

# ISWA Beacon Conference on Sustainable Landfills

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# Anaerobic and Aerobic Landfills

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# Landfills

- › On impermeable layer
- › Compacted in order to decrease waste volume
- › Covered periodically

# Landfills (cont.)

- › Leachate formation
- › Soil pollution
- › Water and groundwater pollution
- › Environmental problems

# Composition of Leachate

- › Volatile fatty acids, causing high COD values
- › High concentration of ammonium-N
- › High pH
- › Color

***Treatment should be applied***

# End-products of Anaerobic Decomposition at Landfills

- › Biogas
- › CO<sub>2</sub> and CH<sub>4</sub>
- › Biogas converted to heat and electricity

# End-products of Anaerobic Decomposition at Landfills (cont.)

- › Waste converted to methane phase in short time,
- › Organics are converted to gas phase,
- › Leachate contains less organic material

# Leachate Treatment

- › Decreases the expenses
- › Increases biogas production
- › Economic

# Composition of Domestic Waste

- › 50% cellulose
- › 15% lignine
- › 10% hemicellulose
- › 5% protein
- › Some starch and pectin
- › CO<sub>2</sub> formation by chemical oxidation

# Chemoorganotroph

- › Active microorganism
- › More energy produced by redox reactions
- › Microorganisms use some of the energy
- › Adenosin trifosfat - ATP

# Mechanism summarized as...

- › No need for energy source
- › Reactions yielding more energy are preferred
  - Primarily oxygen, then nitrate, manganese, iron and sulphate oxidation
  - Afterwards, methanogenesis reactions by fermentation
- › Produced energy is excess for ATP formation

# Aerobic Systems in Landfills

## Aims:

- Accelerate waste stabilization
- Decrease pollutant and methane formation by leachate
- Suitable air/oxygen ratio and humidity
- Faster than anaerobic systems

# Aerobic Systems in Landfills (cont.)

By leachate recycling:

- › Faster decomposition
- › Nutrient and humidity for bacteria

# Acceleration of Biological Decomposition of Organics

- › Acceleration of waste stabilization
- › Increase in biomass
- › Acceleration in hydrolysis capacity of cellulosic materials by microorganisms
- › Decrease in methane production
- › Decrease in long term environmental effects
- › Decrease in landfill closure and monitoring costs

# Application – Japan

## Example of Aerobic Landfill:

- Semi-aerobic landfill
  
- Air is given by the leachate collection system
  - Waste/environment temperature – high
  - Chimney effect – low
  
- Air is dispersed in waste when drawn to the pipes

# Application – Japan (cont.)

System enables:

- › Decrease in amount of waste
- › Increase in density
- › Improvement of leachate quality
  
- › Injection of leachate to waste
  - Waste stays humid
  - Hence, accelerating decomposition

# Application – Japan (cont.)

Landfill design:

- › Leachate collection-recycling system
- › Gas collection
- › Management

# Application – Japan (cont.)

Stabilized wastes after decomposition:

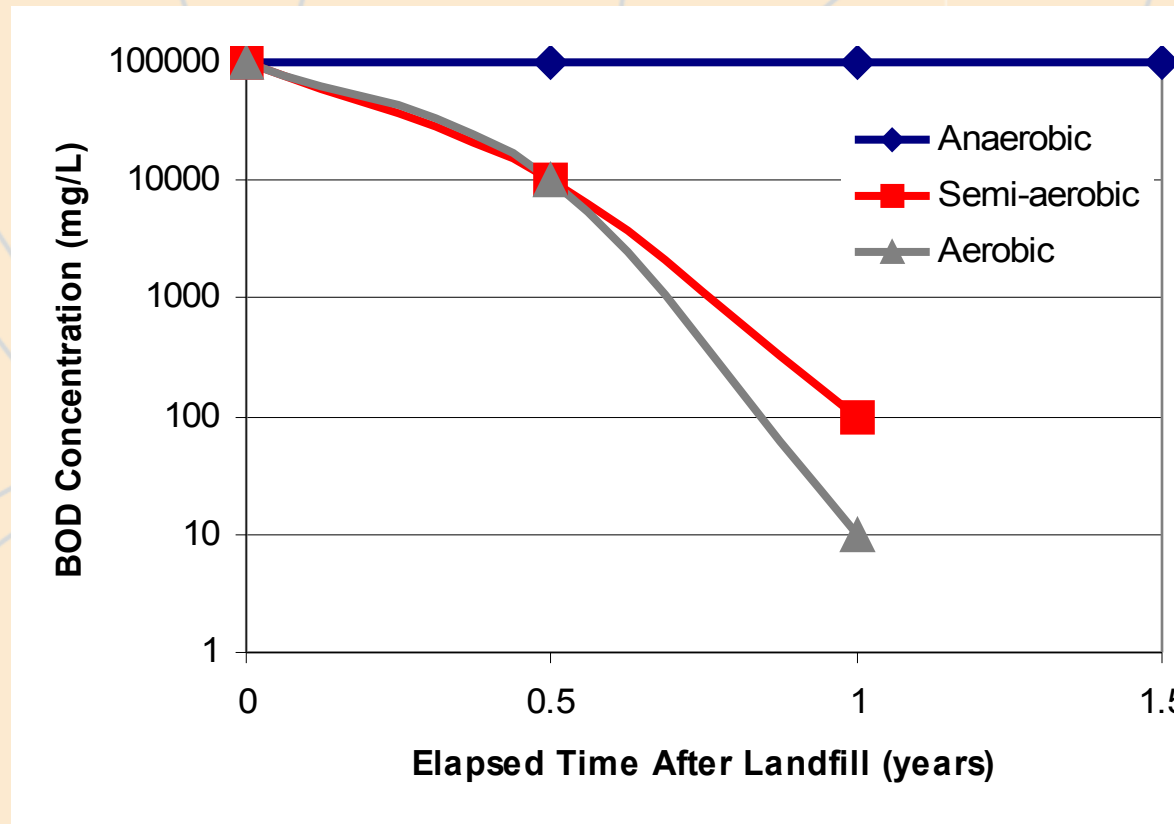
- › For cover and final cover
- › Landscape planning

# Application – Japan (cont.)

By recycling of leachate:

- Landfill also acts as treatment plant
- Pollutants in leachate decreases
  - Toluene
  - Vinylchloride
  - Ammonia
- Decrease in the need for leachate treatment

# Application – Japan (cont.)



Results of the study conducted by Fukuoka

*Waste Wise With ISWA*

# Application – USA

- › 2 landfills are converted to aerobic landfills

## System:

- › Vertical air injection chimneys within waste
  - Air is given by blowers or compressors

# Application – USA (cont.)

## Landfill 1

- › Leachate collection system (present)
- › Air injected through the leachate collection system

## Landfill 2

- › No leachate collection system
- › Air injected through horizontal and/or vertical air chimneys
- › Leachate collected at the tank is pumped on top of waste

# Application – USA (cont.)

In both applications, leachate is injected to

- main cover material (sludge)
- waste

Air and leachate pumping rate adjusted for

- › Optimum waste temperature, and
- › Optimum humidity

# Application – USA (cont.)

If not adjusted correctly;

- › Waste temperature increases
- › Efficiency decreases
  
- › Leachate that is not used drains
  - To the collection system, and
  - Pumped to collection tank and onto the wastes

# Application – USA (cont.)

In order to achieve the optimum conditions the process is examined for 2-5 months.

Examined parameters:

- › Humidity
- › Temperature
- › Gas concentrations (VOCs, CO<sub>2</sub>, O<sub>2</sub>, CH<sub>4</sub>)
- › BOD of leachate
- › Metal concentrations

# Application – USA (cont.)

- › Operators need to spend a lot of time
- › Use of automation system decreases the time spent by operators

# Application – USA (cont.)

Design Parameters	Landfill 1	Landfill 2
Cell capacity	1.6	1.0
Average waste depth	3.0	10.0
Total waste volume (m <sup>3</sup> )	45.2	49.0
Age of the waste at the beginning of the research (month)	18.0	36.0
Injection rate of leachate (L/day)	13.6	25.2
Total amount of injected leachate (L)	> 7 000 000	6 676 200
Air injection rate (m <sup>3</sup> /min)	56.0	100.0
Research period (month)	18	9
Annual rainfall (cm/year)	137.0	114.0

# Application – USA (cont.)

Parameter	Landfill 1	Landfill 2
Biological decomposition rate <sup>a</sup>	50% increase	110% increase (from 0.167 to 0.351 mg O <sub>2</sub> /hr)
Settlement of municipal waste (m/m) <sup>b</sup>	9% max (23 cm) 4.5% average	10% max (30 cm)
Methane generation <sup>c</sup>	50-90% decrease	50-90% decrease
Leachate BOD	70% decrease (1100-300 ppm) (3 months)	70% decrease
VOCs in leachate	75-99% decrease <sup>d,e</sup>	50% decrease
Odor	Decrease	Some successful observations
Removal of waste from landfill area	Some of the waste was removed	Compost generated was used as cover material
Leachate volume	86% decrease	50% decrease

a: CO<sub>2</sub> generation, O<sub>2</sub> use and waste temperature is taken into consideration  
 b: Future formations considered according to physical studies  
 c: 70-90% at areas closer to air injection points  
 d: 75-90% decrease in iron concentration, lead decreased to original value  
 e: toluene, acetone, etc.

# Proposed Methodology

## Anaerobic Landfill → Aerobic Landfill

- › Covering the waste
- › Increasing the humidity of waste
  - 40% → 70%
- › Air/oxygen injection to waste

# Proposed Methodology (cont.)

## Air injection to wastes

- fulfills aerobic conditions
- enables temperature control
- kills anaerobic microorganisms

## For pathogens to die

- Temperature should be held at high levels for some time
- For aerobic degradation, temperature 55-68°C

## Different combinations enables aerobic degradation

- O<sub>2</sub> concentration
- Humidity
- Temperature

# Proposed Methodology (cont.)

## Humidity

- › One of the most important parameters
- › Optimum humidity: 60%
- › Below 40%: degradation slows down
- › Below 20% degradation stops

# Proposed Methodology (cont.)

## Temperature

- › Best range for aerobic degradation: 55-68°C
- › Pathogenic microorganisms die at 57°C

# Proposed Methodology (cont.)

Increase in waste temperature, even if air injection rate increases:

- › Stabilization achieved
- › Waste composted
- › No need to monitor the formations in the landfill

# Proposed Methodology (cont.)

Methane < 10% → Aerobic conditions

Methane ~ 50% → Anaerobic conditions

# Proposed Methodology (cont.)

In order to sustain aerobic conditions

- › Nitrogen, carbon and phosphorus injection
  - Increasing microorganism population

Optimum C:N ratio is between

**20:1 – 50:1**

# Conclusion

- › Aerobic Landfills – Economic

## Economic benefits:

- › Increase lifetime of landfills
- › Decrease leachate and pollutants
- › Decrease methane generation
- › Decrease closure and rehabilitation expenses
- › Decrease negative environmental effects

# Thank You

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