Special Session III

Landfill Disposal for Solid Waste Management

THE 17th Expert Meeting on SWAPI

Transfer of Appropriate Technology by Semi-aerobic Landfill: Fukuoka Method

By Prof.Y.MATSUFUJI
Prof.A.TANAKA
Fukuoka University ,JAPAN

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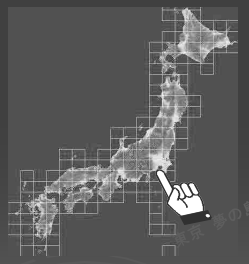
"Dream Island" before GARBAGE WAR in Tokyo 1957-1971



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"Dream Island,Tokyo" under GARBAGE WAR 1957-1971

Before Tokyo Olympic Game 1964

Open Burning Dream Island (1970)

Open Dumping under GARBAGE WAR (1971)

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Open Dumping of Landfills in Fukuoka (1971)

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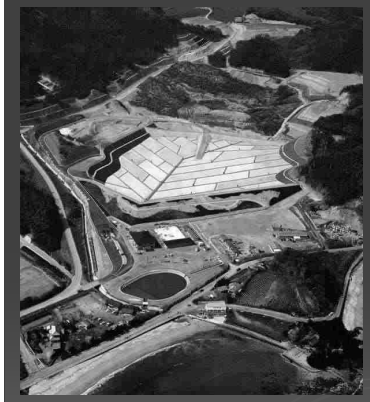
Intergraded Sanitary Landfills based on Fukuoka Method



Reuse of Completed Landfills in Fukuoka

What is Fukuoka Method?

The Fukuoka Method is a semi – aerobic landfill technology that is:

- **cost effective**;
- utilizes **local material**;
- **addresses the harmful effects** of open dumping.

By maximizing the aeration of waste, it increases the rate of biodegradation and decreases release of greenhouse gases.

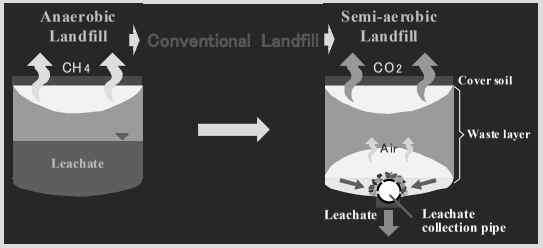
Challenging for Landfills Research by Fukuoka University

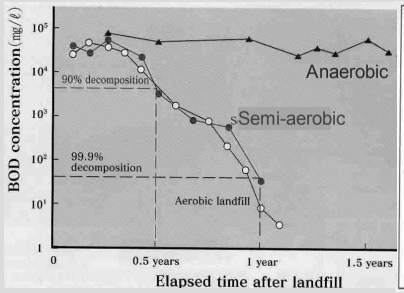
①Field Survey in Existing Landfills (Gas Monitoring)

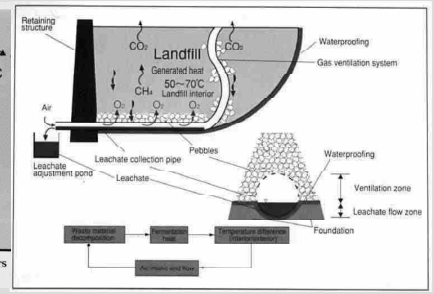
②1st Experiment on Aerobic Landfill Type with Wooden Lysimeter in Japan

③Prof.H.HANASHIMA 1st Pioneer of Landfill Researcher in JAPAN

Mechanism of Semi-aerobic Landfill Type







1.Title:NM0333:Avoidance of landfill gas emissions by passive aeration of landfills
2.Approved date by UNFCCC :July 15,2011
3.URL:http//cdm.unfccc.int/EB/index.html

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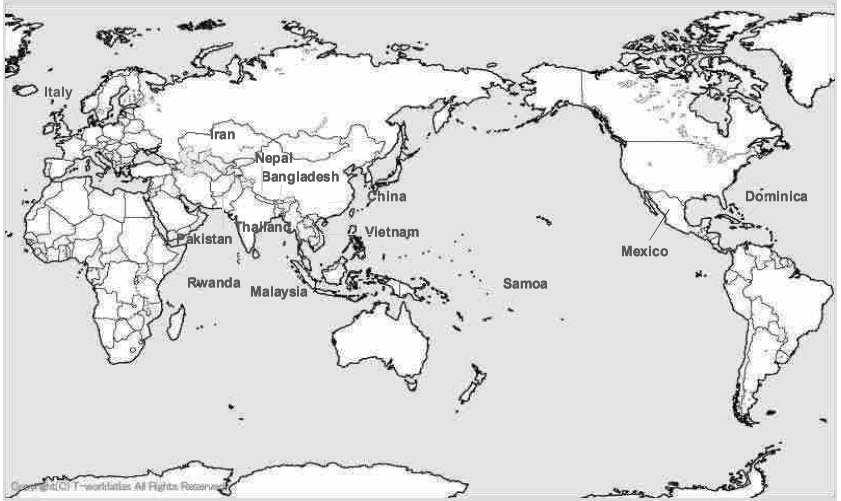
Transfer Technology to Developing Countries based on Fukuoka Method



On going 13pilot projects

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1st Trial Improvement of Landfills based on Fukuoka Method in Malaysia

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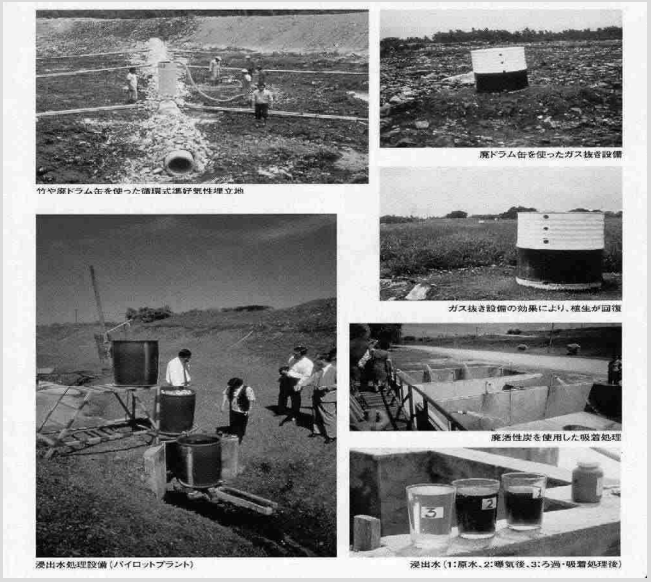
Low-cost Leachate Treatment system in Malaysia



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Case-study based on F.M in Iran

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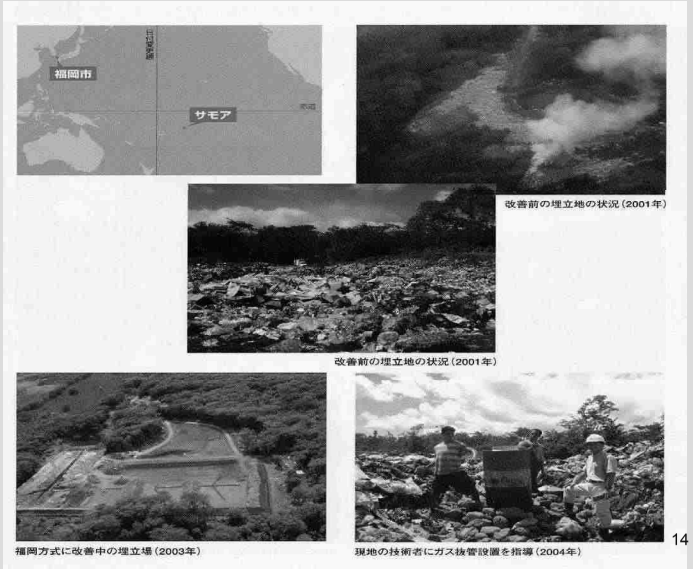
Case-study based on F.M in Samoa



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Pilot Project by F.M and Leachate Treatment in Vietnam

Eco-Fan

Tornado Treatment Facility

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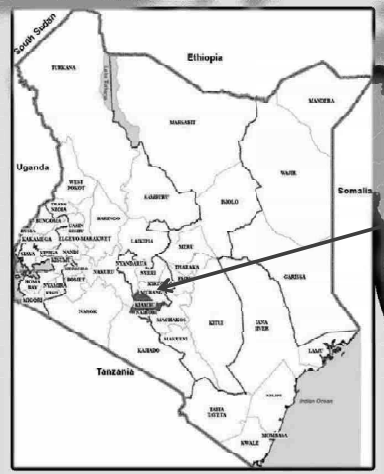
Africa's first

SEMI-AEROBIC LANDFILL



COUNTY GOVERNMENT OF KIAMBU

Improvement Process by F.M from Open Dumping to SLF

Semi-aerobic Concept

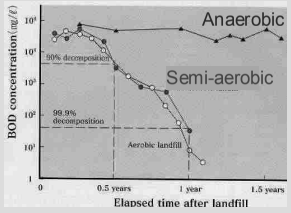
"If Landfill is under aerobic condition, Landfill have not only dumping function but also treatment function"

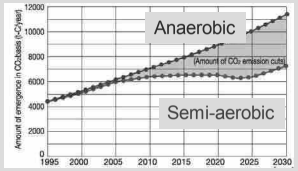
Advantages

1. To reduce
   Pollutant of Leachate
2. To reduce
   Methane Emission
3. To reuse & recycle
   Completed Landfills

⬇

Low Cost、Simple、Eco-Friendly





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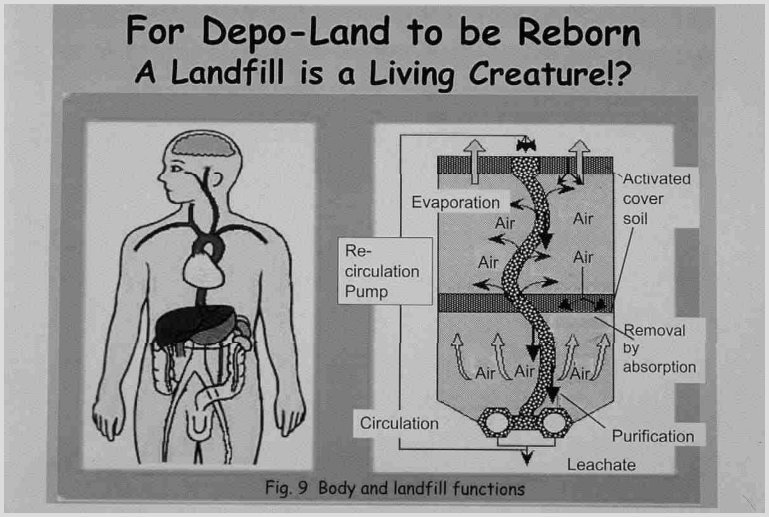
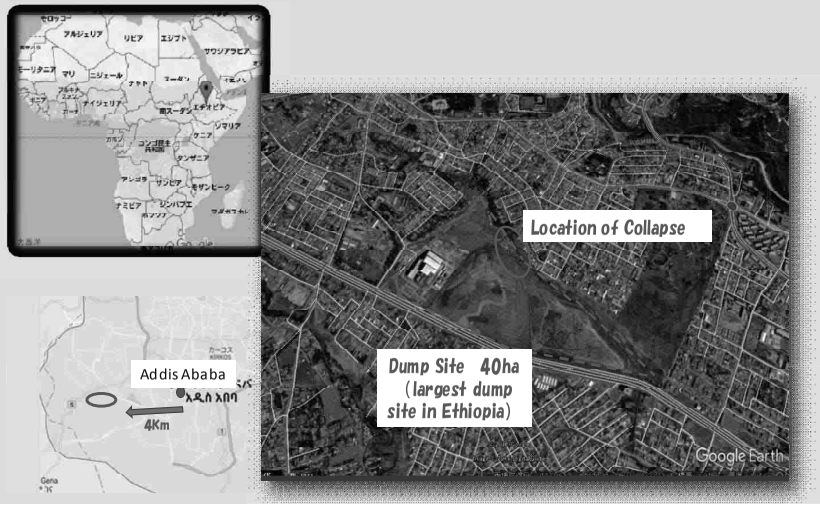


Table 5. Comparison between landfill and human body

Landfill	Human body	Roles	Remarks
Activated cover soil	Liver	Detoxification	For organic waste
Lime/ash	Kidney	Scaling/filtering	For liquid, inorganic waste, salt, heavy metal
Leachate collection pipe	Blood vessels	Re-circulation	To purify
Re-circulation pump	Heart	Pressure	To control operation and management
Monitoring	Health check up	Function check	Risk management
Not available yet	Brain	Safety control	Total management

Challenge for Unknown !!

Addressing the Collapsed Dump Site in Addis Ababa City



2017年4月スリランカの最大都市コロンボ埋立地の崩落事故

Example of Reuse of Completed Landfills by F.M in Fukuoka

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Conclusion

Success of Fukuoka Method Transfer is a road to

★ Peace

★ Friendship & Sustainable Society of SWAPI (Solide Waste Management in Asian Pacific Islands)

Win-Win Strategies for Conservation of Environment

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ご静聴ありがとうございました

Past, Present and Future of Landfill Technology in Sri Lanka

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The 17th Expert Meeting on Solid Waste Management in Asia and Pacific Islands (17th SWAPI)
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University of Peradeniya

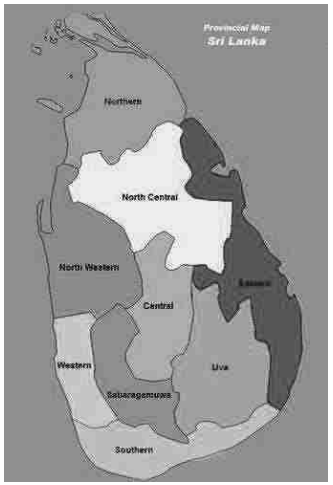
Content

Introduction

- MSW management is poor in Sri Lanka.
- The problem has been curtailed to some extent through improved collection systems and awareness programmes.
- There is more recycling activities than before.
- Nevertheless, dumping of wastes continues
- Causing tremendous hardships to the populations living in the neighbourhood due to pollution.
- Leachate and gas emissions needs to be curtailed from dumpsites
- Rehabilitation of dumpsites is a must
- New landfills are needed.

Description of LAs and wastes

Distribution of local authorities by province



Provincial Map

Province	MC	UC	PS	Total
Central	4	6	33	43
Eastern	3	5	37	45
North Central	1	0	25	26
North Western	1	3	29	33
Northern	1	5	28	34
Sabaragamuwa	1	3	25	29
Southern	3	4	42	49
Uva	2	1	25	28
Western	7	14	27	48
Total	**23**	**41**	**271**	**335**

MC: Municipal Council, UC: Urban Councils, PS: Pradeshiya Sabha

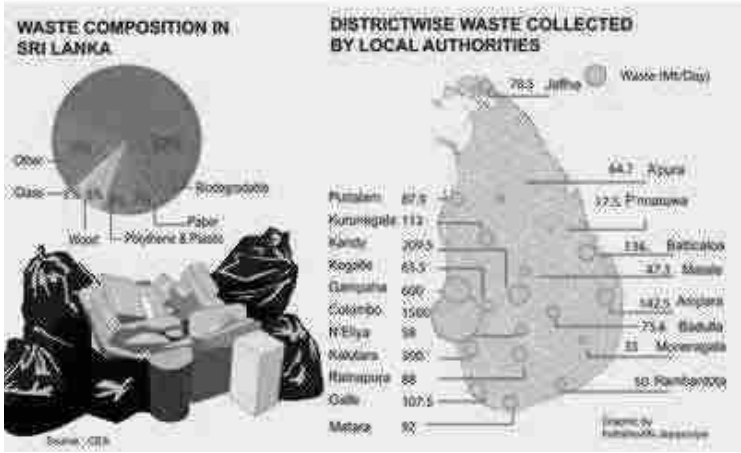
Population and Waste Generations

Province	Western	Southern	Central	Sabaragamuwa	North-Western	Uva	North-Central	Northen	Eastern
Population 2012 (millions)	5.99	2.55	2.74	1.97	2.39	1.35	1.26	1.22	1.59
Waste Generation (t/day)	2840	630	775	523	942	389	344	373	483
Per capita generation (kg/day)	0.48	0.25	0.29	0.27	0.40	0.29	0.28	0.31	0.31

Annual growth rate of waste generation: 1.2%
Total waste generation around 7,500tonne/day

MSW Composition and Characteristics

- 60% or little over are biodegradable of which short term is 56%
- Due to the rapid economic development, a tremendous increase in non-degradable packaging materials such as plastic, polythene, metals and glass can be seen in recent years
- Approximately 60% moisture content, dryer parts lower and very much seasonal



Waste composition and District wise waste collected by local authorities

(http://www.sundaytimes.lk/160619/news/drowning-in-waste-garbage-problems-out-of-control-197746.html)

Quantity of waste collection

Province	LA type	Quantity of waste collection (tons/day)								
		>100	100-50	50-30	30-20	20-10	10-5	5-1	>1	NA
Central	MC	1			2	1				
	UC				2			4		
	PS				1		4	28		
Eastern	MC		2		1					
	UC			1	1	1	1	1		
	PS				3	7	7	20		
North Central	MC				1					
	UC									
	PS						6	17	2	
North Western	MC			1						
	UC					1	2			
	PS				1	1	8	16	2	1

Province	LA type	Qunatity of waste collection (tons/day)								
		>100	100-50	50-30	30-20	20-10	10-5	5-1	>1	NA
Northern	MC		1							
	UC				1		1	3		
	PS				1	1	5	13	8	
Sabaragamuwa	MC			1						
	UC				1	1	1			
	PS				1	1	6	17		
Southern	MC			2		1				
	UC				1	2	1			
	PS					1	7	26	4	4
Uva	MC				2					
	UC							1		
	PS						6	16	3	
Western	MC	3	3		1					
	UC		2	2	4	4	2			
	PS			4	3	9	7	4		

Current Practices of Landfill Disposal

Province	Landfill			Open and control dumping		
	MC	UC	PS	MC	UC	PS
Central	1	1		2	4	30
Eastern	1	1	2	3	3	21
North Central	0	0	1	1	0	24
North Western	0	0	0	1	2	11
Nothern	0	0	0	1	5	29
Sabaragamuwa	0	0	1	1	1	16
Southern	0	1	3	3	3	24
Uva	0	0	0	1	1	24
Western	0	0	2	4	7	18
Total	**2**	**3**	**9**	**17**	**26**	**197**

Waste recycling technologies and practices to reduce volume of landfill waste

Province	Composting			Bio gas production			Recycling centres		
	MC	UC	PS	MC	UC	PS	MC	UC	PS
Central	1	5	20	1	0	0	3	3	9
Eastern	2	3	18	1	1		0	0	0
North Central	1		18	0	0	3	1	0	4
North Western	1	2	24	0	0	3	1	0	3
Nothern	1	2	2	0	0	0	0	1	1
Sabaragamuwa	1	3	14	1	1	0	1	2	1
Sothern	3	1	24	1	1	4	1	1	7
Uva	2	1	15	1		2	4	1	13
Western	3	2	15	2	2	0	12	11	23
Total	**15**	**19**	**150**	**7**	**5**	**12**	**23**	**19**	**61**

Pollution Control and Reduction of Environmental Burden in Solid Waste Management (ReEB Waste) Project by JICA

Purpose:

To enhance capacity of the officials of CEA to formulate and implement new projects by utilizing SATREPS Guide (Guide is for Sustainable Planning, Management, and Pollution Control of Waste Landfills in Sri Lanka formulated under SATREPS project).

*SATREPS was research project done by some Japanese and Sri Lankan universities from 2011 to 2016.

Activities:

1. To expand technical operation and outcome of SATREPS Guide.
2. To formulate pilot project (to construct the sanitary landfill etc.) utilizing SATREPS Guide.
3. To advice and guide O&M and upgrading of existing landfill sites.
4. To facilitate formulation of projects in future for constructing new sanitary landfill and upgrading/ rehabilitating of existing landfill through discussion with related counterpart personnel and others.
5. To facilitate formulation of projects in the solid waste management sector other than those mentioned above based on the result of "Data Collection Survey on Solid Waste Management in Sri Lanka" by JICA.
6. To support promotion of 3Rs (as extra activity) through pilot projects at LAs.

(Sato, 2017)

Pilot projects

PP site		Pilot project		Commitment
		Rehabilitation of disposal site	Promotion of 3Rs	
1	Kurunerala MC	✔	-	6th April 2017
2	Ratnapura MC	-	✔	6th April 2017
3	Kataragama PS	✔	✔	15th May 2017

(Sato, 2017)

On going JICA surveys in LAs in Sri Lanka

- Survey on method of solid waste management annual budget making and utilizing waste collection and disposal data in 15 local authorities in Sri Lanka: October – December 2017
- Ratnapura MC Solid Waste Management Labours Satisfaction Survey : October – November 2017

Tipping fee

Tipping fee	Amount (LKR)	Unit
Kardiyana waste disposal facility, Colombo		
Weighing charge	50	LKR/vehicle
Segregated organic waste	250	LKR/Ton
Inorganic waste	1,000	LKR/Ton
Bulky waste	1,300	LKR/Ton
Slaughter house or industrial waste	3,300	LKR/Ton
Muthrajawela Disposal site, Colombo		
Organic waste	3,000	LKR/Ton
Mixed waste	5,000	LKR/Ton
For other LAs except Pathadumbara PS Kundaslase PS		
Segregated waste	500	LKR/Ton
Pallakadu Semi-engineered landfill of Addalaichenai Pradeshiya Sabha		
Waste	250	LKR/Ton

Recent Dumpsite Disasters

Fire erupted in Badulla dumpsite

- The landfill which has accumulated waste for over thirty years has been a cause for concern for residents in surrounding areas, due to the menace of flies and mosquitoes and the risk of skin disease.
- On 11th October 2016 a fire erupted in the Badulupitiya municipal dump yard spread rapidly threatening neighboring areas.
- The four-acre landfill erupted in flames in several sections.
- Several thousand tons of garbage has been gutted in the fire filling the air with toxic fumes.
- The thick smog from the garbage dump has spread across Badulla town.
- At the Badulla Base Hospital alone about 30 people have been treated for smoke inhalation.

(http://dailynews.lk/2016/10/13/local/95797)

Surrounding details of the Baddulla Municipal Solid waste dump Site

(http://www.sundaytimes.lk/161016/news/hazardous-badulla-smog-still-hugs-town-212729.html)

Attempts to douse the emanating fumes

(http://www.sundaytimes.lk/161016/news/hazardous-badulla-smog-still-hugs-town-212729.html)

Disaster of Meethotamulla dumpsite

- A waste slide occurred on April 14, 2017, at the Meethotamulla dump site in Colombo.
- Extensive damage to lives and property (32 people dead, 315 families affected, and 82 houses damaged).
- Created in the mid-1990s, over undeveloped marshland, Meethotamulla is the main disposal site for all municipal solid waste from the Colombo Municipal Council and Kolonnawa Urban Council areas.
- As of May 25, 2017, the Urban Development Authority (UDA) has already evacuated and permanently resettled 98 individuals who were directly affected by the collapse (Ministry of Megapolis & Western Development, 2017)

Location and the surrounding details of the Municipal Solid waste dump Site- Meethotamulla

(NBRO, 2017)

Spatial details of the Municipal solid waste dump in February 2017 before the collapse

(NBRO, 2017)

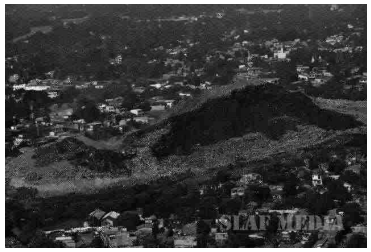
- Collapse of houses and flooding in the SW section of the toe area of the waste fill had been reported in 10th October 2012.
- The canal, which was situated at the toe of SW slope had been deepened and widened to drain storm water which has inundated the houses during rain, and that could have initiated the failure.

Ground movement and damages to houses due to deepening of' the drainage canal; which removed toe support in the toe region at the South-West section in Oct 2012

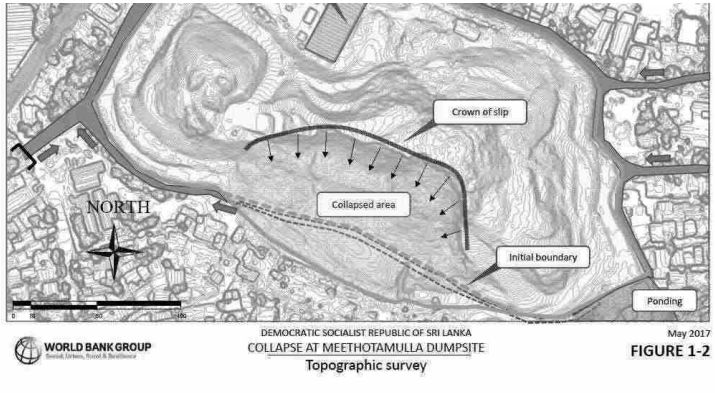
(NBRO, 2017)

(Ministry of Megapolis & Western Development, 2017)

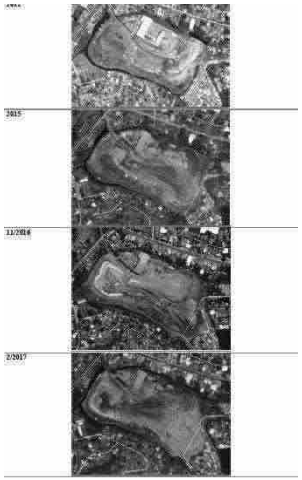
August 2016 that clearly shows instability in the Meethotamulla garbage mound



Damage caused by the Meethotamulla garbage dump landslide

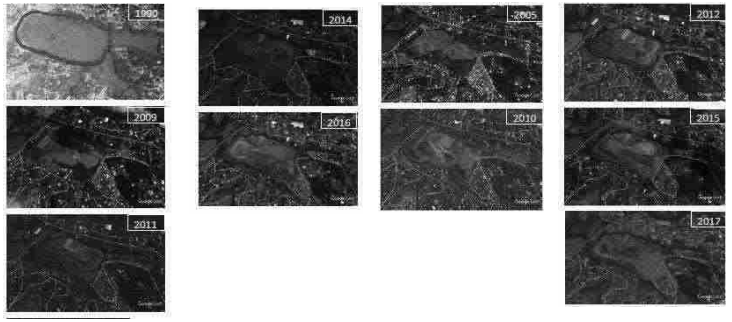


(Ministry of Megapolis & Western Development, 2017)



Aerial photo and Google images at the site showing lateral expansion of the waste fill

(Ministry of Megapolis & Western Development, 2017)



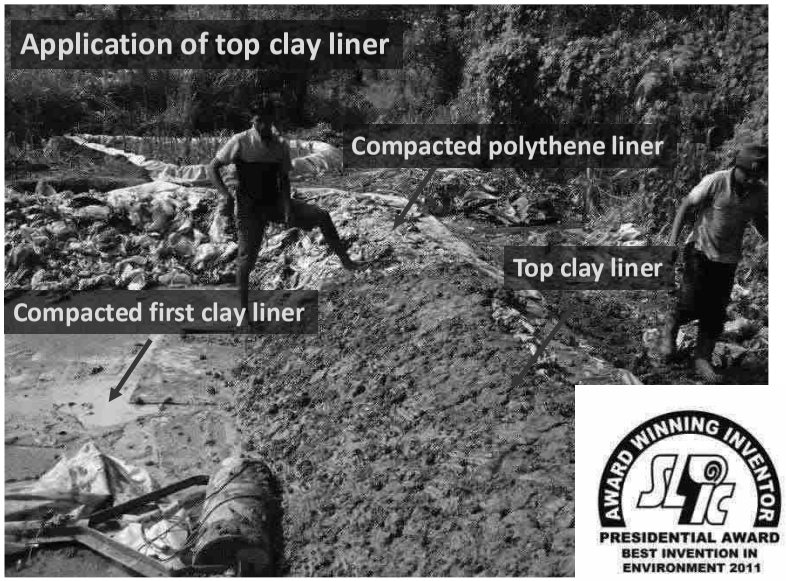
Aerial photo and Google images at the site showing lateral expansion of the waste fill from 1990-2017: Note marshy ground in 1990 and progressive expansion of waste load and occupations of mash by settlements over the time

(NBRO, 2017)

Landfill Constructions in Low Lying Lands

- Soon after the Meethotumulla dumpsite disaster, the University of Peradeniya submitted a proposal to implement Rapid Construction of a Sanitary Landfill in the Colombo District.
- The Officials insisted that the only location that can be used is in the largest and conserved salt mash (consisting of peat bog) of Muthurajawela.
- However, it was suggested to undertake IEE study, since the location is ecologically very sensitive and a natural flood plains.
- It was also pointed out that an EIA study is not needed because it will be a very temporary landfill until materialization of the Aruwakkaru landfill project in 2019.

- The technology that was suggested was with a biofilter liner system consisting of clay-waste polythene-clay



Construction of composite clay-polythene-clay liner

- Japanese Expert team along with local experts approved the project.
- Soon after, a Cabinet approval was obtained.
- The planning process was such that within one month to complete the IEE, thus considering alternate sites, although political will was not to be.
- The Engineering Design Centre of the University of Peradeniya insisted on submitting a technical report rather than undertake IEE study based on selection of location.
- As expected the World Bank is not in favor of the project, because the location is officially a biodiversity conservation sanctuary and a flood plain.
- All of the government officials (Central, Western Province and Colombo Municipal Council) have approved to continue disposing waste in the sanctuary without adequate protection and also make compost in a primitive manner.

Need Assessment (information) for Improving Landfill Disposal

- It is imperative to develop a sound database on solid waste management, because data on generation and collection of wastes are unreliable.
- This unreliability is due to burning of plastics, garden wastes etc.
- Therefore, estimations and projection of disposals are major obstacles for implementing a realistic planning process for establishing landfills in the country.
- Making land available for landfill construction and operation is a crucial issue for most local authorities.

- In the Western Province, both leading political parties, in governance and in opposition oppose establishment of landfills in their constituencies.
- Therefore, a sound land selection process cannot be entered into, engaged upon or even suggested, let alone implemented.
- In the hilly part of the country, the problem is more acute due to undulating terrain.
- The officials, including experts at all levels have their own opinions on promoting landfills, waste to energy, mega projects, but only a few have a sound understanding on ISWM.

- Some of these officials work hand-in-glove with the politicians, particularly establishing mega projects to get handouts from the contractors.
- Therefore, it is difficult to get them to focus on a defined cost effective approaches.
- In the absence of a sound policy on waste management, which compels the foreign agencies and lending banks to follow ad hoc projects that only lasts the period of funding.
- Therefore, the sustainability of these projects is questionable.

How about Plastics Waste in Landfill Disposal?

- It is only a small percentage of the plastics, say <10% is recycled.
- The remaining is burnt or dumped.
- Once again, information is lacking on importations, productions, consumptions, quantity recycled and disposed.
- The estimated quantity of plastics in 2010 was 6% of the total wastes disposed in the dumps.
- @ of 2% increase, it could very well be 7% at present

Acceptance by Citizens of Landfill Disposal Facilities

- In the absence of a clear guidelines on the selection of landfill sites, which should be based on political will, the ordinary citizen reacts violently to any facility to be within their neighborhood.
- Most of the projects have been failures endangering people because of the odor nuisance, poorly functioning (used)of haulage vehicles, triggering disasters, thus people have no confidence in the waste management projects.
- However, it should be noted that most people live in dwellings surrounded in squalor and dereliction

- These dwellings could be shanties or middle class residential areas or mixed populations with rich and poor.
- The notion of cleanliness and good neighborhood conduct in keeping the surrounding beautiful is very much desired need in Sri Lankan society.
- Therefore, educational programs are needed to point out the weaknesses and inadequacies of the rapidly growing populations and urbanization.
- The communities have to ensure cleaner surrounding with no signs of dereliction and squalor, thus it would create a glut (considerable quantities in the short term) of C&D wastes and other wastes needing landfills.
- In view of material recycling, the citizens have to agree on sharing resources as well as disposing the wastes safely.

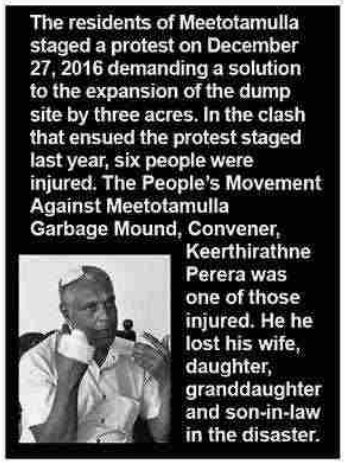
In 2008, the project to establish a sanitary landfill in Waga Pelpola has been abandoned due to local communities protests

(https://ejatlas.org/conflict/dumping-garbage-in-colombo)

Residents of Meethotamulla staged a demonstration on 27th December 2015 demanding solutions to the longstanding issue of garbage

http://newsfirst.lk/english/2015/12/meethotamulla-waste-problem-remains-unresolved-as-anger-festers-among-residents/122717

A protest by Meethotamulla residents in March 2017



http://nation.lk/online/2017/04/22/right-royal-mess.html
http://dailynews.lk/2017/03/06/local/109549/meethotamulla-protest-hampers-traffic-awissawella-%E2%80%93-colombo-road

Meethotamulla tragedy: Alternate dumping sites spark protests from locals

(http://newsfirst.lk/english/2017/04/meethotamulla-tragedy-alternate-dumping-sites-spark-protests-locals/165897)

Policy on Waste Management

- On the 8th of December 2017, a workshop was held to revise the present solid waste management policy.
- The recommendations of the UN-Habitat/MMD&E document on Comprehensive Integrated Solid Waste Management Plan for Target Provinces in SL were viewed as major changes that are needed to resolve the present crisis of waste management.
- The salient points to be included are;
- To develop and implement periodically comprehensive waste management plans at different levels of Local Authorities, Provincial Councils and Central Government for plans of different sectors of wastes, namely.

i. Integrated Solid Waste Management,
ii. Healthcare Waste Management HCWM,
iii. Industrial Hazardous and Non-hazardous Waste Management,
iv. Wastewater Management,
v. Agriculture waste management and
vi. Control and Management of Air Pollution

- For each of the plans, there will be sub-sector plans defined as:

i. Institutional structure,
ii. Infrastructure development,
iii. Research and development (R&D) and educational training,
iv. Social development,
v. Environmental management,
vi. Resource allocations,
vii. Monitoring, risk and disaster management, and
viii. Regulatory and law enforcement.

- These plans should be cohesively bound to each other so as to reduce costs and duplication, and also be effective in achieving sustainable waste management practices in these different sectors.
- To review attained targets of comprehensive waste management plans and adjust, if need arises to such plans so as to reach sustainable development within the specified period.
- To establish Environmental Courts/Tribunals for providing judicial services by reviewing and evaluating ongoing and proposed activities to improve and monitor social, technical and financial progress of those activities and environmental compliances while minimizing health related issues.

- Rehabilitation, including mining of dumpsites consistent with the comprehensive ISWM plans will be undertaken so as to prevent environmental contaminations and minimize risk to public and eco-systems.
- To divert wastes from landfills over a specified period defined in the comprehensive ISWM plans.

Ongoing Waste Management Projects in Western Province in Sri Lanka

1. Sanitary Landfill Project in Puttalam - Ministry of Megapolis & Western Development

2. Waste to Energy Project at Karadiyana - Fairway Waste Management (Pvt) Ltd

3. Waste to Energy Project at Muthurajawela - KCHT Lanka Jang (Pvt) Ltd

4. Waste to Energy Project at Muthurajawela - Western Power Company (Pvt) Ltd

Sanitary Landfill Project in Puttalam

- 1200 MT/day of solid waste collected from Colombo City Area will be transported to the proposed Sanitary landfill in Puttalam.
- Construction activities will be completed by December 2019.
- Estimated total cost is US$ 100 MN.
- Following Components are included to the Project.
  - Waste Loading Transfer Station in Colombo
  - Rail Transportation System from Colombo to Puttalam.
  - Waste Unloading Transfer Station in Puttalam
  - Sanitary Landfill in Puttalam

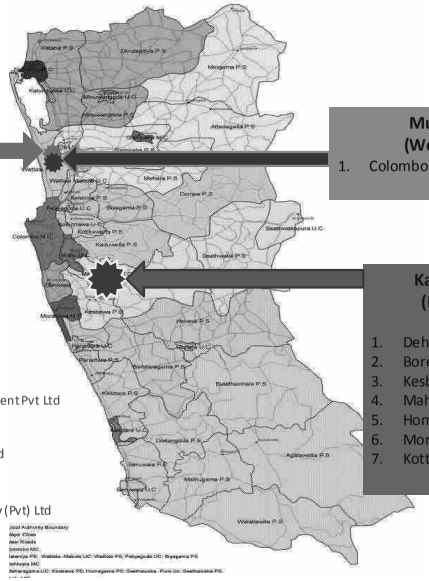
2. Waste to Energy Project at Karadiyana-Fairway Waste Management (Pvt) Ltd

- Total quantity of waste to be treated is 500 MT/day
- Waste from Local Authorities in South of Colombo will be treated
- A 10 acre land owned by Waste Management Authority – Western Province (WMA-WP) at Karadiyana is allocated for the Plant
- Project to be implemented as a Public Private Partnership (PPP) project with the WMA-WP
- Commercial operations are expected to be commenced by 2019.

Identified Mass Scale Waste To Energy Projects in the Western Province

Muthurajawela (KCHT)

1. Wattala PS
2. Wattala UC
3. Keleniya PS
4. Peliyagoda UC
5. Jaela UC
6. JaEla PS
7. Mahara PS
8. Meerigama PS
9. Negambo MC
10. Katana PS
11. Minuwangoda Uc
12. Minuwangoda PS
13. Diviulapitiya PS
14. Katunayake UC



Muthurajawela (Western Power)

1. Colombo Municipal Council / CMC

Karadiyana (Fairway)

1. Dehiwela MC
2. Borelesgamuwa UC
3. Kesbewa UC
4. Maharagama UC
5. Homagama PS
6. Moratuwa MC
7. Kotte MC

Karadiyana
Faiwar Waste Management Pvt Ltd

Muthurajawela
KCHT Lanka Jang (Pvt) Ltd

Muthurajawela
Western Power Company (Pvt) Ltd

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Proposed Project Location at Karadiyana

. Waste to Energy Project at Muthurajawela
KCHT Lanka Jang (Pvt) Ltd

Project Proponent : KCHT Lanka JANG (Pvt) Ltd
Location : Muthurajawela
Capacity : 600T/Day
Source : MSW from LAs in Gampaha District
Power Generation : 10 MW

Project Components

Waste reception/separation
Biological treatment with power generation
Incineration with steam turbine generation unit

.Waste to Energy Project at Muthurajawela
Western Power Company (Pvt) Ltd

Project Proponent : Western Power Company Pvt (Ltd)
Location : Muthurajawela
Capacity : 700-800 MT per Day
Source : MSW from Colombo Municipal Council (CMC)

Project Components

Waste reception/separation
Feeding system
Incineration
10 MW Power Generation

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Practices and Improvements of Solid Waste Landfill in China

Nie Yongfeng

School of the Environmental,
Tsinghua University, China

CONTENT

- Overview of Solid Waste Landfill in China
- Practices of MSW Landfill in China
- Practices of MSW Landfill in China

Overview of Solid Waste Landfill in China

- Roly of Landfill in Solid Waste Management

  Landfill is the most important ways for the eventual disposal of various solid waste in China. Even with implementation of waste reduction, recycling, and transformation technologies, disposal of residual solid waste in landfill still remains an important component of an integrated solid waste management strategy

- Classification of Solid Waste Landfill
  - General Industrial solid waste landfill
  - Hazardous waste Landfill
  - Municipal sold waste Sanitary Landfill
  - Construction waste and Muck landfill

Practices of MSW Landfill in China

- **Brief History of MSW Landfill**
  - Before 1990, there were hardly any MSW disposal facilities. A large number of waste dumps and simple landfill appeared in the suburbs of cities and towns.
  - In 1991, the first MSW sanitary landfill was build up in Hangzhou Tianziling .
  - In 1997, the first MSW sanitary landfill, using HDPE membrane as liner material, was put into use in Shenzhen Xiaping.
  - Since 1998, National Debts have been allocated to support investment in MSW treatment, which promoted the construction of sanitary landfills all over the country. At the same time, the capacity of harmless treatment facilities increased significantly, and the operation of such facilities is continuously improving.
  - By the end of 2011, the amount of MSW sanitary landfills became 1295, in which 547 MSW sanitary Landfills in cities, and 648 MSW sanitary Landfills in county.

Relevant regulations and requirements

Regulation

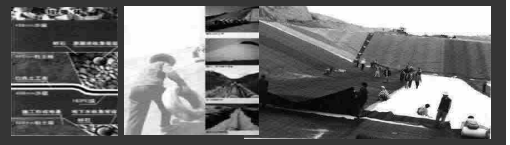
Since 2006, a series of technical standard and code were formulated and promulgated, resulted in formed a set of relatively complete standard system regarding design, construction, operation, pollution control and resource utilization, and evaluation of MSW sanitary landfill.

- Standard for pollution control on the landfill site of municipal solid waste (GB 16889-2008)
- Technical code for municipal solid waste sanitary landfill (GB 50869-20013)
- Standard for design of MSW sanitary landfill" (CJJ 17-2004)
- Standard for supervision on operation of municipal solid waste landfill (CJJT 213-2016)
- Standard for harmless evaluation on MSW Landfill site (CJJ/T107-2005)
- Technical requirement for environmental monitor on MSW sanitary landfill site (GB/T 18772-2008)
- Technical code for municipal solid waste sanitary landfill clousure (CJJ112-2007)

Relevant regulations and requirements of the landfill

Requirement on landfill construction

- Base liner system
  - Installing the composite liner consisting of both HDPE membrane and clay at the base of the landfill site to minimize generation and emission of leachate.
- Leachate
  - Installing appropriate leachate collection system and adjusting pool of large enough to storage leachate.
  - Effective leachate treatment facility in situ should be set up. And the treated leachate can meet national standard.
- Landfill gas
  - LFG collection, treatment and utilization system should be installed.



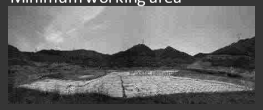
Relevant regulations and requirements of the landfill

Requirement on landfill Operation

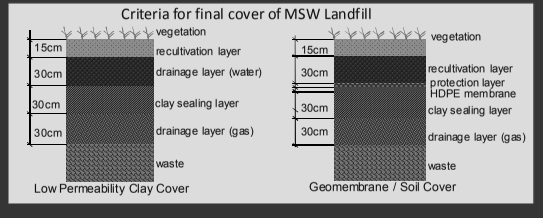
Landfill operation has a direct impact on the maximum LFG recovery and minimum surface emission of odor and methane, as well as leachate emissions. The key elements in landfill operation:

- Regular compaction

- Minimum working area



- Effective collection and treatment of landfill gas
- Effective collection and treatment of leachate
- Regular and sufficient covering of the waste: daily, interim and final cover



Level and Quantity of MSW Landfill site

MSW landfill in Operation

- By the year of 2014, there are 1549 landfills in operation, with the disposal capacity of up to 421776 tons/day in 2014.
- More and more of MSW sanitary landfill have be built up in small cities and counties. Most of MSW landfills are concentrated in the eastern region, accounted for 42.24% of the total landfill capacity.
- Most of the landfills built in last 15 years can not meet the environmentally sound criterion on landfill design, construction and operation.
- Nearly half of these landfills are constructed and put in use from 2006 to 2014.
- In the next 5 to 15 years, 1469 landfill of them will gradually stepped into the stage of closed landfill site

Time period of built up and put into operation of MSW landfill in operation

Built and put into operation	Number of landfill	Proportion
Before 1995	30	1.94%.
1996 - 2000	50	3.23%.
2001 - 2005	220	14.20%.
2006 - 2010	737	47.58%.
2011 - 2014	462	29.83%.
Unknown	50	3.23%.

Level and Quantity of MSW Landfill site

Sanitary Landfill

- Sanitary landfill is that can meet the demands of the nation standards in design, construction, operation of landfill, including:
  - Sites are located in the most environmentally acceptable areas, as far from human habitation as feasible.
  - Installing the composite liner consisting of both HDPE membrane and clay at the base of the landfill site to minimize generation and emission of leachate .
  - Installing appropriate leachate collection and treatment systems and treated leachate can meet national standard.
  - Installing appropriate LFG collection/treatment or recovery/utilization system.
  - Regularly and routinely monitoring potential emissions of leachate and LFG through comprehensive monitoring networks within and around site boundaries.
- In 2013, there are 605 MSW sanitary landfill sites in China, in which only 51 sanitary landfills are in counties. Most of them MSW are in the cities.
- In some small and middle cities an counties, the well-designed and constructed landfill could not meet the environmentally sound standard because of low management level in operation.

Level and Quantity of MSW Landfill site

- Since 2006, a grading evaluation system for MSW is establish to promote the construction and operation of MSW landfill site. According to its construction level and operation level, landfill site is divided into the following four types of landfill: (1) Class I: Excellent landfill, (2) Class II: good landfill, (3) Class III: Not good landfill, (4)Class IV: Bad landfill
- Assessment Result In 2012,
  - Nearly 200 landfills involved in the assessment. More than 90% of the landfills achieve class I or class II standard. And class I and class II landfill number is almost the same.
  - Construction level of landfills improve faster. Most of landfills constructed the liner system, the landfill gas collection system, leachate collection and treatment system.
  - Operation level of landfills gradually improved. Most landfills can meet the environmentally sound standard .

Type and distribution of MSW Lanfill

Informal Landfills

In addition to the sanitary landfill, there are a lot of informal landfills, including:

- Dumping sites:
  - Dumping sites is that they are badly managed, with little or no site preparation works, no operational plant and equipment and no on-going monitoring within or around the sites. Control over the nature of the deposits is also poor.
  - Centralized dumping and simple landfill are still the main approaches used for MSW management in most of small cities, township and rural area.
- Old landfill
  - There are still many MSW landfill sites in termination of service, without the final caver for landfill and the effective control for leachate and landfill gas emission.

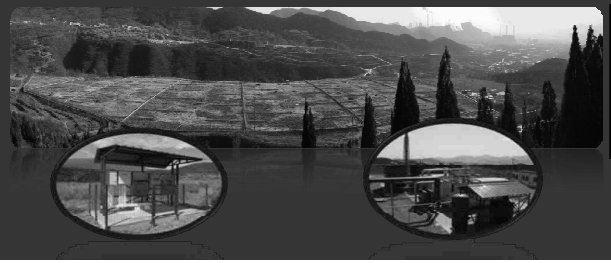
Historical and operational dumping sites exist in large numbers around all cities.

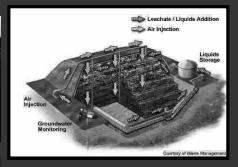
Progress in Informal Lanfill Management

- Strengthening the management of informal landfill sites has became a important environmental issue in municipal solid waste management.
- In the 12th five-year national plan on MSW disposal facilities construction, the reclamation, closure and remediation of informal landfills was first written into the national plan, including:
  - Upgrading reclamation of substandard MSW sanitary landfill sites: 503 projects
  - Closure of closed sanitary landfills: 802 project
  - Remediation of informal landfill or dumping sites: 577 projects
- The options for site remediation are site-specific but include:
  - Removal of deposits and transfer to an approved sanitary landfill
  - Installation of the low-permeability vertical barriers, LFG collection/utilization system, and permanent monitoring;
  - Landfill Aerobic-Biological Remediation: Injecting air into the waste mass, using vertical or horizontal wells, to promote aerobic activity and accelerate waste stabilization

Case : Remediation Project of Heishikou Landfill Site

Location：Shijingshan District, Berijing
Scale： Area: 140,000 m2, service : 14 yeas, landfilled MSW : 140,000 m^3 , Depth: 10m
Disposed waste: MSW with construction waste （1989-200）。
Landfill type: informal landfill
Technology: Landfill Aerobic-Biological Remediation
Governance time: construction: 9 months, Remediation: 2 years
Effect: meet the national environmental protection standards and stabilization using standard.





Practices of Hazardous Waste Landfill in China

Development

- The first of HW landfill in China was build up in 1985 in Shenzhen.
- In the National Construction Plan on Hazardous Waste and Medical Waste Disposal Facility, formulated in 2004, it is determined to construct 31 provincial and 24 regional hazardous waste centralized disposal centers.
- A hazardous waste landfill facility is part of a HW centralized disposal centers.
- By the end of 2008, 40 of the 55 hazardous waste disposal projects have started construction or have been completed.

Standard on Design and Construction of HW Landfill

- Standard for Pollution Control on the Security Landfill Site for Hazardous Wastes （GB 18598-2001）
- Standard for construction of Hazardous waste landfill disposal facilities （2005.6

General Requirements for HW Landfill

- Landfill should included disposal units and waste pretreatment facilities, waste facilities and landfill leachate collection and treatment facilities.
- The pre-tretment faclilities, including temporary waste storage, sorting and crushing, volume reduction, solidification/stabilization and other conservation facilities.
- The material in contact with the waste should be compatible with, and consider its corrosion resistance.
- The saturated hydraulic conductivity of the natural base layer should not exceed 1.0×10-5cm / s, and its thickness is not less than 2m.

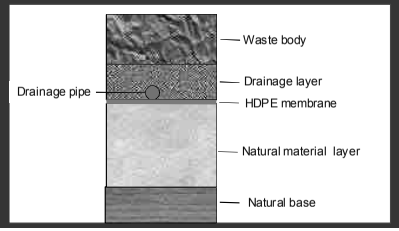
Site Selection

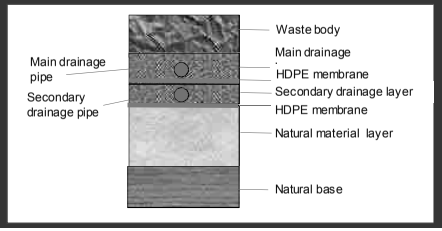
- Landfill sites should not be selected in the urban planning area of industrial and agricultural development, agricultural protection areas, nature reserves, scenic spots, cultural (archaeological) protected areas, drinking water source protection areas, water supply, long-term planning area, the vision of mineral resources reserve areas and other areas in need of special protection.
- Landfill site boundary should be located in residential area 800 meters away, and should ensure that weather conditions in the local atmospheric environment on the surrounding neighborhood does not have an impact.

Liner system

Double artificial liner or composite liner can be used deponded on the saturated hydraulic conductivity and thickness of the natural base layer

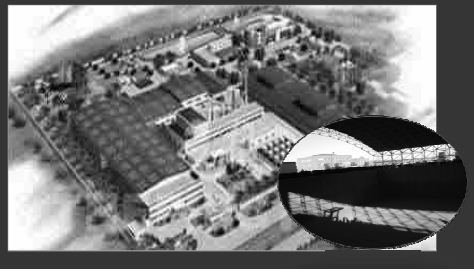
- Composite liner :
  - saturated hydraulic conductivity < 10-6cm/s
- Double artificial liner:
  - saturated hydraulic conductivity > 10^{-6}cm /s
  - the thickness > 5m.





- Landfill above ground：Tianjing HW Landfill
  - Build up: 2001
  - Landfill site
  - Area: 11,442 square meters,
  - Capacity: 6200t /year;
  - Service time: 20 years
  - The landfill is divided into four areas, mainly by double-impermeable system, drainage system, exhaust system, settlement monitoring system, groundwater monitoring systems, covering system.

- Landfill with irigid structure：Beijing HW Landfill
  - Build up: 2008
  - Operated by Eco-Island is a comprehensive treatment center, including storage, physical and chemical treatment, incineration, landfill and utilization of hazardous waste.
  - Landfill area:8400 square meters
  - Landfill capacity: 61,000 tons/y



HW Landfill in Huizhou,Dongjiang

- Guangdong Hazardous Waste Comprehensive Treatment Centre is one of the 31 hazardous waste comprehensive treatment centres listed in the "Construction Program for Hazardous Waste and Medical Waste Treatment Facilities in China"
- Demonstration Centre provides hazardous waste collection and treatment services in 13 cities in the Pearl River Delta and East Guangdong areas 。

①Administration Building
②Canteen
③Storage House
④Stabilization Workshop
⑤Main Power Room
⑥PCT/WWT Workshop
⑦Maintenance Workshop
⑧Incineration Workshop
⑨Incineration Workshop, Phase II

- Type of landfill : Valley landfill
- Landfill area:106,000 m2
- Design capacity of 3.51 million m3 .
- Life time : >over 52 years
- Four construct in phases.
- Phase One covers an area of 32,000 m2 with the capacity of 308,000 m3, and consists of A and B Cells. The Cell A of Phase One of the landfill site has a capacity of approximately 40,000 tons per year.
- The design of anti-seepage system is more strict and advanced than of the national standards.
- Surface water and underground water discharge system, leachate collecting, pumping and storage system are equipped.
- Five underground water monitoring wells are located around the landfill site for regular monitoring.

Thank you for your attention

Landfill Disposal for Solid Waste Management

Presented By:
Dr. Sunil Kumar
Sr. Scientist, CSIR-NEERI (INDIA)

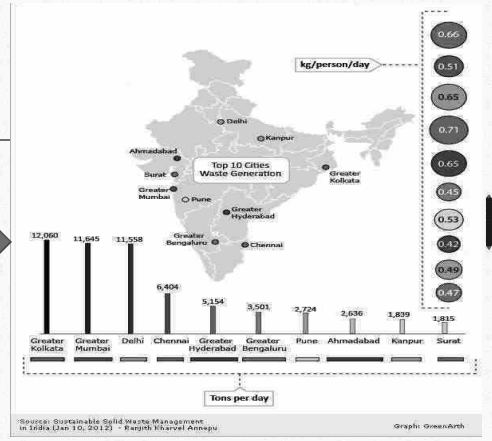
Contents

- Municipal Solid Waste Generation in India
- Current Practices for MWSM in India
- Landfill Disposal
- Issues with Sustainable MSWM and Landfill operations
- Mismanaged Landfills
- Sustainable Landfill

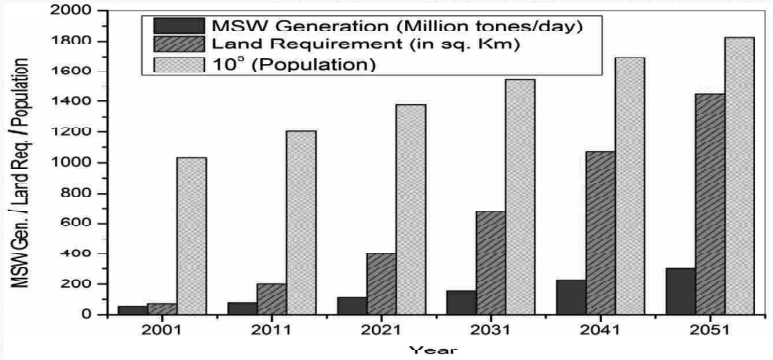
MUNICIPAL WASTE GENERATION IN INDIA

- India alone generate more than 1,00,000 metric tonnes of solid waste every day
- Large metropolis, such as Mumbai and Delhi generate around 9,000 metric tonnes and 8,300 metric tonnes of waste per day
- Today, 62 million tonnes of garbage is generated annually by the 377 million people living in urban India.
- 43 million TPA of SW is collected, 11.9 million is treated and 31 million is dumped in landfill sites, which means that only about 75-80% of the municipal waste gets collected and only 22-28 % of this waste is processed and treated.

Municipal waste generation in top ten cities of India



MSW : Past, Present and Future for India



Source : Joshi & Ahmed, *Cogent Environmental Science* (2016), 2: 1139434

COMPOSITION OF MSW

MSW IN INDIA HAS 40-60% COMPOSTABLE, 30-50% INERT WASTE AND 10-30% RECYCLABLE WASTE

Region/City	MSW (TPD)	Compostables (%)	Recyclables (%)	Inerts (%)	Moisture (%)	Cal. Value (MJ/kg)	Cal. Value (kcal/kg)
Metros	51,402	50.89	16.28	32.82	46	6.4	1,523
Other cities	2,723	51.91	19.23	28.86	49	8.7	2,084
East India	380	50.41	21.44	28.15	46	9.8	2,341
North India	6,835	52.38	16.78	30.85	49	6.8	1,623
South India	2,343	53.41	17.02	29.57	51	7.6	1,827
West India	380	50.41	21.44	28.15	46	9.8	2,341
Overall Urban India	130,000	51.3	17.48	31.21	47	7.3	1,751

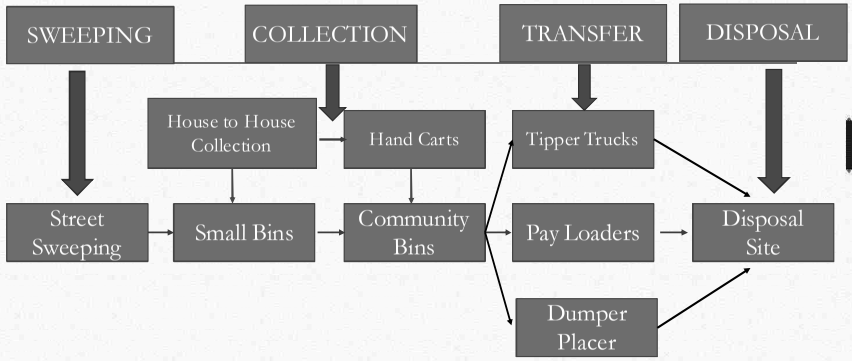
Source : Sustainable solid waste management in India by Ranjit Kharvel,January 10, 2012

CHEMICAL CHARACTERISTICS OF MSW IN INDIA

Population Range	Nitrogen (Total)	Phosphorus (P_2O_5)	Potassium (K_2O)	C/N Ratio	C.V. Kcal/kg
0.1-0.5	0.71	0.63	0.83	30.94	1009.89
0.5-1.0	0.66	0.56	0.69	21.13	900.61
1.0-2.0	0.64	0.82	0.72	23.68	980.05
2.0-5.0	0.56	0.69	0.78	22.45	907.18
5.0 & above	0.56	0.52	0.52	30.11	800.70

Source : NEERI, 1995

CURRENT PRACTICES OF MSWM



ROAD SWEEPING

HANDCARTS

Collection of solid waste from bins into trucks for manual loading and a pay loader with tipper truck

PRESENT ISSUES REGARDING SWM IN INDIA

- Generally solid waste is disposed off in low-lying areas, outskirts of cities, alongside roads or any vacant place wherever waste collectors find that they will not be seen or objected by anybody.
- Handling of waste by solid waste workers is done without taking any precautions or protective measures which lead to many communicable and non-communicable diseases to them.
- Community bin collection system is usually practiced in India for collection of waste by civic bodies. But these bins neither they are properly designed nor properly placed

PRESENT PRACTICES REGARDING SWM IN INDIA

- Vehicles transporting this waste are also not designed properly. Neither they are covered nor equipped with instruments to collect the whole waste. So waste scatters here and there during collection and transportation.
- Landfill sites are also not scientifically designed so create air, water and soil pollution. Incineration method is usually followed in maximum places to reduce the waste which itself releases many toxic elements and gases
- Lack of coordination among various departments of civic bodies also lead to poor management of solid waste management.
- Public apathy and low social status assigned to this task has made the situation worse.

MAJOR WEAKNESSES IN SWM IN INDIA

- **Mixed *Waste :*** In India all waste whether it is biodegradable, recyclable, construction, hazardous or soiled are mixed together. No system of segregation at the source level exists here.
- ***Rapidly increasing population and waste respectively:*** Now we are 1.32 billion (census 2017) and are rapidly increasing.
- ***Lack of Planning:*** No law regarding waste disposal and treatment of residential areas/apartments/flats at the time of passing plan of these areas
- ***Lack of Resources:*** As civic bodies give very low priority to SWM accordingly very less budget is assigned for it.
- ***Societal Apathy:*** Since the social status assigned to SWM is very low and people think it as a degraded task

OPEN DUMPING SITE NEAR JAIPUR BEARING HALF OF THE MSW OF THE PINK CITY

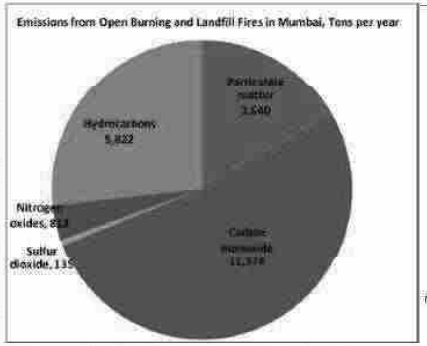
OPEN BURNING

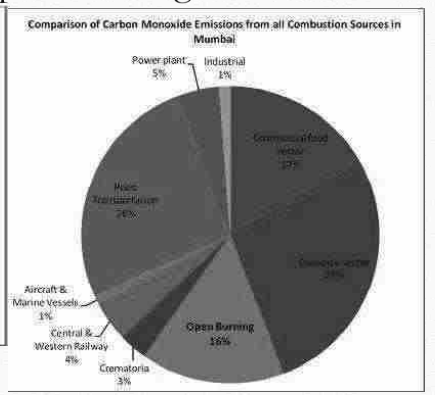
- Open burning of wastes is practiced all over India which results in air pollution and serious health hazards. Open burning is practiced by waste-pickers for recovery of metals from mixed wastes,by municipal workers or residents to empty MSW collection bins, by street dwellers for warmth at night

Open burning in a bin in Hyderabad

Open burning for warmth in New Delhi

Air Pollution due to Open Burning in Mumbai





Source : "Air Quality Assessment, Emissions Inventory and Source Apportionment Studies:Mumbai", NEERI, 2010

LANDFILL FIRES

Landfill fire at a Sanitary landfill in India

- Landfill fires are common at every landfill in India
- They are caused due to the build-up of heat inside waste beds due to decomposing or organic matter
- These fire continue for weeks at a stretch, even after long showers

PUBLIC HEALTH ISSUES

The groups at risk from the unscientific waste disposal include:

- Populations in areas where there is no proper waste treatment method.
- Children
- Waste workers
- Populations living close to waste dump
- Animals

Exposures occurs through

- Ingestion of contaminated water or food
- Contact with disease vectors
- Inhalation
- Dermal

PUBLIC HEALTH ISSUES

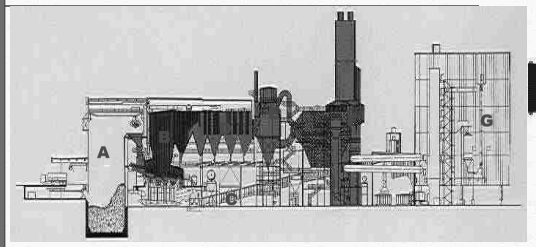
Unscientific disposal and exposure to solid waste may result to :

- Chemical poisoning through chemical inhalation
- Uncollected waste can obstruct the storm water runoff resulting in flood
- Low birth weight
- Cancer
- Congenital malformations
- Neurological disease
- Nausea and vomiting
- Increase in hospitalization of diabetic residents living near hazard waste sites.
- Mercury toxicity from eating fish with high levels of mercury.

TECHNOLOGIES FOR MWSM

INCINERATION

- Proven technology for volume reduction
- Costs vary between US$ 200.-/ton and US$ 600.-/ton
- Creation of air pollution and highly toxic ashes
- Problematic disposal of created ashes (approx. 25% of input)

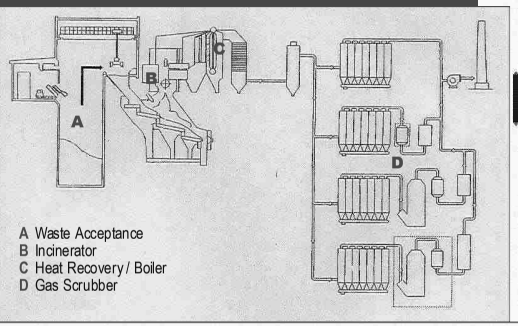


A Waste Acceptance C Slag Remover E Drier G Active Carbon Filter
B Combustion Chamber D Steam Boiler F Gas Scrubber

TECHNOLOGIES FOR MWSM

INCINERATION WITH DIOXIN BREAKER

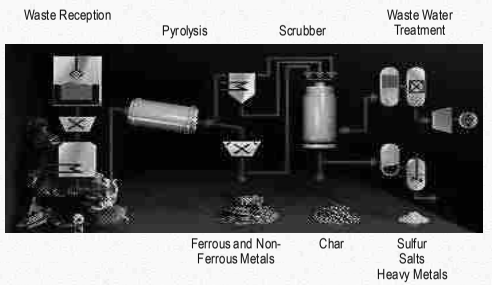
- Proven technology for volume reduction
- Air pollution is reduced at relatively high costs
- Problem of highly toxic residue ashes remains



TECHNOLOGIES FOR MWSM

STANDARD PYROLYSIS

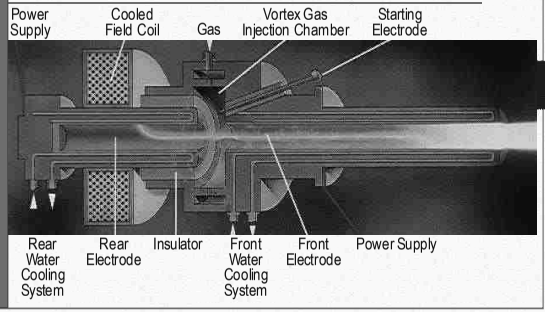
- Relatively expensive
- Permanent operating problem with tar and oils
- Problematic disposal of created char residue (toxic)



TECHNOLOGIES FOR MWSM

PLASMA ARC

- Totally destroys all organics, but shows inefficient energy balance
- Small throughput
- Expensive operation and maintenance, approx. US$ 1000.-/ton



TECHNOLOGIES FOR MWSM

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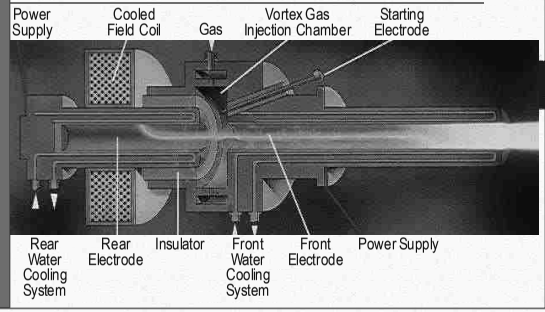


TECHNOLOGIES FOR MWSM

ANEROBIC DIGESTION

Well known technology for domestic sewage and organic wastes treatment, but not for MSW

Biological conversion of biodegradable organic materials in the absence of oxygen at temperatures 55 to 75 °C (thermophilic digestion – most effective temperature range)

Residue is stabilized organic matter that can be used as soil amendment after proper dewatering

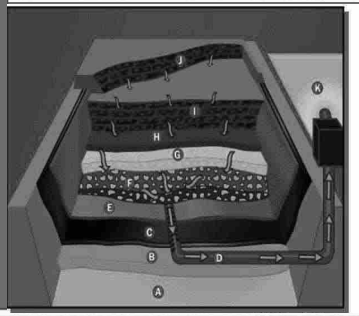
Digestion is used primarily to reduce quantity of sludge for disposal / reuse

Methane gas generated used for electricity / energy generation or flared

TECHNOLOGIES FOR MWSM

SANITIZED LANDFILL

- Costs are approx. US$ 40.-/ton
- Ground water decontamination partly prevented by expensive lining system installed in the dump prior to filling
- Monitoring of gases required for over 100 years



COMPARISON OF TECHNOLOGIES FOR MWSM

Technology	Plant capacity (tons/day)	Capital cost (M US$)	O&M cost (US$/ton)	Planning to commissioning (months)
Pyrolysis	70-270	16 - 90	80 - 150	12 - 30
Gasification	900	15 - 170	80 - 150	12 – 30
Incineration	1300	30 - 180	80 - 120	54 – 96
Plasma gasification	900	50 - 80	80 - 150	12 – 30
Anaerobic digestion	300	20 - 80	60 - 100	12 - 24
In vessel composting	500	50 – 80	30 - 60	9 – 15
Sanitary landfill	500	5 - 10	10 – 20	9 – 15
Bioreactor landfill	500	10 – 15	15 - 30	12 – 18

DEVELOPING A LANDFILL

PLANNING PHASE	DESIGN PHASE	CONSTRUCTION PHASE
• Site Selection • Site Investigation • Landfill layout and section • Evaluation of landfill capacity • Phased Operation	• Design of liner, leachate collection and Treatment • Gas Collection and Treatment • Cover System • Landfill Stability • Surface Water Drainage • Environmental Monitoring	• Site Development • Construction Schedule • Material and Equipment Requirement • Environmental Control During Operation • Closure and Post Closure Programmes

ESTIMATION OF LANDFILL CAPACITY

Waste generation rate	W tons per year
Active life of landfill	n years
Total waste in n years (T)	W x n tons
Volume of waste(V)	T/density cum
Volume for daily cover	0.1 V
Volume for liner and final cover	0.2V to 0.3V
Total volume(Landfill capacity)	V+0.1V+0.25V
Total area available	A sqm
Area for infrastructure	0.15 A to 0.25A
Area of land filling	0.8A
Height (+depth) of landfill =	1.35V/0.8A

STABILITY ASPECTS FOR A LANDFILL

The stability of a landfill should be checked for the following cases:

- Stability of excavated slopes
- Stability of liner system along excavated slopes
- Stability of temporary waste slopes constructed to their full height (usually at the end of a phase)
- Stability of slopes of above -ground portion of completed landfills
- Stability of cover systems in above -ground landfills.

ANNOYANCE CREATED BY LANDFILL

- Unbearing Foul Smell
- Attracts Birds, Insects and Rodents
- Breed Germs and Pathogens
- Emission of Methane gas and CO_2
- Reduce Oxygen and increase Carbon dioxide
- Ground water contamination
- Air Pollution

LANDFILL COLLAPSE : CASE STUDY OF DELHI'S GHAZIPUR LANDFILL

The East Delhi Municipal Corporation dumps over 2,000 tonnes of mixed garbage at Ghazipur every day

The garbage hill is over 50 metre high

Ghazipur Landfill site : A disaster

- A large portion of the 50-metre-high Ghazipur dumpsite in East Delhi collapsed on September 1, leaving at least two people dead.
- 33-year-old dumpsite was saturated with garbage, having exceeded its capacity in 2004 with 2000 tonnes of mixed garbage everyday with in total 1.3 million tonnes thrown in the landfill since 1984
- The dumpsite poses a severe threat to land, water and air in the surrounding areas. The leachate or liquid waste from the landfill is left untreated. It goes down the drain, thus posing severe threat to ground and surface water resources in the vicinity. Fires are common in the landfill, making the landfill toxic.
- The area has a pilot waste-to-energy plant with about 12 megawatt capacity which is operational for only 15 days in a month. A methane-capturing gas-to-electricity plant was also set up in 2015, but it did not run due to low levels of methane.

METHODS TO REDUCE SOLID WASTE

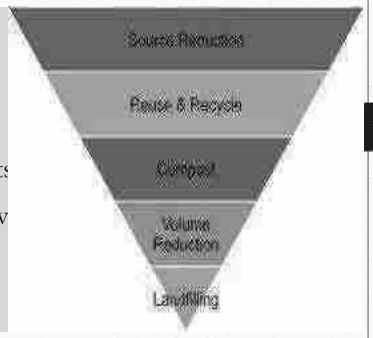
- Source reduction
  - Alter the design, manufacture, or use of products and materials to reduce the amount and toxicity of what gets thrown away.
- Recycling
  - Sorting, collecting, and processing materials to manufacture and sell them as new products.
- Composting
  - Decomposing organic waste, such as food scraps and yard trimmings, with microorganisms (mainly bacteria and fungi) to produce compost.
    - Compost is the biologically stabilized residual organic material that can be used as a soil amendment or as a medium to grow plants.

REMEDY TO REDUCTION OF MSW IS 3R CONCEPT

REDUCE	REUSE	**RECYCLE**
Source reduction is when products are designed, manufactured, packaged, and used in a way that limits the amount or toxicity of waste created.	Reusing the products we are reducing the overall amount of waste produced by giving the item a second function and expanding the typical lifespan of the item	Reprocessing of the disposed items to new or the original products

Role of Authorities in Reducing MSW

- Source Segregation
- Promoting recycling
- Providing Subsidy on recycling plants
- Providing Subsidy on other WTE plants
- Penalty for defaulters with stringent law
- Public Private Partnerships
- Improving Institutional framework



GLIMPSES OF MSW RULE 2016

- Every Waste Generators shall segregate waste and store separately and hand over to Municipal workers or authorized waste pickers.
- MoUD shall frame National Policy on SWM and coordinate with States/UTs, provide technical guidelines, financial support, training to local bodies, etc
- Departments of Fertilizers & Chemicals shall assist in market development for city compost and make available to companies (3/4 bags compost: 6/7 bags Fertilizers)
- Ministry of Power shall fix tariff of power generation from W-T-E project and ensure distribution through companies.

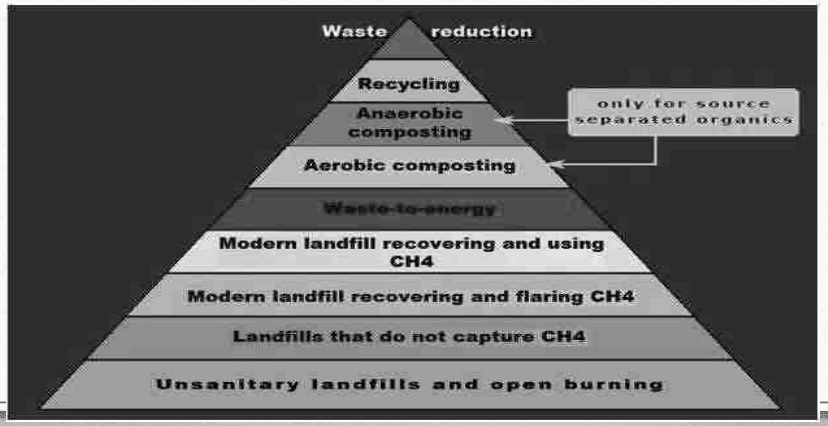
GLIMPSES OF MSW RULE 2016

- MNRE shall facilitate infrastructure for waste-to-Energy plants and provide subsidy
- District Collector/Magistrate shall facilitate identification of landfill site, quarterly review the performance of local bodies.
- CPCB shall coordinate with SPCBs/PCCs for monitoring and Annual Reports, formulation of standards, review new technologies, prepare guidelines for buffer zones restricting from residential, commercial and construction activities areas; and inter-state movement of waste.
- Manufacturers/Brand owners shall facilitate collect back wastes of their products and provide pouch for packaging sanitary wastes, etc

GLIMPSES OF MSW RULE 2016

- Local Authority/Panchayats shall prepare SWM plan with time line and its implementation, segregate, adopt 3-Rs, material recovery, processing/ disposal of Waste, user fee and levy spot fine
- Industry (cement, power plant, etc.) shall use RDF within 100 km
- Avoid landfill, make waste transfer stations, strict action for littering and construct landfill at plain areas.
- Waste to Energy plant for waste with 1500 Kcal/kg and above for co-incineration in cement and power plants.

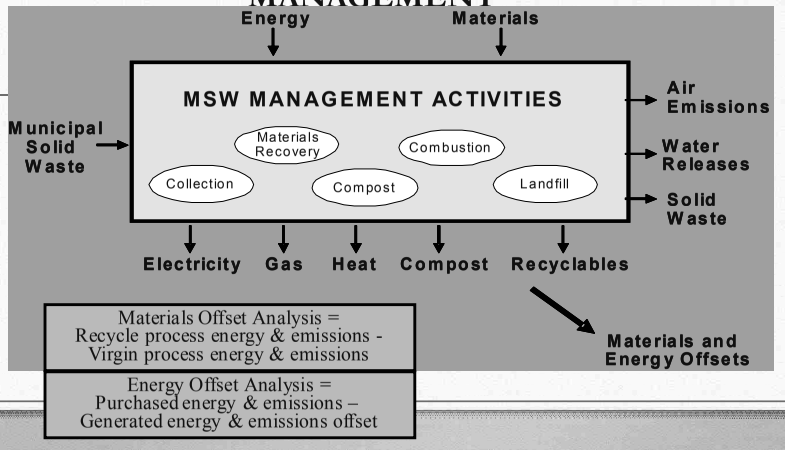
WASTE REDUCTION



Solid Waste Management Principles for Sustainable Cities

- **Equity** for all citizens to have access to waste management systems for public health reasons
- **Effectiveness** of the waste management system to safely remove the waste
- **Efficiency** to maximize benefits, minimize costs, and optimize the use of resources
- **Sustainability** of the system from a technical, environmental, social (cultural), economic, financial, institutional, and political perspective

SUSTAINABLE MUNICIPAL WASTE MANAGEMENT



ENHANCING FINANCIAL SUSTAINABILITY IN MSWM

(i) Improved fee collection efficiency by linking the fees of solid waste collection to water supply

(ii) Increasing the value chain by sales of organic waste recycling products

(iii) Diversifying revenue streams and financing mechanisms (polluter-pays-, cross-subsidy- and business-principles)

(iv) Cost reduction and improved cost-effectiveness.

Research on Landfills

- ENERGY ESTIMATION FROM LANDFILL
- POCKETS OF RESEARCH
- RESEARCH GAPS

How Can We fill the GAP Together?

1. Characterization of solid waste in a comprehensive way
2. Urbanization and lack of funding
3. Implementation of rules at ground level
4. Financial auditing
5. Appropriate technological solution using expertise
6. Failure of waste to energy projects
7. Involvement of organized sectors
8. Development of sustainable landfills for smart cities

THANK YOU!

Brief Observation of MSW Landfills in Bali, Indonesia

The 17th Expert Meeting on Solid Waste Management in Asia and Pacific Islands (SWAPI)

Tokyo 17-19 Januari 2017

Enri Damanhuri and I Made Wahyu Widyarsana
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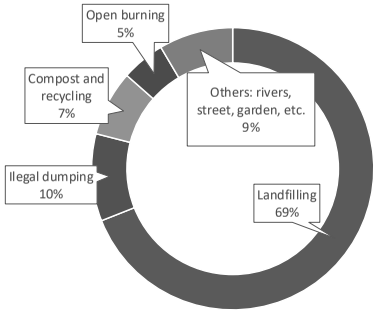
Faculty of Civil and Environmental Engineering – ITB
Jalan Ganesa 10, Bandung 40132, Indonesia

Outline:

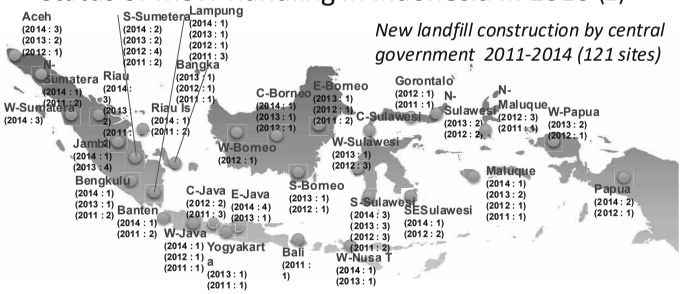
- MSW Landfilling status in Indonesia
- Staging in landfill development
- Some criteria of landfill design
- The obstacles
- Brief observation of landfill sites in Bali

Status of MSW handling in Indonesia in 2016 (1)

(Min. Env. Forest, 2016)



Status of MSW handling in Indonesia in 2016 (2)



New landfill construction by central government 2011-2014 (121 sites)

(Putra, 2016 based on Profile Book of Landfill of Min PW, 2014)

- *In average per-year: 30-40 new landfills site (1-2 Ha) are developed in small-medium cities by Central Government since 2008*
- *In 2016: 32 new landfill sites have been constructed*
- *Cost per-Ha: JPY 38,500,000-44,500,000 (in Java) → twice in remote area (such as in Maluques islands, Papua).*
- *Plus another JPY 27,500,000 for leachate treatment*

Status of MSW handling in Indonesia in 2016 (3)

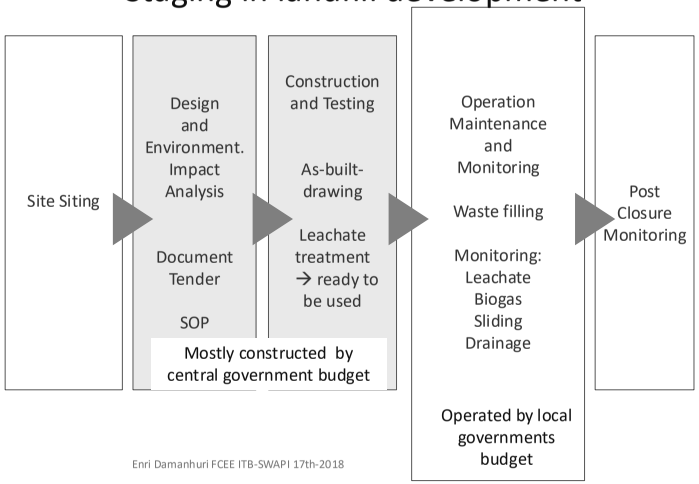
(Min. Env. Forest, 2016)

The landfills: mostly constructed by central government, and operated by local government (with their own budgets)

Landfill monitoring from 355 districts/cities:

- 45% of landfills (at 161 districs/cities): still open dumping
- 55% of landfills (at 194 districts/cities): sanitary landfill, and mostly only 'controlled landfill'
- 29 landfills: with gas capture have distributed the gas to community near the site.

Staging in landfill development



Utilities in landfill site

PRINCIPAL FACILITIES

- Waste registration room
- Landfilling (cells) area
- Operational road
- Embankment – for cell dividers
- Liner system
- Leachate collection and treatment
- Gasbio venting
- Surface water drainage
- Groundwater monitoring wells
- Loading and unloading area

Utilities in landfill site

OPERATIONAL FACILITIES

- Heavy equipment: dozer, loader, exavator
- Weight scale
- Communication devices
- Safety equipment and fire-extinguisher
- Operational vehicles
- Laboratorium

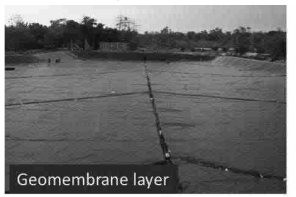
GENERAL FACILITIES

- Fences and gate
- Access road
- Office, garage, parking lot
- Site surface drainage
- Washing truck
- Water supply and electricity

Some Criteria of Simple MSW Landfill in Indonesia

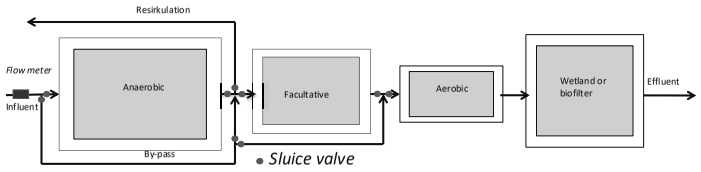
Component of landfill	Criteria
Access	All weather access road to landfill site and optional temporary roads to unloading areas
Land areas	a minimum of 5 – 7 years to hold the MSW. Area for buffers zone should be included
Landfilling method	Vary with terrain condition. Open dumping method is not allowable
Liner system	- in location where there is no groundwater or the groundwater more than 3.00 m in depth, the original compacted soil will be used as liner. - In location where there is a possibility of groundwater pollution, a single compacted clay liner of 0.25 m (< 1 x 10 $^{-7}$ cm/sec) will be applied as liner system. - In location where groundwater level is low or in low land area (swamp areas), a special liner such as geomembrane liner should be used. - Protective soil layer (gravel layer) : optional
Soil cover	Delaying the application of the covering layer of soil to once every 5-7 days
Leachate management	- Lechate collection by terraces soil grading to the point of collection - Anaerobic and aerobic ponds combined with simple landtreatment - Leachate recirculation into landfill cells is highly recommended
Surface water drainage	Simple surface drainage to keep away the surface water from the landfill
Monitoring well	At least 2 units at the up-and downstream of the groundwater flow
Biogas venting	Simple gravel gas well layer to evacuate the gas
Weight bridge	Optional
Heavy equipment	Track dozer and loader are recommended

Utilities in landfill site: liner system



Leachate treatment

Leachate management for small-medium cities	- Simple leachate treatment (lagoon system) is applied: anaerobic, facultative and aerobic ponds, combined with simple wetland; - Leachate recirculation into landfill cells is highly recommended.



The obstacle

The principal obstacle is the limitation of budget of many local governments to operate their landfill properly:

Routine cover material:

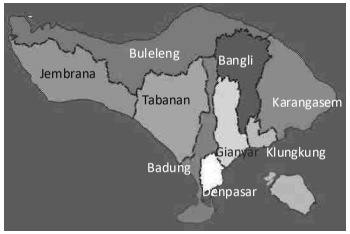
- Criteria of a good sanitary landfill: distributing the wastes layer by layer, compacted, covered with a soil layer by the end of the operation day (daily soil cover);
- Fact: daily cover criteria is not achievable by most local governments, mostly due to the limited budget;
- General (Indonesia) standard for soil cover 15-20 cm:
  - Sanitary landfill: daily, every 1.5-2.0 m of 'dumping' height.
  - Controlled landfill: between 1-3 weeks, after 5,0 m of dumping height.

Leachate treatment

Leachate pollution:

- Is the most negative issue in landfill application;
- Most of leachate teratment facility: not operated properly;
- Low responsibility and awareness: no budget to monitor, and no skill-operator to operate;

MSW Generation in Bali



No	District/City	Population	Waste Generation	Input to Landfill
			tpd	tpd
1	Jembrana	343,929	133	79
2	Tabanan	435,900	187	122
3	Buleleng	641,290	270	102
4	Bangli	223,800	70	24
5	Karangasem	471,820	189	90
6	Klungkung	231,430	89	77
7	Gianyar	499,043	213	104
8	Badung	630,000	310	227
9	Denpasar	863,400	462	315
TOTAL	BALI	4,340,612	1,924	1,141

Location of Landfills in Bali

The landfill sites (TPA) in Bali:

1. Peh - Jembrana district
2. Mandung - Tabanan district
3. Bengkala - Buleleng district
4. Bangklet - Bangli district
5. Linggasana - Karangasem district

6a. Sente (inland area of Klungkung),

6b. Jungut and Biaung (in Nusa Penida)

7. TPA Temesi - Gianyar distric
8. TPA regional Suwung - Badung district and Denpasar city

JEMBRANA REGENCY 1

No	Description	Data
1	Name of final disposal	**PEH Landfill**
2	Location of final disposal	Kaliakah village
3	Geographical overview	Flat
4	Volume of waste to landfill	180 m3/d (79 tpd)
5	Final disposal area • Has been operated • Has not been operated yet	3 Ha 2 Ha 1 Ha
6	Distance from center of city	12 km
7	Distance from the closest settlement	1 km
8	Operational System	Open-dumping
9	Leachate treatment facility	Available
10	Equipments in final disposal : • Truck Loader • Dump Truck	 1 unit 6 units

Description :

- Tabanan City
- Landfill Location

2 TABANAN DISTRICT

No	Description	Data
1	Name of final disposal	MANDUNG Landfill Regional SUWUNG
2	Location of final disposal	Sembung Gede Village,
3	Geographical overview	Flat
4	Volume of waste to landfill	258 m3/d (122 tpd)
5	Final disposal area • Has been operated • Has not been operated yet	2,25 Ha 2,25 Ha
6	Distance from center of city	7 km
7	Distance from the closest settlement	1 km
8	Operational system	Open-dumping
9	Leachate treatment facility	Available
10	Equipments in final disposal : • Wheel loader • Bulldozer	 1 unit 1 unit

Description :

- Singaraja City
- Landfill Location

3 BULELENG DISTRICT

No	Description	Data
1	Name of final disposal	**BENGKALA Landfill**
2	Location of final disposal	Bengkala village
3	Geographical overview	Valley + mainland
4	Volume of waste to landfill	371 m3/d (102 tpd)
5	Final Disposal Area • Has been operated • Has not been operated yet	4.84 Ha 4.84 Ha -
6	Distance from center of city	12 km
7	Distance from the closest settlement	1 km
8	Operational system	Semi controlled landfill
9	Leachate treatment facility	Available, but does not work
10	Equipments in final disposal : • Excavator • Bulldozer	 1 unit 2 units

2nd REGIONAL LANDFILL in Bali Province

Description :

- Bangli City
- Landfill Location

4 BANGLI DISTRICT

No	Description	Data
1	Name of final disposal	**BANGKLET Landfill**
2	Location of final disposal	Bangklet village
3	Geographical overview	Valley + cliff
4	Volume of waste to landfill	225 m3/d (24 tpd)
5	Final disposal area • Has been operated • Has not been operated yet	6.19 Ha 1.89 Ha 4.3 Ha
6	Distance from center of city	12 km
7	Distance from the closest settlement	0.5 km
8	Operational system	Open dumping
9	Leachate treatment facility	Available, but does not work
10	Equipments in final disposal : • Excavator	 1 unit

- The first landfill with HDPE geomembrane liner
- Designed for regional: Bangli, Klungkung, Gianyar and Karangasem Districts – but only served for Bangli district

Description :

- Amlapura
- Landfill Location

5 KARANGASEM DISTRICT

No	Description	Data
1	Name of final disposal	**TPA Linggasana** TPA Regional Bangklet
2	Location of final disposal	Linggasana village
3	Geographical overview	Valley
4	Volume of waste to landfill	155 m3/d (90 tpd)
5	Final disposal area • Has been operated • Has not been operated yet	2.195 Ha 0.7 Ha 1.495 Ha
6	Distance from center of city	10 km
7	Distance from the closest settlement	3 km
8	Operational system	Open dumping
9	Leachate treatment facility	Available
10	Equipments in final disposal : • Wheel loader • Bulldozer	 1 unit 2 units

Description :

- Semarapura City
- Landfill Location

6 KLUNGKUNG DISTRICT

No	Description	Data
1	Name of final disposal	**TPA Sente** TPA Regional Bangklet
2	Location of final disposal	Sente village
3	Geographical overview	Valley
4	Volume of waste to landfill	180 m^3/d (77 tpd)
5	Final disposal area • Has been operated • Has not been operated yet	0.8 Ha 0.8 Ha -
6	Distance from center of city	7 km
7	Distance from the closest settlement	0.5 km
8	Operational System	Open dumping
9	Leachate treatment facility	Available, but does not work
10	Equipments in final disposal : • Bulldozer	 1 unit

Description :

- Gianyar City
- Landfill Location

7 GIANYAR DISTRICT

No	Description	Data
1	Name of final disposal	**TEMESI Landfill** Regional Suwung Regional Bangklet
2	Location of final disposal	Temesi village
3	Geographical overview	Valley
4	Volume of waste to landfill	420 m^3/d (104 tpd)
5	Final disposal area • Has been operated • Has not been operated yet	3.3 Ha 2 Ha 1.3 Ha
6	Distance from center of city	7 km
7	Distance from the closest settlement	2 km
8	Operational system	Open Dumping
9	Leachate treatment facility	Available
10	Equipments in final disposal : • Excavator • Bulldozer	 1 unit 1 unit

MSW Processing Facilities of Temesi Landfill

Frist step of construction (30 tonnes / day)

Solid waste segregation

Two shredders

Forced aeration with blower

Aeration ducting. Volume control with butterfly vales in each inlet

Crusher

Final product

Packaging

The development into 2400 m^2 (total 60 tons/day)

Leachate Treatment Plant of Temesi Landfill

APLAS-Bali 2012

Description :

- Mangupura City
- Landfill Location

8 BADUNG DISTRICT

Designed for regional: Denpasar, Badung, Gianyar and Tabanan – but only served for Badung district and Denpasar City

No	Description	Data
1	Name of final disposal	**Regional Suwung (SARBAGITA)**
2	Location of final disposal	Suwung village
3	Geographical overview	Beach + Mangrove Forest
4	Volume of waste to landfill	1,151 m^3/day = 225 tpd
5	Final disposal area • Has been operated • Has not been operated yet	22 Ha 22 Ha -
6	Distance from center of city	10 km
7	Distance from the closest settlement	1 km
8	Operational system	Open dumping
9	Leachate treatment facility	Available
10	Equipments in final disposal : • Truck Loader • Others (mini-truck, tank truck, etc)	 4 units 15 units

1st REGIONAL LANDFILL in Bali Province

Description :

- Denpasar City
- TPA Location

9 DENPASAR CITY

No	Description	Data
1	Name of Final disposal	**Regional Suwung (SARBAGITA)**
2	Location of final disposal	Suwung village
3	Geographical overview	Beach + mangrove Forest
4	Volume of waste to landfill	2,420 m^3 /day (315 tpd)
5	Final Disposal Area • Has been operated • Has not been operated yet	22 Ha 22 Ha -
6	Distance from center of city	7 km
7	Distance from the closest settlement	1 km
8	Operational System	Open dumping
9	Leachate treatment facility	Available, but does not work
10	Equipments in final disposal : • Wheel Loader •Truck Loader •Dump Truck •Excavator •Bulldozer	 2 units 1 unit 52 units 3 units 3 unit

LANDFILL REGIONAL SARBAGITA (Suwung)

Leachate treatment plant of Regional Suwung

Closing Remark

Accelerating the implementation of the sanitary landfill in Indonesia requires the commitment of all stakeholders (especially local governments) to jointly appropriate roles and abilities of each to contribute to realizing the goal of better landfill condition.

The information used in this presentation was partly taken from:

I Made Wahyu Widyarsana and Enri Damanhuri (2017): *Study of Waste Management in Bali Province as the Basic Recommendation Towards Bali Green and Clean (in Indonesian language), ITB-Press, ISBN 978-602-5417-57-3*

THANK YOU

17th Asia Pacific Ocean Waste Expert Meeting

SWAPI

Optimization of nitrous oxide in Aerobic and Aerobic-Anaerobic Landfill Method with leachate recirculation conditions on MSW degradation

Mitali Nag and Takayuki Shimaoka

Department of Urban and Environmental Engineering
Faculty of Engineering, Kyushu university, Japan

Introduction

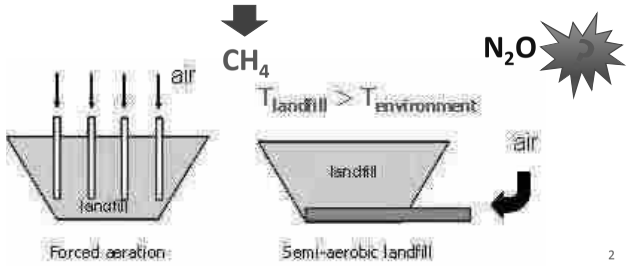
Creation of sustainable landfills by in-situ aeration is an effective technique

Aims:

- Reduction of methane emissions
- Creation of environmentally compliant landfills
- Shortening of landfill aftercare

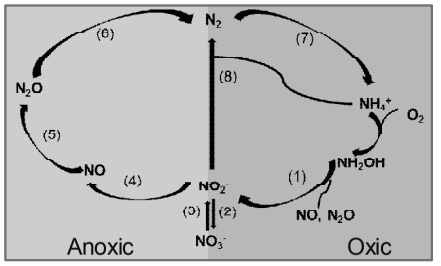
Concepts:

- In-situ aeration of landfill with forced aeration (aerobic landfill)
- Natural convection aeration (semi-aerobic landfill)



- Nitrous oxide (N_2O) is a
  - powerful GHG
  - GWP 298 times (CO_2 100-year)
  - 7.9 % of the overall greenhouse effect
  - potent for destruction of the ozone layer
- Landfill aeration induce in-situ N removal, but impel N_2O emission.
- Formation of N_2O as a by-product from nitrification, or as an intermediate product of denitrification.
- Fluxes of N_2O higher in MSW landfill than others.

N_2O Generation Pathway



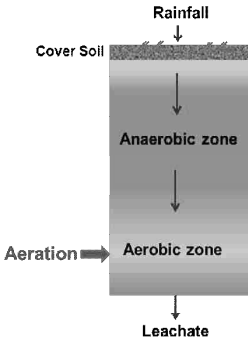
Kampschreur et al. 2009

(1) Aerobic ammonium oxidation
(2) Aerobic nitrite oxidation
(3) Nitrate reduction to nitrite
(4) Nitrite reduction to nitric oxide
(5) Nitric oxide reduction to nitrous oxide
(6) Nitrous oxide reduction to nitrogen gas
(7) Nitrogen fixation
(8) Ammonium oxidation with nitrite to nitrogen gas (Anammox)

Objectives

- Investigate the production potential of N_2O in aerobic and AALM (**A**erobic and **A**erobic-Anaerobic **L**andfill **M**ethod)
- Analysis the N_2O formation phenomenon with nitrogen transformation
- Optimize the GHG reduction by aeration with various leachate recirculation regime.

AALM: Intermittent aeration



Prospects and attainments

- GHGs attenuation
- Ammonia removal
- Enhanced waste stabilization
- Shorten perpetual aftercare
- Energy cost reduction

Nag et al. 2015, Waste Management, 55 (2016), 71–82

Aerobic-Anaerobic conditions are alternatively created by intermittent air injection

Experimental Design

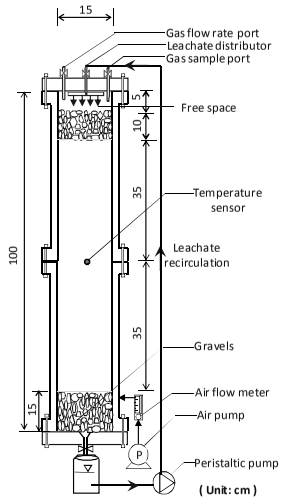


Fig.: Schematic diagram of experimental column reactor

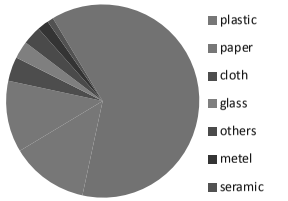


Fig.: Modified MSW composition

(source: World Bank 2013, in East Asia and Pacific region)

Aeration and leachate recirculation

Table 1 Operational condition

Parameters	Reactor A1R*	Reactor AA1R*	Reactor A2R*	Reactor AA2R*
Packing density (t/m^3)	0.50 (dry), 0.70 (wet)			
Volumetric ratios (m^3/m^3)	0.25 (solid), 0.35 (liquid), 0.40 (gas)			
Ambient temperature (°C)	30±5			
Duration of continuous **air injection** (h/day)	**24**	**8**	**24**	**8**
Air injection rate (l/kg DM h)	**1.6**		**4.8**	

* R: Recirculation leachate

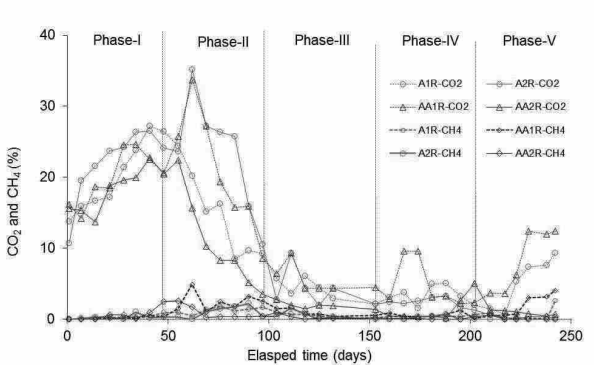
Aeration and leachate recirculation

Table 2 Leachate recirculation regime

Phase	Period (days)	Leachate (ml/week)	Water (ml/week)	Frequency (per week)	Moisture content (%)
Phase I	0 - 48	250	0	twice	60 - 70
Phase II	48 - 97	250	250	twice	70 - 90
Phase III	97 - 153	750	250	twice	90 - 100
Phase IV	153 - 202	200	0	twice	50 - 60
Phase V	202 - 242	100	0	twice	< 40

9

CO_2 and CH_4



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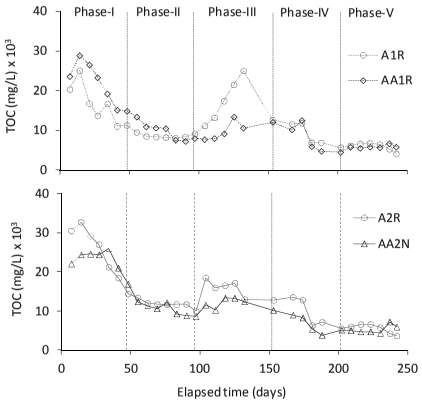
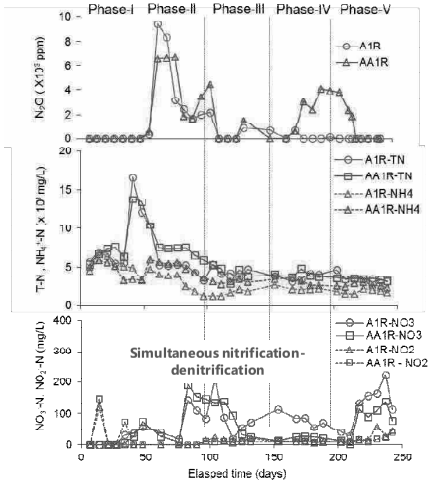
Total organic carbon (TOC)

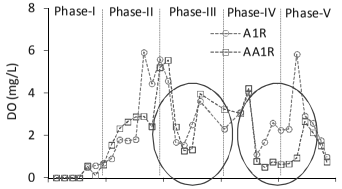


11

N-transformation and N_2O formation

Aeration rate: 1.6 l/kg-DM/h

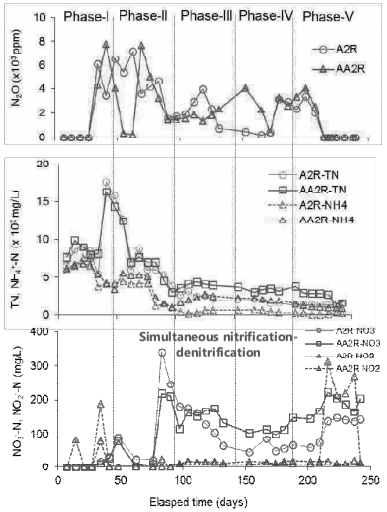


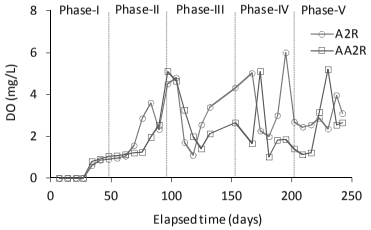


12

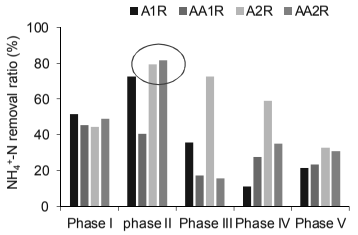
N-transformation and N_2O formation

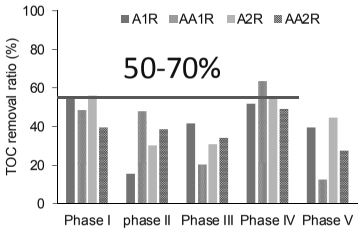
Aeration rate: 4.8 l/kg-DM/h



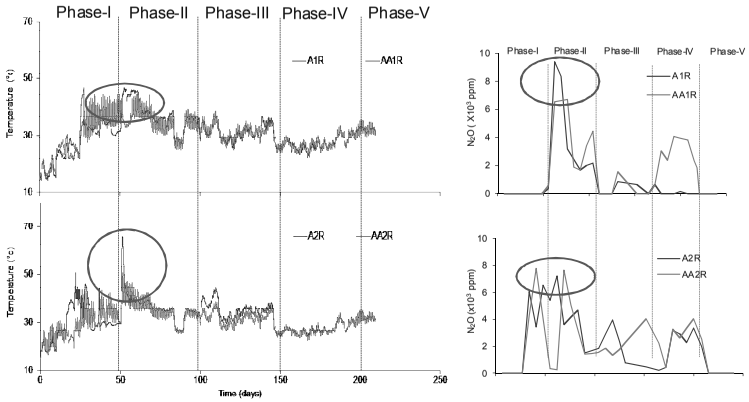


Removal efficiency

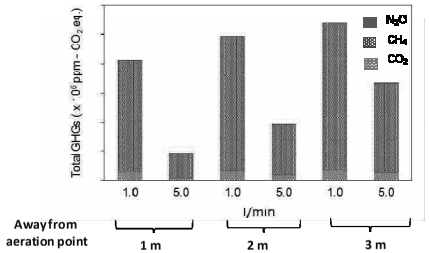


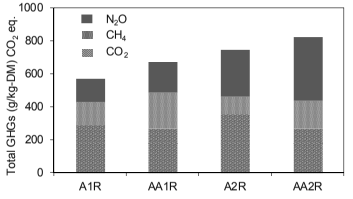


Temperature & N_2O



Evaluation of total GHG emission





- In-situ aeration in Chongming Landfill (7 yrs. old)
- Kitchen Waste: ~20%
- Organic carbon content: ~15%

Nag et al. 2015, J of A&WMA, 66:3, 280-287

- Waste type: MSW with fresh food waste
- Food Waste: 62%
- Organic carbon content: 43%, T-N content: 2.3%

Findings:
- N_2O production correlates with **temp.** (35-50°C) and with **high O_2 conc.**.
- *In-situ* aeration in MSW landfill is effective way for GHGs reduction.

Findings:
- N_2O production is correlates with **temp.** and **O_2 conc.** that stimulated the nitrification process.
- Initial high NH_4^+-N conc. is the initial substrate for N_2O production in earlier biodegradation.

Conclusions

- Aerobic and AALM accelerate the degradation of organic matter as well as **NH_4^+-N removal and diminishing CH_4 conc.**
- However, **N_2O is obvious by aeration** as it stimulate the process of simultaneous nitrification-denitrification process.
- **Initial high NH_4^+-N is the initial substrate** for N_2O in both Aerobic and AALM.
- Leachate recirculation with additional nutrients might also effects N_2O production.
- **Dry condition is potential for N_2O production**; optimization of moisture content is important.
- Consideration the global warning potential of N_2O, aeration technique might **feasible in old landfill after energy recovery** rather than new waste emplace in landfill.

Thank you for your kind attention!

The 17th Expert Meeting on SWAPI

使用言語 英語 Language English

参加費無料 Free of Charge

第17回　アジア太平洋廃棄物専門家会議

The 17th Expert Meeting on Solid Waste Management in Asia and Pacific Islands

2018.1.17▸1.19

会場 Venue　**砂防会館別館３階　六甲 Sabo Hall (Schönbach Sabô) 3F**

主催者 Organizers　アジア太平洋廃棄物専門家会議 Society of Solid Waste Management Experts in Asia and Pacific Islands(SWAPI)
廃棄物資源循環学会 Japan Society of Material Cycles and Waste Management (JSMCWM)

本会議は、アジア・太平洋諸島地域における廃棄物の適正処理と３Ｒを推進するための専門家ネットワークの形成を目的として、各国・地域の専門家を招聘して、 環境省の環境研究総合推進費のもと毎年開催しています。
自治体、企業、研究者の皆様など幅広い方々のご来場をお待ちしております。
Expert meeting on Solid Waste Management in Asia and Pacific Islands has been held every year since 2005 supported by the Environment Research and Technology Development Fund, Ministry of the Environment, Japan for formation of networks between experts to facilitate proper waste management and 3R in Asia and Pacific Islands region. We would highly appreciate for your active participation in this meeting!

1/17 Wed

企画セッションⅠ　アジア太平洋地域の災害廃棄物処理
Special Session I　Theme: Moving on to the next stage for Disaster Waste Management in Asia and the Pacific

1/18 Thu

平成２９年度循環型社会形成推進研究発表会
Presentation of Research Projects promoted by the Environment Research and Technology Development Fund by MOE, Japan
国際的な循環型社会の構築に向けた研究成果の発信

企画セッションⅡ　PPP手法による公共事業（ごみ発電）発注入札管理の在り方
Special Session II　Theme: Waste to Energy (WtE) Bidding Process

1/19 Fri

企画セッションⅢ　廃棄物処理のための埋立処分
Special Session III　Theme: Landfill Disposal for Solid Waste Management

※上記の情報は12月現在のものです。

運営事務局 Secretariat

一般財団法人日本環境衛生センター　総局　国際事業部
International Cooperation and Business Department, Japan Environmental Sanitation Center
〒210-0828 神奈川県川崎市川崎区四谷上町10-6 /10-6 Yotsuya-kamicho, Kawasaki-ku, Kawasaki City
TEL : 044-288-4937 / FAX : 044-288-5217 Email : kokusai@jesc.or.jp Website : http://www.jesc.or.jp/

❖ プログラム Program

1/17 (Wed) 13:30-16:30
企画セッション I Special Session I
アジア太平洋地域の災害廃棄物処理
Moving on to the next stage for Disaster Waste Management in Asia and the Pacific

ファシリテーター Facilitator 酒井 伸一 (京都大学) Prof. Shinichi Sakai (Kyoto University)

講演者 Speakers
小岩 真之 (環境省) Mr. Masayuki Koiwa (Ministry of the Environment, Japan)
Ms. Vicki Hall (Secretariat of the Pacific Regional Environment Programme)
ASEAN Secretariat (Environment Division)
浅利 美鈴 (京都大学) Dr. Misuzu Asari (Kyoto University)
築地 淳 (廃棄物資源循環学会) Mr. Makoto Tsukiji (JSMCWM)

1/18 (Thu) 10:00-12:00
平成２９年度循環型社会形成推進研究発表会
Presentation of Research Projects promoted by the Environment Research and Technology Development Fund by MOE, Japan

ファシリテーター Facilitator 藤吉 秀昭 (日本環境衛生センター) Dr. Hideaki Fujiyoshi (JESC)

講演者 Speakers
浅利 美鈴 (京都大学) Dr. Misuzu Asari (Kyoto University)
高橋 史武 (東京工業大学) Dr. Fumitake Takahashi (Tokyo Institute of Technology)
寺園 淳 (国立環境研究所) Dr. Atsushi Terazono (National Institute for Environmental Studies)

1/18 (Thu) 13:30-16:30
企画セッション II Special Session II
PPP手法による公共事業（ごみ発電）発注入札管理の在り方
Waste to Energy (WtE) Bidding Process

ファシリテーター Facilitator 山本 誠 (日本環境衛生センター) Mr. Makoto Yamamoto (JESC)

講演者 Speakers
藤吉 秀昭 (日本環境衛生センター) Dr. Hideaki Fujiyoshi (JESC)
Prof. Agamuthu Pariatamby (University of Malaya, Malaysia)
Prof. Enri Damanhuri (Institute of Technology Bandung, Indonesia)
Dr. Orawan Siriratpiriya (Chulalongkorn University, Thailand)

1/19 (Fri) 9:30-12:30
企画セッションIII Special Session III
廃棄物処理の為の埋立処分
Landfill Disposal for Solid Waste Management

ファシリテーター Facilitator 田中 勝 (SWAPI会長/公立鳥取環境大学)
Prof. Masaru Tanaka (President of SWAPI / Tottori University of Environmental Studies)

講演者 Speakers
松藤 康司 (福岡大学) Prof. Yasushi Matsufuji (Fukuoka University)
Prof. B.F.A. Basnayake (University of Peradeniya, Sri Lanka)
Prof. Yong Feng Nie (Tsinghua University, China)
Prof. Enri Damanhuri (Institute of Technology Bandung, Indonesia)

※上記の情報は12月現在のものです。

❖ 開催概要 Outline

会場 Venue 砂防会館別館会議室3F 六甲
Sabo Hall (Schönbach Sabô) 3F

主催者 Organizers アジア太平洋廃棄物専門家会議
Society of Solid Waste Management Experts in Asia and Pacific Islands(SWAPI)

廃棄物資源循環学会
Japan Society of Material Cycles and Waste Management (JSMCWM)

使用言語 Language 英語 (日本語同時通訳はございません)
English (No simultaneous translation will be provided)

参加費 Registration Fee 無料
Free of Charge

参加申込 Registration 下記のURLより、参加申込を受け付けております。
Please register for participation at the website below;
www.jesc.or.jp/work/tabid/286/Default.aspx

❖ 会場アクセス Access

東京都千代田区平河町2-7-4
2-7-4 Hirakawa-cho, Chiyoda-ku, Tokyo