.54
Human (floating popn.)	2000000	0.2	0	0.8	5	0.8	7	0	1	13	98.43
Cattle	185087	0.3	3	0.3	7	0.0	0	0.4	4	14	109.35
Buffaloes	27429	0.3	1	0.3	2	0.0	0	0.4	1	3	24.40
Sheep	108317	0.3	0	0.2	0	0.0	0	0.6	0	1	4.60
Goats	41392	0.3	0	0.2	0	0.0	0	0.6	0	0	1.76
Horses	500	0.1	0	0.1	0	0.0	0	0.8	0	0	0.12
Dogs	80000	0.5	0	0.4	0	0.0	0	0.1	0	0	2.57
Cats*	50000	0.7	0	0.2	0	0.0	0	0.2	0	0	1.46
Pigs*	100	0.1	0	0.8	0	0.0	0	0.1	0	0	0.09
Poultry*	500000	0.2	0	0.1	0	0.0	0	0.7	0	1	7.43
Ducks	500	0.1	0	0.1	0	0.0	0	0.8	0	0	0.01
other birds			0		0		0		0	0	0.00
fish			0		0		0		0	0	0.00
aquatics			0		0		0		0	0	0.00
Total			6		33		21		7	67	515.75

C-footprint of Bangalore from human and animal wastes corrected for different methods of handling, processing, emission, etc. Please note that >90% footprint would be removed if methane could be recovered for local uses and makes it sustainable.

emissions from the Disruption of the N-cycle

Nitrogen management in
a.Human and Animal Urine
b.Human and Animal Excreta
c.Municipal Solid wastes

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Nitrogen management in

a.Human and Animal Urine

-into UGD sewage

-into soak-pits

-deposited on land

b.Human and Animal Excreta

-into UGD sewage

-into soak-pits

-deposited on land

c.Municipal Solid wastes (to be estimated)

-Decomposition in collection systems

-Dumped without treatment

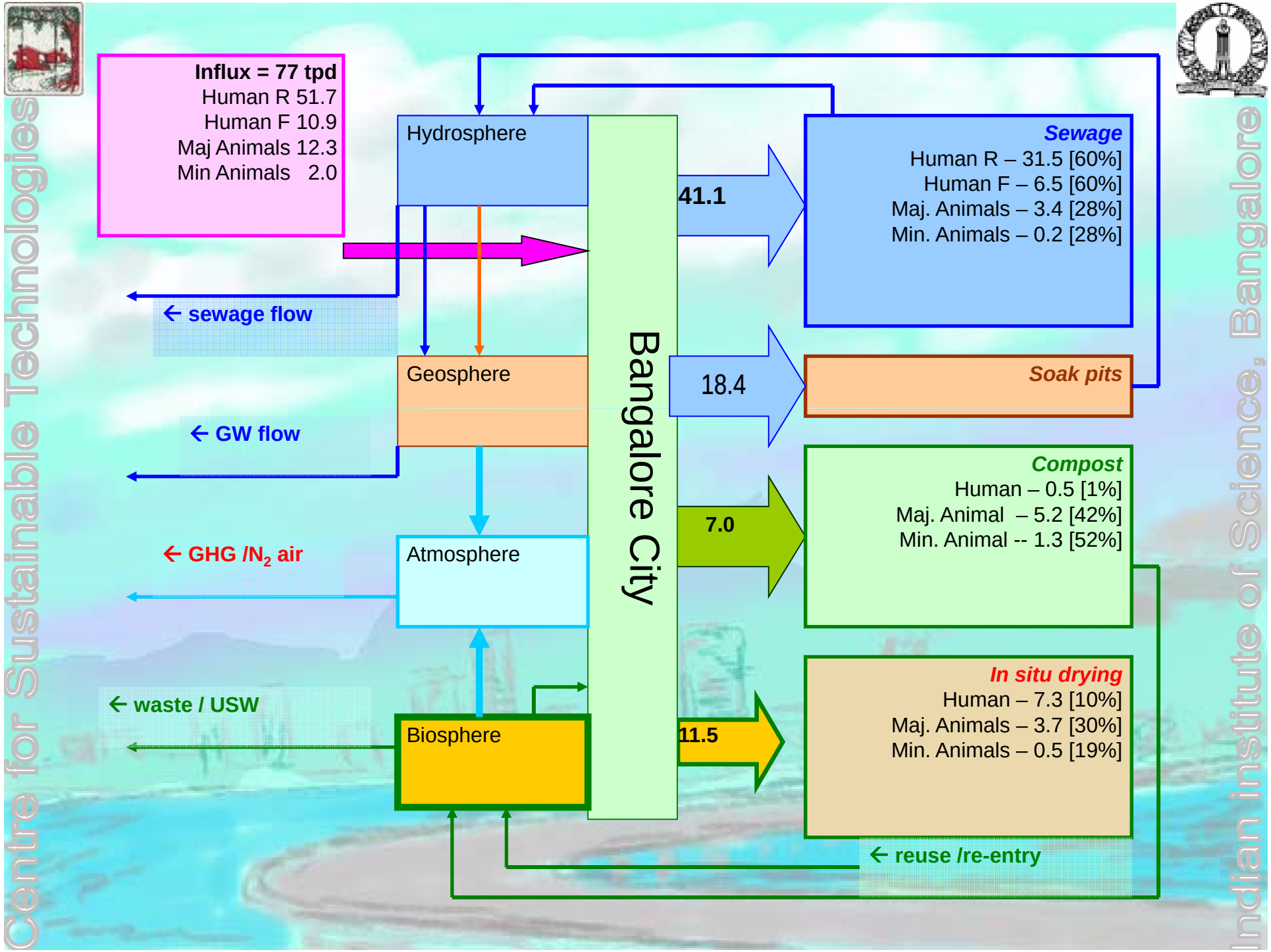
-Composted

-Consumed by micro/macro fauna

Sources of GHGs

a.Nitrogen going through processes of ammonification, nitrosification and nitrification results in N_2O. Experimental and evidence based estimates not available. Generally 1-2% is used as default value.

b.Ammonia volatilization from anaerobic systems


Influx = 77 tpd
Human R 51.7
Human F 10.9
Maj Animals 12.3
Min Animals 2.0
Hydrosphere
Geosphere
Atmosphere
Biosphere
Bangalore City
41.1
18.4
7.0
11.5
Sewage
Human R – 31.5 [60%]
Human F – 6.5 [60%]
Maj. Animals – 3.4 [28%]
Min. Animals – 0.2 [28%]
Soak pits
Compost
Human – 0.5 [1%]
Maj. Animal – 5.2 [42%]
Min. Animal -- 1.3 [52%]
In situ drying
Human – 7.3 [10%]
Maj. Animals – 3.7 [30%]
Min. Animals – 0.5 [19%]
← sewage flow
← GW flow
← GHG /N2 air
← waste / USW
← reuse /re-entry
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No	Source	No.	L/d	Urea%	Total	Fraction dried			Sewage fraction			Fraction composted			Total
					N tons	%	factor	t N_2O	%	factor	t N_2O	%	factor	t N_2O	t N_2O
1	Human (residents)	5200000	1.25	0.7	42.3	10	0.005	0.02	89	0.01	0.4	1	0.005	0	0.4
2	Human (floating.)	2000000	0.65	0.7	9.1	20	0.005	0.01	80	0.01	0.1	0	0.005	0	0.08
	Total as N kg.d^{-1} or N_2O				51.4			0.03			0.45			0	0.48
3	Cattle	185087	4	0.7	5.2	30	0.005	0.01	30	0.01	0	40	0.005	0	0.03
4	Buffaloes	27429	4	0.7	0.8	30	0.005	0	30	0.01	0	40	0.005	0	0
5	Sheep	108317	1	0.7	0.8	30	0.005	0	15	0.01	0	55	0.005	0	0
6	Goats	41392	1	0.7	0.3	30	0.005	0	15	0.01	0	55	0.005	0	0
	Total as N kg.d^{-1}				7			0.01			0.02			0.01	0.04
7	Horses	500	1.6	0	0	10	0.005	0	10	0.01	0	80	0.005	0	0
8	Dogs	80000	0.05	0	0	50	0.005	0	40	0.01	0	10	0.005	0	0
9	Cats*	50000	0.05	0	0	70	0.005	0	15	0.01	0	15	0.005	0	0
10	Pigs*	100	1.3	0	0	10	0.005	0	80	0.01	0	10	0.005	0	0
11	Poultry*	500000	0.06	0	0	20	0.005	0	10	0.01	0	70	0.005	0	0
12	Ducks	500	0.06	0	0	10	0.005	0	10	0.01	0	80	0.005	0	0
13	other birds		0.06	0	0		0.005	0		0.01	0		0.005	0	0
14	Fish				0		0.005	0		0.01	0		0.005	0	0
15	Aquatics				0		0.005	0		0.01	0		0.005	0	0
16	Total				58.4			0.04			0.47			0.02	0.53

Nitrogen pool size arising from urine fraction undergoing different processes of mineralization and N_2O liberation

No	Source	No.	DM. d^{-1}	N% TS	Total	Fraction dried			Sewage fraction			Fraction composted			Total
			tons		N $kg.d^{-1}$	%	factor	Kg N_2O	%	factor	kg N_2O	%	factor	kg N_2O	kg N_2O
1	Human (residents)	5200000	312.0	3.00	9360	10	0.005	4.7	89	0.010	83.3	1	0.005	0.5	88
2	Human (floating)	2000000	60.0	3.00	1800	20	0.005	1.8	80	0.010	14.4	0	0.005	0.0	16
	Total as ($DM.d^{-1}$) N $kg.d^{-1}$		372		11160		1296			9770			94		
3	Cattle	185087	307.2	1.25	3841	30	0.005	5.8	30	0.010	11.5	40	0.005	7.7	25
4	Buffaloes	27429	68.6	1.25	857	30	0.005	1.3	30	0.010	2.6	40	0.005	1.7	6
5	Sheep	108317	14.3	3.00	429	30	0.005	0.6	15	0.010	0.6	55	0.005	1.2	2
6	Goats	41392	5.5	3.00	164	30	0.005	0.2	15	0.010	0.2	55	0.005	0.5	1
	Total as ($DM.d^{-1}$) N $kg.d^{-1}$		395.6		5291		1587			1498			2205		
7	Horses	500	0.8	2.30	18	10	0.005	0.0	10	0.010	0.0	80	0.005	0.1	0
8	Dogs	80000	4.0	3.00	120	50	0.005	0.3	40	0.010	0.5	10	0.005	0.1	1
9	Cats	50000	2.5	3.00	75	70	0.005	0.3	15	0.010	0.1	15	0.005	0.1	0
10	Pigs	100	0.1	3.80	5	10	0.005	0.0	80	0.010	0.0	10	0.005	0.0	0
11	Poultry	500000	30.0	6.00	1800	20	0.005	1.8	10	0.010	1.8	70	0.005	6.3	10
12	Ducks	500	0.0	6.00	2	10	0.005	0.0	10	0.010	0.0	80	0.005	0.0	0
13	Other birds		0.0	6.00	0		0.005	0.0		0.010	0.0		0.005	0.0	0
	Total as ($DM.d^{-1}$) N $kg.d^{-1}$		37.5		2020		475			241			1299		
14	Fish			6.00	0		0.005	0.0		0.010	0.0		0.005	0.0	0
15	Aquatics			4.00	0		0.005	0.0		0.010	0.0		0.005	0.0	0
16	Total		805		18471			16.8			115			18.0	150

Consolidated data of N-pool sizes and N_2O production from various sources and treatment methods for human and animal wastes (excreta) in Bangalore

C-emissions from MSW by Disruption of the C-cycle

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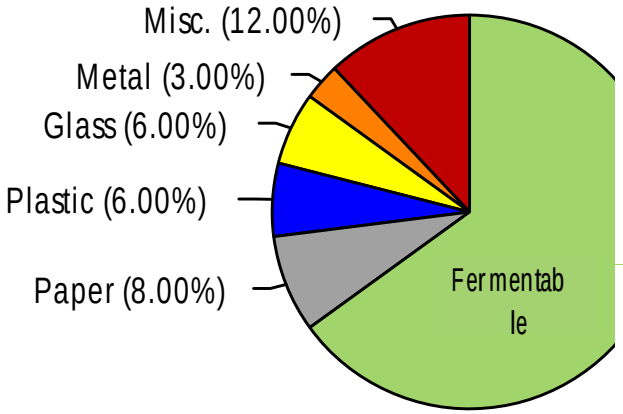
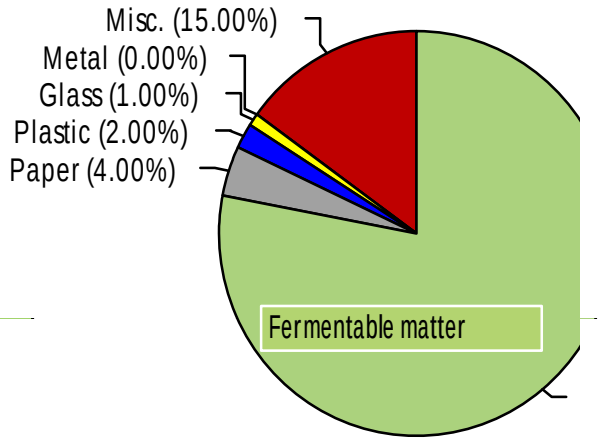
c.Municipal Solid wastes (emissions to be estimated)

- **-C loss in collection systems**
- **-C-lost when dumped without treatment**
- **-When composted**
- **-C-Consumed by micro/macro fauna**
- **-C-lost and emission during burning**

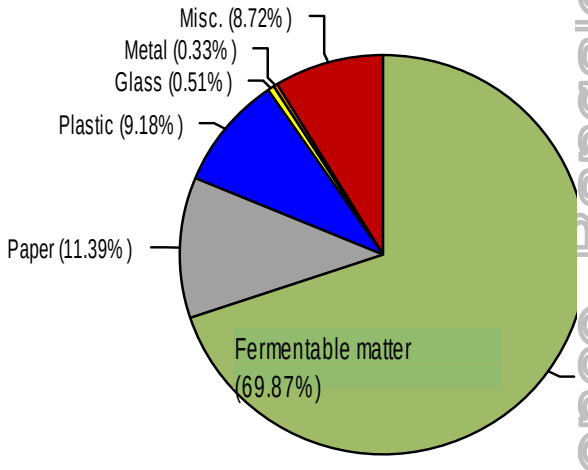
USW in bin before rag-picking



W after rag-picking



USW composition at dump site
(TIDE 2000)



Changes in USW composition from source to dump sites.

– anthropo-neogeogenesis

VAM - windrow composting with auger /turning type aeration- 1960 technology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Waste-to-Wealth?

a.Municipal Solid wastes (emissions to be estimated)

-C loss in collection systems
-C-lost when dumped without treatment
-When composted
-C-Consumed by micro/macro fauna
-C-lost and emission during burning
C-loss influenced by rain and dry weather
-emission types during wet and dry period?

b.C-footprint of MSW transportation

c.C-emissions from leachates

USW data has been disaggregated into
Domestic,
Hotels and eateries
Gardens, parks and street sweepings (leaves)
Commercial and Trade
Slums

Typical composition arrived from over 80 samples (Many studies available ASTRA-1988; Exnora-2000, TIDE 2002-3, IDeCK – 2008, BBMP – ongoing)

BMP of common materials estimated by experimentation

GHG of each types is estimated after removing non-fermentables, lignin etc. fractions and corrected for duration of possible fermentation

Validated and compared to “Default” values

GHG/C-foot print has been done @1450tpd (2005) and needs to be updated to present 3600 tons /day level

Summary

1. Methane has 21time more GWP than CO_2 – waste emission's footprint is therefore large (N_2O=200 times)
2. Default values are too high and improper to use in India – but may be useful when CDM will be applied for to make a good case for funding and showing the success
3. Corrected values suggest about
   - 0.5 million tons for human and animal waste
     (Recovering methane reduces potential by 90%, increases sustainability)
   - 1.4 million tons from USW (default; actuals to be calculated)
4. Role and value for recyclers, re-users, micro-macrofauna, etc. to be incorporated
5. Compelete recycle and reuse is possible with segregated collection – most economic and sustainable and benefits outstrip costs – CDM need not be a carrot

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Thank you

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