MSW MANAGEMENT IN INDIA

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PLATINUM JUBILEE
1944-2018
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CSIR - IICT
Touching Lives

Municipal Solid Waste generation scenario in India

Per capita waste generation in India

- 200 grams in rural
- 600 grams in urban

Waste in Million Tons (annually)

Generation	62
Collection	43
Treated	12
Land fill dumping	31

Plastic	5.60
Bio medical	0.17
Hazardous	7.90
E	1.50

Organic Fraction of MSW (OFMSW)

MSW: Calorific Value and Characteristics

Parameter	Unit	Range
pH	-	5.5 - 6.5
TS	(%)	23 - 30
VS	(%)	15 - 25
VS/TS	-	0.65 - 0.83
MC	(%)	70 - 77
COD	(mg/L)	70,000 - 78,000
BOD	(mg/L)	65,000 - 68,580
BOD/COD	-	0.87 - 0.92

- Minimum Calorific Value – 1070 kcal/kg
- Maximum Calorific Value – 1650 kcal/kg
- Calorific Value (actual) – 1200 kcal/kg

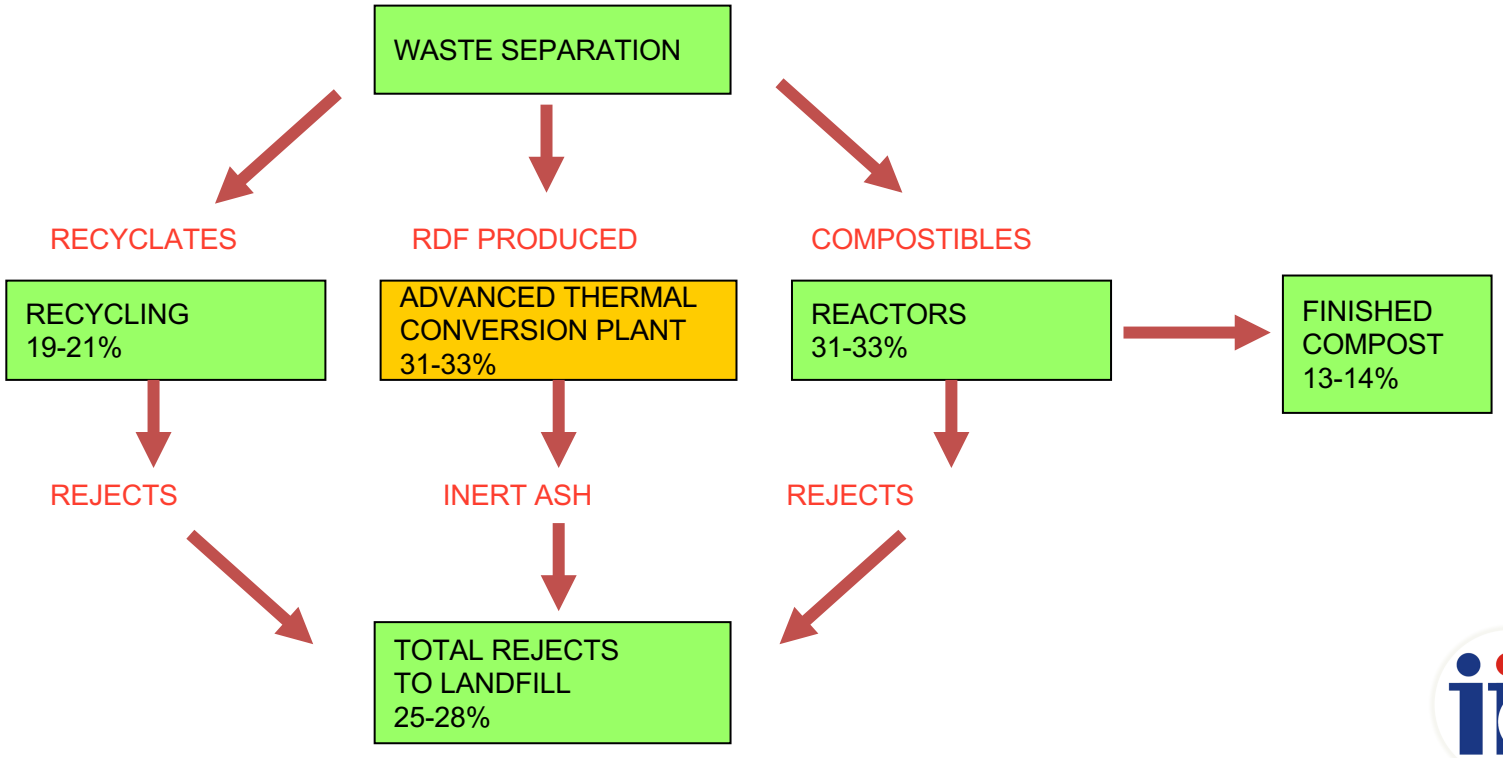
MSW Analysis

- Carbon - 15% (range 15 – 22)
- Hydrogen – 0.80%
- Oxygen- 11.81%
- Sulphur- 0.13%
- Nitrogen – 0.34%
- Chlorine – 0.10%
- Ash - 33.4%
- Moisture- 35% (Range 25-50)

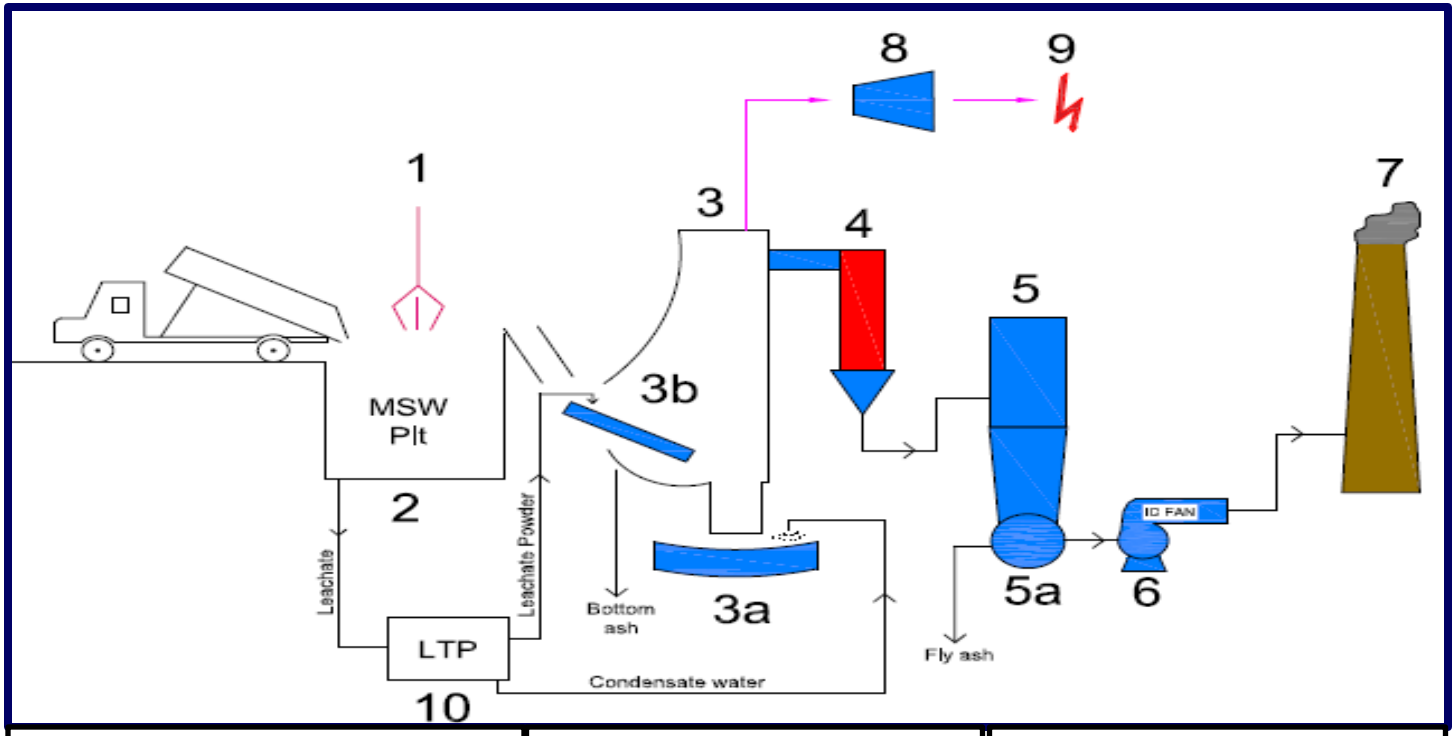
Mode of disposal

- Landfill
- Refuse derived fuel (RDF)
- Mass Incineration
- Biomethanation
- Bio Mining

Landfill Application – Resource Recovery



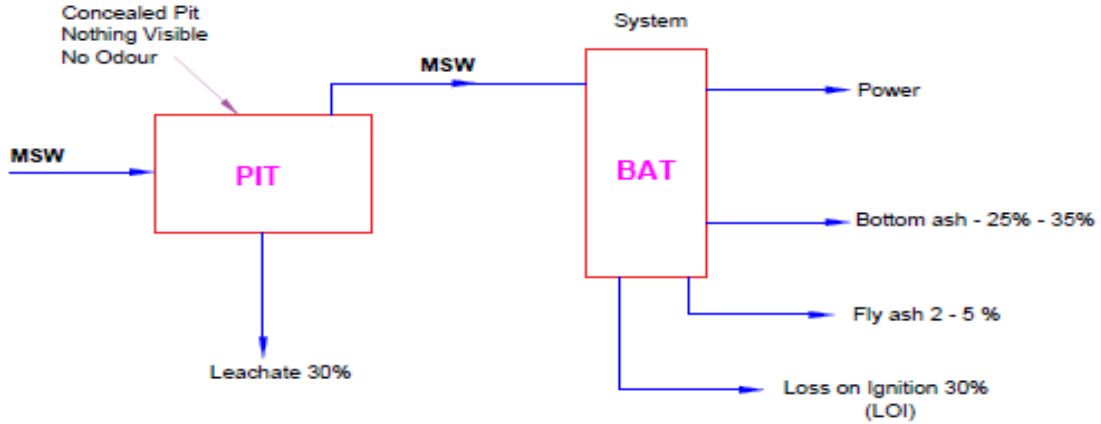
Mass (MSW) Incineration Process Flow



1. Grab Crane 1
2. MSW Pit
3. Boiler
   3a. Bottom Ash Conveyor
   3b Grate
4. Reactor
5. Bag Filter
   5a. Fly Ash Conveying System
6. ID Fan
7. Chimney
8. Turbine
9. Power
10. Leachate Treatment Plant

Mass Balance of MSW Incineration

Objective of minimizing the Landfills



Input	Output		Remarks	Conclusion
MSW 100%	1. Leachate	30%	Can be Reused as a fuel, after separation of Water	Out of 100% MSW after salvage only 5% or even <5% will go to SLF. i.e, Fly ash only. This possible in mass incineration with today's available technology.
	2. Bottom ash	25 - 35%	Can be used as construction material	
	3. Fly ash	2 - 5%	Treatment and Land fill	
	4. LOI	30%	Irrecoverable	
	5. Power	-	Export to grid	
100%	Total	100%		

MSW : Muncipal Solid Waste

BAT : Best Available Technology In the world, even applicable to Indian conditions also.
i.e, Okhla (running for past 4 years) and Essle Jabalapur MSW Pvt. Ltd. (running past 6 months)

SLF : Scientific Land Fill

Mass Incineration

Emission Norms

Parameter	Unit	Limits as per SWM Rules, 2016	International Standards
Particulate Matter	mg/Nm^3	50	10
Nox	mg/Nm^3	400	200
SO2	mg/Nm3	200	50
HCl	mg/Nm^3	50	10
HF	mg/Nm^3	4	-
Dioxins & Furans	$ngTEQ/Nm^3$	0.1	0.1
CO	mg/Nm^3	100	50
TOC	mg/Nm^3	20	-
Cd + Th + their Compounds	mg/Nm^3	0.05	-
Hg and its compounds	mg/Nm^3	0.05	-
Sb+As+Pb+Cr+Co+Cu+Mn+Ni+V+their compounds	mg/Nm^3	0.5	0.5
(TEQ: Toxic equivalents)			

Solid Waste Management Rules (SWM), 2016: MOEF, GOI

- The segregation of waste at source has been mandated to channelize the waste to wealth by recovery, reuse and recycle
- The bio-degradable waste should be processed, treated and disposed of through composting or biomethanation within the premises as far as possible
- All hotels and restaurants should segregate biodegradable waste and such food waste should be utilized for composting / biomethanation

Need of the hour

Remunerative

Decentralized Solid Waste Management (OFMSW)

A way forward for SWACHHA BHARATH

Segregation of solid waste in India: 2 bin policy

- Kitchen and food waste

Wet Waste

Dry waste

- Recyclable waste
- Plastic, paper, metal, Glass

Rejects / Sanitary Waste

- Placed near toilets and kitchen
- Minimize this by using stainless steel cutlery
- Avoid disposable cutlery

Collection Point

- Use labeled color coded 15 liter cans
- No plastic liners

Garbage pick up point

- Supervisor should monitor the process and provide training every 15 days.
- Assign a person to collect waste and transfer to collection point. He should be reporting to supervisor in case of any irregularities.
- Supervisor should manage a record of daily quantum of waste.

Initiative by GHMC

- 44 Lakh green and red bins to each household for home segregation
- Green bin for biodegradable waste
- Red bin for non recyclable waste

Source

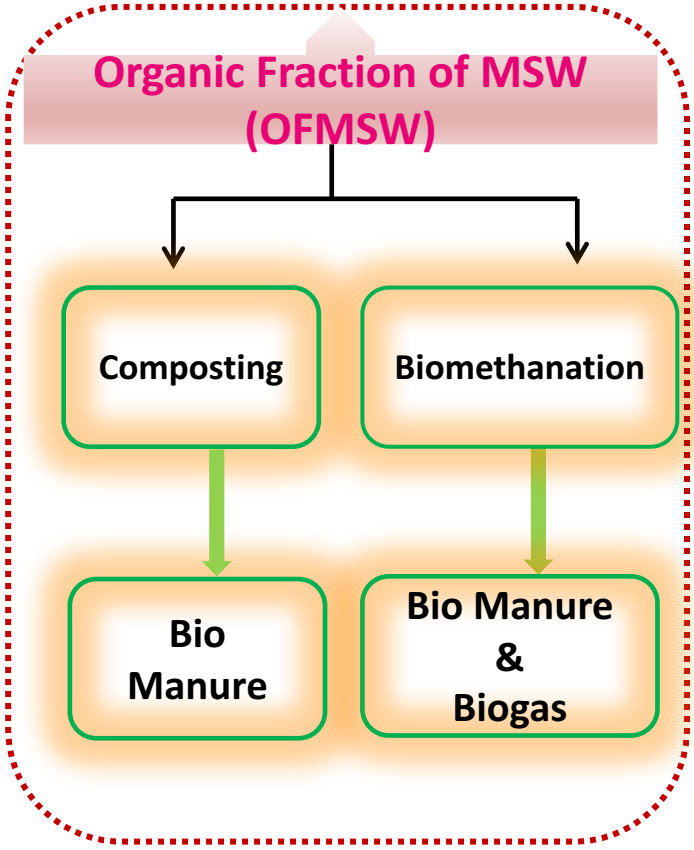
http://www.deccanchronicle.com/151022/nation-current-affairs/article/clean-telangana-red-and-green-bins-change-city%E2%80%99s-face

Sustainable treatment solutions for Organic fraction of municipal solid waste (OFMSW)

Resources from OFMSW

GENERATION OF OFMSW (per annum)	BIOMETHANATION METHOD		LPG consumption (per annum)	LPG replacement with biogas generated from waste (per annum)	Replacement of LPG with biogas (%)
	Biogas generation from waste (per annum)	Compost generated (per annum)			
25 Million Tons (MT)	2500 million cubic meter	3 million tons per annum	19 million tons	1 million ton	5.3

Treatment through biotechnological solutions developed by CSIR-IICT



AEROBIC Vs ANAEROBIC

Aerobic respiration

ENERGY CONSUMPTION

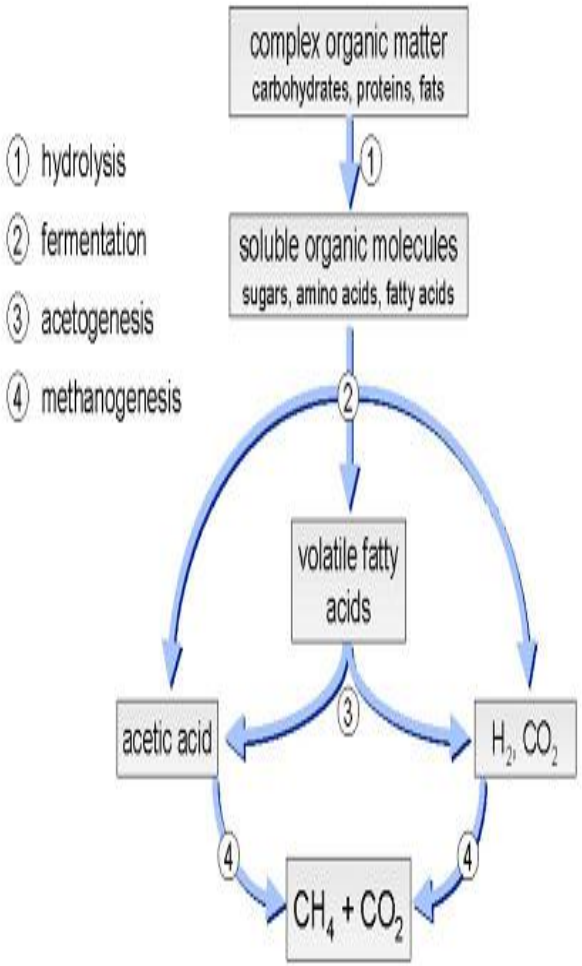
$$\text{Organic compound} + O_2 \longrightarrow CO_2 + H_2O$$

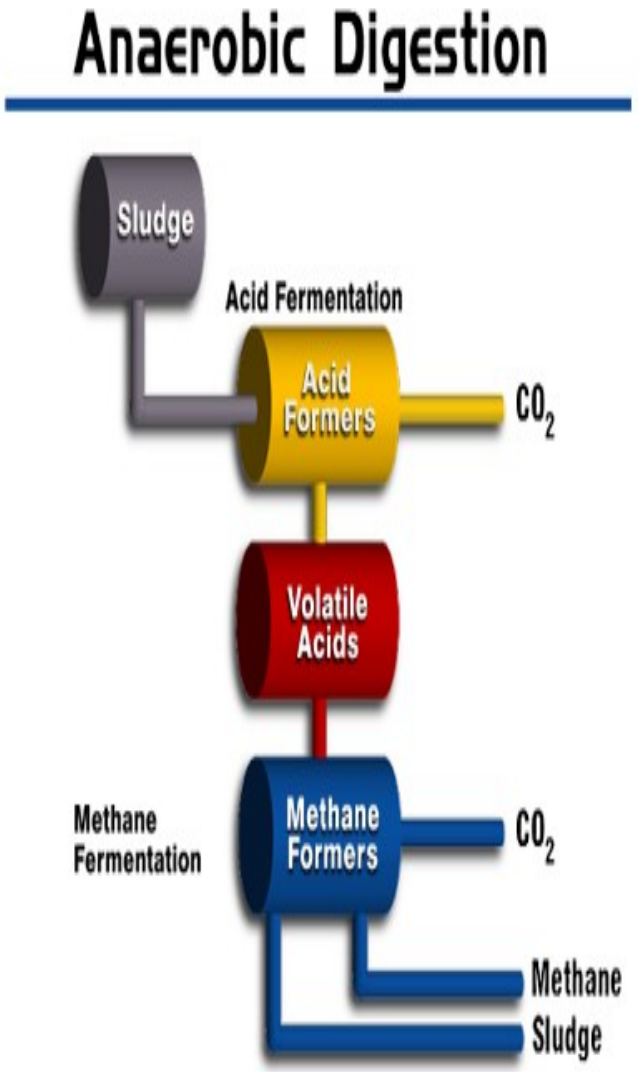
Anaerobic respiration

$$\text{Organic compound} \longrightarrow CH_4 + CO_2 + H_2O$$

BIO-ENERGY GENERATION

Mechanism


complex organic matter
carbohydrates, proteins, fats
1 hydrolysis
2 fermentation
3 acetogenesis
4 methanogenesis
soluble organic molecules
sugars, amino acids, fatty acids
volatile fatty acids
acetic acid
H_2, CO_2
$CH_4 + CO_2$


Anaerobic Digestion
Sludge
Acid Fermentation
Acid Formers
CO_2
Volatile Acids
Methane Fermentation
Methane Formers
CO_2
Methane
Sludge

Suitability of substrates for biomethanation

❖ It is a biological process carried out by a set of bacteria in the absence of molecular oxygen

❖During the process complex organic solids are converted to Bio-gas and Bio-manure

Any Organic feedstock including

- Vegetables and other agricultural waste,
- Parts of animals,
- Poultry
- Fish that we cannot eat,
- Excreta of human and animal
- Weeds such as water hyacinth,

Suitable for Small Capacity installation near generation of feed stock where transportation is expensive

Vegetables Waste

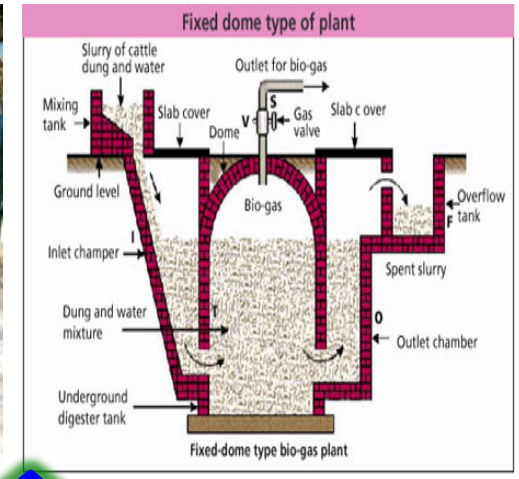
Fish Waste

Poultry Waste

water hyacinth Waste

Types of conventional digesters

FIXED DOME MODEL
(China)



FLOATING DOME
(India)

- Designed for cattle manure
- Simple design and even mason can construct
- Low cost
- MNRE subsidy (50% cost)
- 12 million digesters in India
- As per survey, 50 to 60% digesters are abandoned

Advantages and disadvantages of conventional digesters

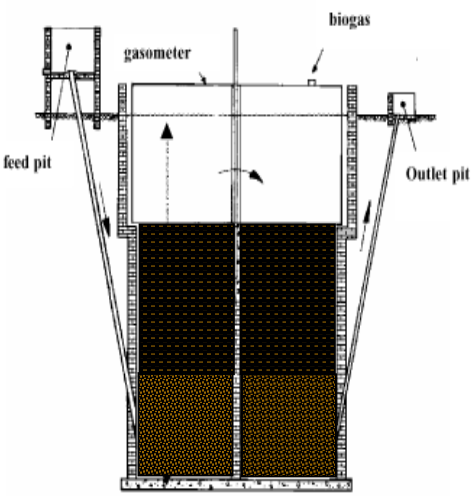


Figure 1 - Indian-type digester.

- Easy to construct, any mason can construct
- Suitable for small quantity of waste treatment
- Easy to clean re-assemble the unit below the capacity of 10 m^3
- MNRE, GOI, spent good amount of money for repair

Reasons for failure of conventional digesters

- Single stage digestion
- No mixing: Choking (scum formation at the top & Inorganic solids accumulates at the bottom) of the reactor
- Poor biogas quality (less methane content)
- Higher the capacity, the cost of repair is more than cost of installation

Conventional Digesters are not suitable for treating organic solid waste or cattle manure with quantities higher than 100 kg/day

High rate biomethanation technology

PRESENT REQUIREMENTS

HIGH RATE BIOMETHANATION TECHNOLOGY - SOLID WASTE

- HIGH RATE BIOMETHANATION TECHNOLOGY IS AN EFFICIENT MEANS FOR BIOGAS PRODUCTION USING ORGANIC SOLIDS
- MOST POPULAR TECHNOLOGY IN THE WORLD FOR SOLID WASTE TREATMENT
- M/s KOMPOGAS, VALORGA, DRANCO, PEARTH, AGRONIEN AND BIMA ARE THE LEADING VERSIONS OF THIS TECHNOLOGY
- THERE ARE INSTALLATIONS IN INDIA BASED ON BIMA TECHNOLOGY (By M/s Entec Austria)

Conventional V/s High rate

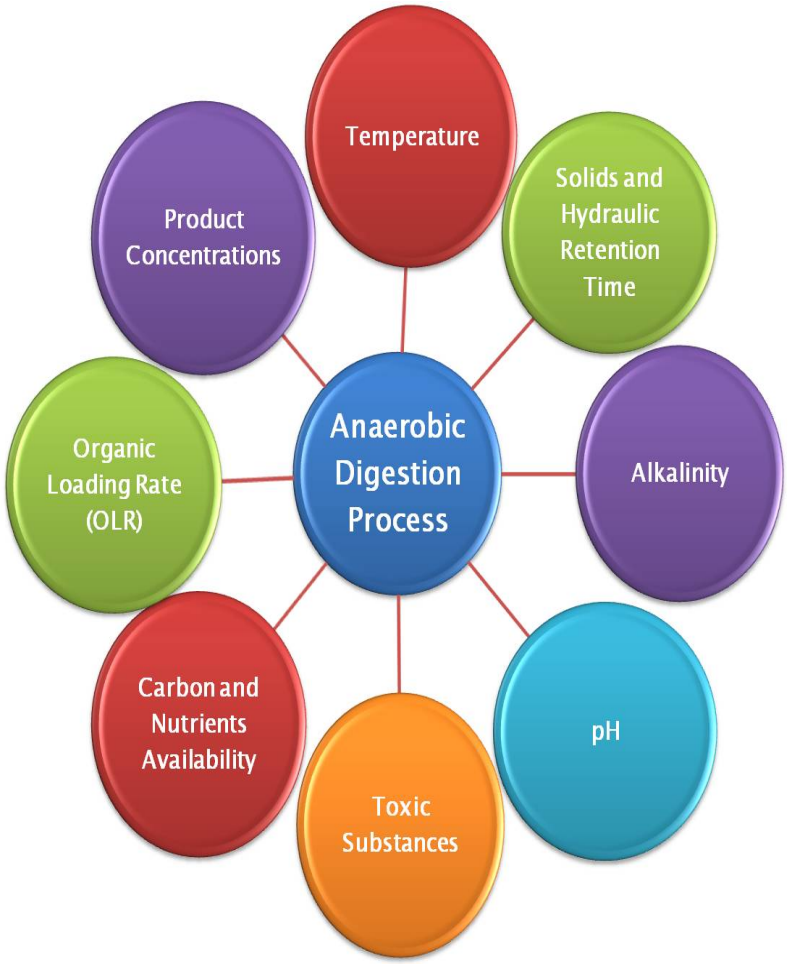
CONVENTIONAL	HIGH RATE
Requires 50 to 60 days to complete the digestion	Digestion completed within 15 to 25 days
Treatment efficiency is less than 50%	Efficiency in terms of solids digestion is 80-90%
Loading rate less than 1 kg/m^3 volume of digester	Loading rate up to 10 kg/m^3 volume of digester
Suitable ONLY for small installations	Suitable for any size
High water consumption and generate secondary effluents	Very little water consumption and no secondary effluents
Choking, Scum formation & many operational problems	No operational problems
Entire operation is manual	Fully mechanized

Transformation of conventional to high rate biomethanation digesters

Transformation of conventional to High Rate Digester

Research Challenge

Anaerobic Digestion Process: Optimum parameters



- **pH: 7-8**
- **Temperature:**
- **Mesophilic (Best : 33–42^{0}C); Thermophilic (Best : 55–60^{0}C)**
- **Total Solids/Slurry concentration:10-15% TS**
- **Volatile solids Loading Rate: 3 – 5 kg VS/m^3**
- **Hydraulic Retention Time (HRT):**

  24-60 days for Solid waste

  1-6 days Liquid Waste
- **C/N Ratio: 25-30 :1**
- **Volatile Solids: 70-80% of TS**

Technological intervention of CSIR-IICT for waste management

Remunerative

Decentralized Solid Waste Management (OFMSW)

Through

Anaerobic Gas lift Reactor (AGR) Technology Developed by CSIR-IICT

Highlights of Technology

- Advanced digester design
  - Smaller digester volume
  - Easier to scale-up and multiplication
  - Semi-automatic plant operation
- Higher biogas yield
- Generation of organic fertilizer
- Locally available enriched microbial consortia
- Remunerative for decentralized application
- Distributive biogas plants at waste generation source
- Use of by-products will make the plant sustainable
- Employment generation

Waste to energy from kitchen to kitchen

CSIR-IICT
promoting
Swachh Bharat Mission

Waste generated in kitchen

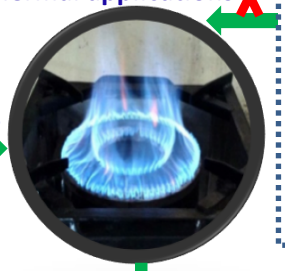
Organic waste water

Food waste

Say 'No' to LPG
Implement
Bioenergy from
kitchen waste

Biomanure

Biogas



Clean fuel for thermal applications

LPG

Biomanure as fertilizer in agricultural fields

LPG replacement with Biogas

Remunerative Decentralized Solid Waste Management (Food Waste)

Success Stories of full scale plants based on AGR Technology for food waste

Replacement of LPG with Biogas

- Food waste: 250 to 500 kg/day
- Biogas 35 to 80 m^3/day
- LPG 15 to 30 kg/day
- IICT, Hyderabad
- Capgemini, Hyderabad
- Kurnol vegetable market yard, AP

- Food waste: 1 TPD
- Biogas-150 m^3/day
- LPG 60 kg/day
- The Akshaya patra foundation (TAPF)
- Bellary and Hubli (Karnataka)
- Ahmadabad, Bhavnagar and Surat (Gujarat)
- Vrindavan (UP),
- Rourkela (Odisha)

- Feed chamber with mixer for convenience
- Recycling & enrichment of bacterial population
- Biogas stored at 50 psig pressure
- Better flame velocity

- Variety of feed stock can be used
- Choking & scum formation eliminated
- Portable, Occupies limited space and Aesthetic looks

AGR technology for different capacities of waste treatment

Quantity of organic waste per day	Footprint required for biogas plant installation	Power consumption (kWh)	Average biogas and biomanure generation per day		Equivalent LPG replacement (kg)	Commercial LPG cylinders 14.2 kg's replacement (No./day)
			Biogas (m^3/day)	Biomanure (kg/day)		
300 kg/day	6m x 3m = 18m^2	Below 10	35 – 40	45	15	1
500 kg/day	8.5m x 3m = 25.5m^2	10	60 – 70	75	30	2
750 kg/day	10m x 3m = 30m^2	Below 15	90 – 100	112	40	3
1 Ton/day	Vertical digester model 10m x 5m = 50m^2 Horizontal digester model 11m x 5m = 55m^2	15	120 – 140	150	60	4
3 - 5 Ton/day	600 m^2	50 - 60	360 – 600	450 – 750	165 – 275	12 – 20
10 Ton/day	1200 m^2	130 - 150	1220 - 1400	1500	550	40

Remunerative Decentralized Solid Waste Management (Food Waste)

5 TPD high rate biomethanation plant at Jawahar Nagar, Hyderabad

Project funded by: Indo-US Science and Technology Forum (PACESetter)

Beneficiary: M/s HiMSWL and GHMC

Input
- OFMSW: 5 TPD

Output
- Biogas-500 m^3/day
- LPG 15 kg/day
- Electrical Power: 300 kWh/day

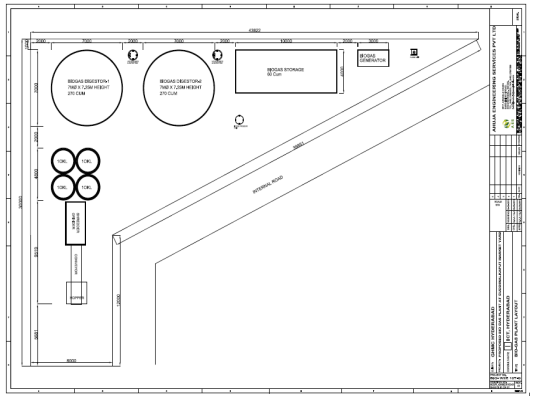
Aim of the high rate biomethanation plants

- Demonstration of decentralized and remunerative waste management model based on CSIR-IICT's AGR Technology
- Generation of value added products (Power and bio manure)
- Avoiding landfills and transportation of waste
- Reduction in the cost of waste management borne by municipalities, Employment generation
- Intangible environmental benefits such as reduction of GHG's
- Replicable technology model that could be adopted by municipalities across India

10 TPD high rate biomethanation plant at Jawahar Nagar, Hyderabad

Project funded by: Department of Biotechnology (DBT), Government of India (GoI)

Beneficiary: Gudimalkapur Market Yard and GHMC



Input
- OFMSW: 10 TPD
- Leachate: 2.5 m^3/day

Output
- Biogas-1250 m^3/day
- Electrical Power: 1440 kWh/day

BIOHOME

Quantity (kg/day)	5	10	25	50	75	100
Biogas generation (L/day)	400	800	2000	4000	6000	8000
Biogas generation (m3/day)	0.4	0.8	2	4	6	8
LPG equivalence (g/day)	160	320	800	1600	2400	3200
LPG equivalence (kg/day)	0.16	0.32	0.8	1.6	2.4	3.2
Size of the digester (L)	300	600	1500	3000	4500	6000
Size of the digester (m3)	0.3	0.6	1.5	3	4.5	6
Size of the biogas holder (L)	400	800	2000	4000	6000	8000
Size of the biogas holder (m3)	0.4	0.8	2	4	6	8
Foot print area required (m2)	2	3	4	6	8	10

BIOHOME at different capacities of waste treatment

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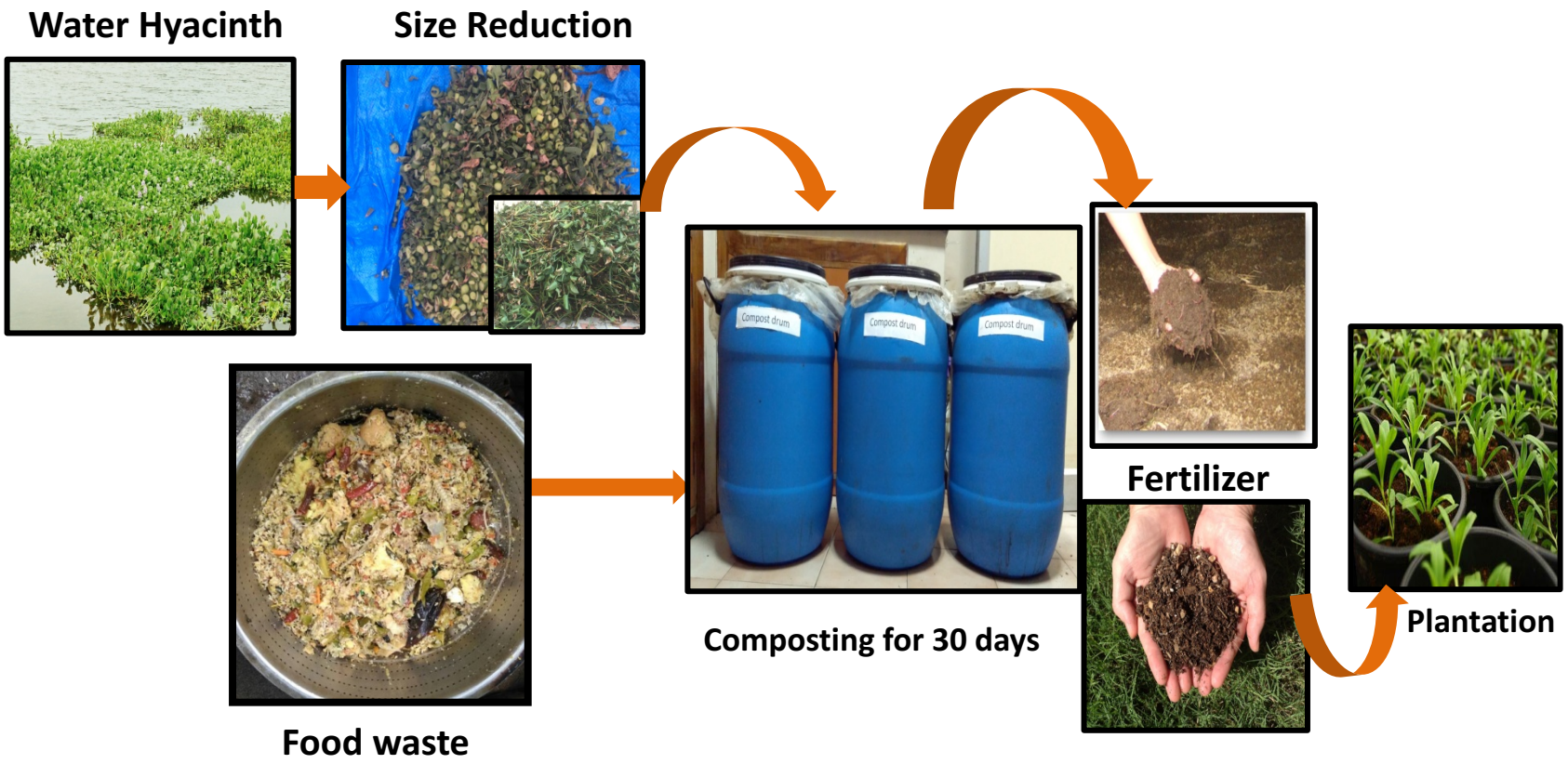
Composting of solid waste

Accelerated Anaerobic Composting of food waste and water hyacinth



Composting of organic waste & Entrepreneurship development

Characteristics of fertilizer after composting

Accelerated Anaerobic Composting (AAC): Techno-Economics

- Food Waste: 50 Kg/day
- Compost: 10 Kg/day
- Capital cost for installing compost bins: Rs. 40,000/- (Forty thousand only)
- Cost of compost: Rs.25 to 50 per kg (varies from place to place based on composition)
- Compost generated per Month : 300 kg
- Revenue from compost : Rs. 7,500 to 15,000 per month
- Unemployed youth could become entrepreneurs with AAC Technology
- CSIR-IICT is ready to train personnel who are interested in this activity

PARAMETER	WATER HYACINTH	FOOD WASTE	According to FCO, Schedule-iv, specification of organic matter Standard values		
			Organic manure	City Compost	Bio-Enriched Organic manure
Total Nitrogen (as N), percent by weight, Minimum	10.09	5.4	0.5	0.8	0,8
Total Phosphates (as P2O5), percent by weight, Minimum	0.40	1.63	0.5	0.4	0.5
Total Potash (as K2O), percent by weight, Minimum	0.48	2.78	0.5	0.4	0.8

Composting of organic waste & Entrepreneurship development

Accelerated Anaerobic Composting (AAC) Technology is developed by CSIR-IICT for the biological decomposition of the organic constituents of wastes under controlled conditions for the production of organic fertilizer

The technology has been licensed to M/s KHAR Energy Optimizers (KEO)
M/s KEO, CSIR-IICT and Greater Hyderabad Municipal Corporation (GHMC) jointly initiated a societal project for the removal of water hyacinth from Kapra Lake, Hyderabad

Accelerated Anaerobic Composting benefits

- ✓Composting makes a valuable resource out of organic waste
- ✓A wonderful soil amendment, improves soil nutrients
- ✓A slow release fertilizer without pollution
- ✓Feasible at ambient temperature
- ✓No oxygen requirement
- ✓Low cost
- ✓Minimization of the loss of carbon and nitrogen

Success Stories

Pilot plant based on AAC Technology at Kapra Lake, Hyderabad
Input: 12,000 Tons of Water hyacinth
Output: Production of 1,200 Tons of soil conditioner

Societal Impact

- Generation enriched compost with good NPK (more than three times better than vermi compost)
- Reduces the problems associated with landfills and incinerators
- Benefits municipalities and villages as well as environment
- Remunerative options for the decentralized treatment of organic wastes
- Useful for villages, apartments, gated communities, restaurants and so on
- Self help groups and unemployed youth could be trained in this area

Parameter	Water hyacinth	Standard (fertilizer control authority)
Nitrogen (N)	10.0	0.8
Phosphorous (P)	0.40	0.5
Potash (K_2O)	0.48	0.8

Waste to wealth: A sustainable approach for nutrients recovery

Research Team

- Sameena Begum
- Kranthi
- Bharath
- Sudharshan
- Vijayalakshmi
- Anil
- Sarath
- Prasoona
- Gayathri
- Jayanth
- Sujan
- Aparna

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THANK YOU