

The 13th International Conference on Waste Management and Technology (ICWMT)  
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**Sustainable Landfill Technologies**  
**—From the Consideration of Cleaner Production and CSR**

可持續填埋技術  
—由清潔生產與企業社會責任的思維



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 **Outline 大綱**

- 1 Origin
- 2 Environmental sustainability
- 3 Economic sustainability
- 4 Social sustainability
- 5 Conclusions

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 **Origin 緣起**

 **Origin 緣起**

@ Resource recovery and reuse satisfied the circulation society principle at present and in the future

**Zero Waste**

- Material Recovery
- Energy Recovery
- Technology Feasibility
- Economic Feasibility
- Environmental Feasibility
- Air Pollution/Dioxins, PM<sub>2.5</sub>
- Carbon Emission
- Fly Ash and Bottom Ash

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**Origin 緣起**

- landfilling still been proceeding around the world even though in the developed countries,
- there are many closed landfill site should be take care carefully for 1 or 2 decades.
- How to manage a closed landfill site



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**Origin 緣起**

- In addition, the concept of urban mining has been pay attention to recovery precious materials from old landfill site.
- How to re-birth an old landfill to dig out the precious materials?



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**Origin 緣起**

- To avoid the negative impression, the concept of **sustainable development** should be considered.



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**Environmental sustainability**



Environmental sustainability

### Sanitary Landfilling

<b>Physical reactions</b>	<ul style="list-style-type: none"> <li>• Particle breakdown</li> <li>• Pollutants flow-out by leachate</li> <li>• <b>Biogas</b> eject as bio-energy</li> </ul>
<b>Chemical reactions</b>	<ul style="list-style-type: none"> <li>• <b>Heavy metals</b> adsorption by soil / complexation with humus / stabilization by sulfide</li> <li>• <b>Pathogens</b> destroyed by itself</li> </ul>
<b>Biological reactions</b>	<ul style="list-style-type: none"> <li>• <b>Thermophilic anaerobic fermentation</b></li> <li>• <b>Anaerobic dehalogenation</b></li> <li>• <b>Biogas</b> production</li> <li>• <b>Humus</b> production</li> </ul>

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Environmental sustainability

❖ a perfect planning and design should concern deeply about the technical, economic, and environmental feasibility at same time

**technical feasibility**

**economic, feasibility**

**environmental feasibility**

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Environmental sustainability

<b>Planning</b>	<ul style="list-style-type: none"> <li>• <b>Siting</b></li> <li>• <b>Semi-aerobic vs anaerobic</b></li> <li>• <b>Final use of the site</b></li> </ul>
<b>Design</b>	<ul style="list-style-type: none"> <li>• <b>Liner</b></li> <li>• <b>Leachate treatment system</b></li> <li>• <b>Slop protection</b></li> <li>• <b>Gas collection system</b></li> </ul>
<b>O &amp; M</b>	<ul style="list-style-type: none"> <li>• <b>Cell construction</b></li> <li>• <b>Cover soil material</b></li> <li>• <b>Leachate recirculation</b></li> </ul>

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Environmental sustainability

### Environmental Impact Assessment

<b>Natural Factors</b>	<ul style="list-style-type: none"> <li>• <b>Geology</b></li> <li>• <b>Topography</b></li> <li>• <b>Watershed</b></li> </ul>	
<b>Environ Factors</b>	<ul style="list-style-type: none"> <li>• <b>Receiving water</b></li> <li>• <b>Air quality</b></li> <li>• <b>Ecology</b></li> </ul>	
<b>Economic Factors</b>	<ul style="list-style-type: none"> <li>• <b>Construction</b></li> <li>• <b>Final use</b></li> <li>• <b>Land-value</b></li> </ul>	
<b>Social Factors</b>	<ul style="list-style-type: none"> <li>• <b>Land use</b></li> <li>• <b>Public health</b></li> <li>• <b>Population</b></li> </ul>	

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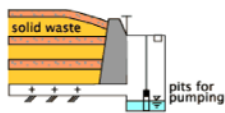
**Environmental sustainability**

@ the difference among anaerobic sanitary landfilling, semi-aerobic landfilling and secured landfilling.

**Anaerobic Landfill**  
Biogas production



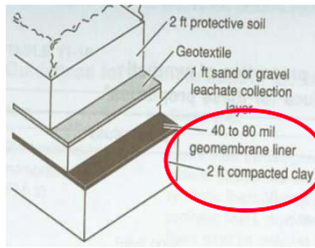
**Semi-aerobic Landfill**  
No air pollution  
Good leachate quality  
Rapid stabilization



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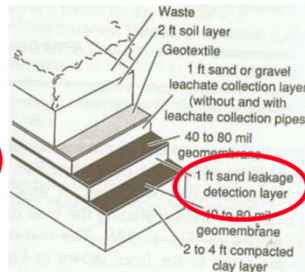
**Environmental sustainability**

**Single Liner**



**Composite Liner**

**Double Liner**



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**Design—Leachate Treatment System**

Discharge to Sewer: Legal, but Unreasonable, no any effect except dilution.

Biological → Coagulation Flocculation → Indirect Electro-oxidation → Carbon Adsorption

Biological → Two-stage Fenton ( $\text{FeSO}_4 + \text{H}_2\text{O}_2$ ) Coagulation/ precipitation/ oxidation → Carbon Adsorption

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**Environmental sustainability**

@ a good operation and maintenance to eliminate the pollution and hazard during the life span of the landfilling,



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**Design—Slop protection**

Gentle Slop

Multi-stage Retaining Wall

Protect the Slop Liner

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**O & M—Cell Construction**

Down-Push

Up-Push

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**O & M—Cover Soil**

Final Cover

Daily Cover

- Sludge
- Incinerator bottom ash
- Stabilized sludge

- Sandy soil
- Fine-grain steel smelting slag

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**O & M—Leachate recirculation**

Leachate recirculation	<ul style="list-style-type: none"> <li>● Evaporation</li> <li>● Bio-degradation</li> </ul>	
Spread on the landfill	<ul style="list-style-type: none"> <li>● Offensive smell</li> <li>● Surface runoff pollution</li> </ul>	✗
Anaerobic landfill	<ul style="list-style-type: none"> <li>● BOD decrease, but COD increase</li> </ul>	✗
Semi-aerobic landfill	<ul style="list-style-type: none"> <li>● Leachate quantity ↓</li> <li>● Leachate quality ↑</li> <li>● Maturation time ↓</li> </ul>	○

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**Environmental sustainability**

@ the ever exchanging characteristic of each pollutant should be considered

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**Design—Leachate Treatment System**

Ammonia Stripping	Anaerobic Treatment	Aerobic Treatment	Coagulation Flocculation	GAC or RO
$\text{NH}_4^+ + \text{OH}^- = \text{NH}_3(\text{g})$	Up-flow Anaerobic Sludge Blanket No any succeed case among 300 site	Unsuitable for old site BOD/COD < 0.1	Limited Effect	GAC expensive; RO Problem of the concentrate

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**Economic sustainability**

**Economic sustainability**

@ From the aspect of economic sustainability, the “Pollution Prevention Pays Principle” of cleaner production concepts should be induced in the system.

- Prevent**  
If you can't prevent, then...
- Re-use**  
If you can't re-use, then...
- Recycle**  
If you can't recycle, then...
- Recover other value**  
If you can't recover value, then...
- Dispose**  
Landfill if no alternative available.

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- ④ An **integrated MSW management system** on the selection and application of suitable techniques, technologies, and management programs to achieve specific waste management objectives and goals,
- ④ to keep the **balance** among source reduction, transformation and final disposal, and extending the consideration of landfill mining in the future.

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Functional Elements of a Waste Management System



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graph TD
    A[Waste Generation] --> B[Waste handling & separation, storage, & processing at the source]
    B --> C[Collection]
    B --> D[Transfer & Transport]
    B --> E[Separation, Processing, & Transformation]
    C --> F[Disposal]
    D --> F
    E --> F
  
```

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**Social sustainability**




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- ④ From the aspect of social sustainability, **corporate social responsibility (CSR)** should be emphasized,



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 **Social sustainability**

@ a self-regulatory mechanism whereby a business monitors and ensures its active compliance with not only the relative regulation, but also the **mercy ethical standards** and national or international norms, to the neighbors and the creatures of the environment.



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 **Social sustainability**

- Chinese Traditional Culture: **The Great Learning** or *Daxue* ([大學]) was one of the "Four Books ([四書])" in Confucianism.
- 大學之道 · 在明明德 · 在親民 · 在止於至善。

The way of great learning	大學之道	
consists in manifesting one's bright virtue	在明明德	Reality
consists in loving the people	在親民	Enviro. friendly
consists in stopping in perfect goodness	在止於至善	Sustain.


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 **Social sustainability**

A common approach to CSR is **corporate philanthropies**.

- ❖ Confucian principles:
  - Love all the people and creatures (仁民愛物).
- ❖ Buddhism principle:
  - Mercy and wisdom (慈悲與智慧)

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 **Social sustainability**

prevent the pollution and hazard

- ❖ In chaos theory, the **butterfly effect** (蝴蝶效應) is the sensitive dependence on initial conditions
- ❖ in which a **small change** in one state of a deterministic nonlinear system can result in **large differences** in a later state.

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reclaim the closed landfill site

- has become important to develop **land re-use** strategies for completed landfills.
- the most common usages are for **parks, golf courses** and other **sports fields**.
- **methane capture** is customarily carried out to minimize explosive hazard within the building.

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Conclusions



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© **Sustainable development**

- ❖ Environment
- ❖ Economic
- ❖ Social

© **Symbiosis with the biotic and abiotic in the environment**

- ❖ 天人合一



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**Thank you for your Attention**

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