USING GEOTEXTILE FILTER AS BIOFILM MEDIA IN ANAEROBIC LANDFILL BIOREACTOR

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The authors acknowledge; The Scientific and Technological Research Council of Turkey (TUBITAK Project No: 115Y299) and Gebze Technical University for supporting this study.
INTRODUCTION - Still Landfilling?.. 

• Landfill is a modern facility which is used for storing solid wastes in a specific engineered lands where MSWs do not create public health hazards.
• As we all know, landfilling or waste disposal is the most undesirable solid waste management method.
• It is at the bottom of integrated waste management (IWM) diagram.
• However, especially in many developing and undeveloped countries, landfill is a indispensable.
• Even in European Union, many countries has been using dominantly landfilling.
• In Turkey, situation is a bit different. Landfilling (including dumping) constitutes over 90% of waste management methods.
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Conventional landfill which is designed for storing solid wastes, can be considered as a ‘bioreactor’ by optimizing the stabilization process and creating the desired environment for microorganisms.

Considering landfills as bioreactor is a new and promising strategy. LBRs aim to accelerate the decomposition of solid wastes and many different techniques were used for this purpose such as leachate recirculation, supplemental water addition, waste compaction, alkalinity addition, and co-disposal of sewage sludge.

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INTRODUCTION - Geotextile Material

• Geotextiles are used in many types of infrastructure projects for filtration, separation, drainage, etc. in civil, geotechnical, and environmental engineering.

• Geotextile is a porous material which mainly use for protection of impermeable drainage layer (geomembrane) in landfill areas.

• Biomass formation in geotextiles has been discovered in 90s. After that some applications were executed with nonwoven geotextile filters in attached growth biologic wastewater treatment systems.

• In this study geotextile material was used as a biofilm media for improving leachate quality and increase system efficiency.
Two PVC reactor at 1 m height and 30 cm diameter was used to simulate anaerobic landfill bioreactors.

Reactor was equipped with several ports for collection and distribution of leachate and biogas.

The leachate was collected after passing through a specifically designed drainage layer where a geotextile fabric was replaced in second reactor.

**METHODOLOGY - Lab-Scale Anaerobic Tanks**
• Two PVC reactor at 1 m height and 30 cm diameter was used to simulate anaerobic landfill bioreactors.
• Reactor was equipped with several ports for collection and distribution of leachate and biogas.
• The leachate produced from the waste body in the reactors was collected after passing through a specifically designed drainage layer where a geotextile fabric was replaced in second reactor.
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• Reactor was filled with 30.8 kg of municipal solid wastes (MSW) which were taken from Istanbul Metropolitan Municipality Waste Disposal Facility.
• The feed MSW samples were obtained from the outlet of Ø 80 mm rotary screen.
• Both reactors were filled and compacted to 700 kg/m³ with municipal solid wastes.
• 1 liter of anaerobic seed sludge was injected to the waste body.

Table-1: **Physical properties of the MSW**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Content</td>
<td>62</td>
</tr>
<tr>
<td>Total Solids (TS)</td>
<td>38</td>
</tr>
<tr>
<td>Volatile Solids (VS)</td>
<td>71</td>
</tr>
<tr>
<td>Fixed Solids</td>
<td>29</td>
</tr>
</tbody>
</table>

Table-2: **Composition of the MSW**

<table>
<thead>
<tr>
<th>Waste Component</th>
<th>Value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food (Organic part)</td>
<td>62</td>
</tr>
<tr>
<td>Paper</td>
<td>16</td>
</tr>
<tr>
<td>Plastic</td>
<td>8</td>
</tr>
<tr>
<td>Other all</td>
<td>14</td>
</tr>
</tbody>
</table>
The simulated LBRs were operated under mesophilic conditions (33-37 °C).

5.5 liters of pure water were added during the first month of operation (1.1 L/week).

Then, the addition of supplemental water was stopped as a result of the waste body was reached the field capacity.

Leachate quality were investigated in terms of pH, total dissolved solids (TDS), chemical oxygen demand (COD) and sulfate ion (SO4) periodically by following standard methods.

The collected landfill gas (LFG) from bioreactors were analyzed for quantity and composition.

### METHODOLOGY — Operational Procedure

- **Parameter** | **Unit** | **Control** | **w/ Geotextile**
- MSW Wet Quantity | kg | 30.8 | 30.8
- MSW Volume | L | 44 | 44
- MSW Density | kg/m³ | 700 | 700
- Seed Sludge Volume | L | 1.0 | 1.0
- Seed Sludge Ratio (V:V) | % | 2.26 | 2.26
- Rainwater Addition | L/week | 1.1 | 1.1
- Number of Rainwater Additions | - | 5 times | 5 times
- Leachate Recirculation | - | Yes | Yes
- Recirculation Frequency | times/week | 3 | 3
- Filter in Drainage Layer | - | No Filter | Geotextile Filter
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Leachate pH is a parameter which highly effect the efficiency of organic removal in the system.

Optimum pH range is known to be in neutral area for methanogenic bacteria.

However, at the early stages of anaerobic biodegradation such as fermentation phase, organic acids are accumulating in the system which causes low pH values that continues until the methanogenesis.

- pH was increased the optimal neutral area just two months of operation in LBR w/ geotextile biofilter.
- Since, control reactor was only be able to reach it more than 3 months later.
RESULTS & DISCUSSION - Total Dissolved Solids (TDS)

• TDS mainly includes all ions (Cl-, F-, NO₃, SO₄ Mg+, Ca+, Na+, etc.) and carbonate species, which reflect the total concentration of dissolved constituents in a water sample.

• Maximum TDS for r-Control: 13.1 mg/L
• Final TDS for Control: 10.4 mg/L
• Decreasing trend started after 5 months.
• Maximum TDS for r-Geotextile: 12.5 mg/L
• Final TDS for Control: 10.0 mg/L
• Decreasing observed in two months.

➢ Lower final concentration of TDS.
➢ Rapid decrement as compared to control.
Sulfate reduction under anaerobic conditions is a well-known phenomenon.

When an anaerobic system goes to methanogenic conditions from the acid phase, sulfate concentrations are rapidly decreased as a result of sulfate reduction.

- Final Sulfate for r-Control: 152 mg/L
- Removal efficiency: 91%
- Final Sulfate for r-Geotextile:
- Removal efficiency: 98%
- Reached minimal concentrations in two months.

- Higher and great removal efficiency.
- Rapid removal of sulfate.
• COD is a typical parameter that is used for determining the organic pollution in water.

• Leachate is known to be its very high organic content.

• Maximum COD for r-Control: 63.0 g/L
• Removal efficiency: 92%

• Maximum COD for r-Geotextile: 52.4 g/L
• Final COD for r-Geotextile: 2.2 g/L
• Removal efficiency: 96%

• Sharp decreasing trend was observed in just three months.

- Extraordinary COD removal efficiency for an anaerobic LBR.
- High COD removal in much shorter time obviously showed that GT has enhanced the biodegradation of organics.
In anaerobic biodegradation processes, methanogenic bacteria consume organics and produce mainly some methane and carbon dioxide gasses.

So that, with high calorific values biogas or more accurately for this process; “LFG” production in LBRs have a great significance.

- Cumulative LFG: 1047 L
- Later production
- Cumulative LFG: 1191 L
- Produced 90% of all, in 106 days.

- Much rapid decomposition of MSW has ben achieved in r-GT as connected with LFG production.
- Higher LFG yield with much faster production.
- Promising LFG yield value as compared to similar studies.
RESULTS & DISCUSSION - Total Biogas (LFG) Production

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CH4 and CO2 are the main gases produced in consequence of the anaerobic waste degradation.

After the initialization of methanogenic conditions in a landfill site, CH4 and CO2 are typically present around 45-65% and 35-55%, respectively.

Maximum Methane content in r-Control: 55.0%
Reached maximal value at 187\textsuperscript{th} day.
Maximum Methane content in r-GT: 54.6%
Reached maximal value at 73\textsuperscript{rd} day.

- Reached the typical methane content of biogas concentrations which is around 50%, in first couple of months.
- Little decrease in methane percentage by time, even after the LFG production rate was highly decreased.
Before the geotextile material was not used as a filter media, there are almost no particles on complex fabric structure.
The complex biomass structure between the widely spaced fibers of the geotextile sample is shown.
Clearly shows that, there are some attached formations on fibers, which is a verification of biofilm growth.

In addition, there are some visible trapped particles between pores of the material in Figure 4.22.a, which resembles suspended growth as in activated sludge process.
To see microbial community more clear and closer, additional pictures were taken with much bigger magnifications in SEM system.

Some healthy bacillus and coccus bacteria can be clearly seen.

It is assumed to be a methanogenic bacteria as compared to previous studies (Chen et al. 2015, Mussati et al. 2005, Pazinato et al. 2010)
CONCLUSION

- Highly polluted leachate wastewater quality was highly improved.
- Leachate was pretreated in-situ (where it is produced; waste body) without using any wastewater treatment plant facility.
- In terms of organic removal, 96% removal efficiency was achieved, which is a unique performance of an anaerobic LBR (Bilgili et al. 2007, Sponza et al. 2004, Sanphoti et al. 2006).
- LBR aims to operate landfills in maximum efficiency. However, to reach the methanogenic degradation phase in the system takes considerable times. Methanogenic conditions was occurred much faster by using of geotextile material as a biofilm media.
- Combining leachate recirculation and attached growth biofilm application (by using geotextile) is now a proven strategy to accelerate the formation of methanogenic conditions in LBRs.
- As a result, faster and better biologic decomposition of solid wastes.
- High potential usage of geotextile fabric/material as a biofilter in leachate recirculated landfill bioreactors for in-situ treatment of leachate and rapid decomposition of organic fraction of MSW.
REFERENCES


THANK YOU.

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