USING GEOTEXTILE FILTER AS BIOFILM MEDIA IN ANAEROBIC LANDFILL BIOREACTOR

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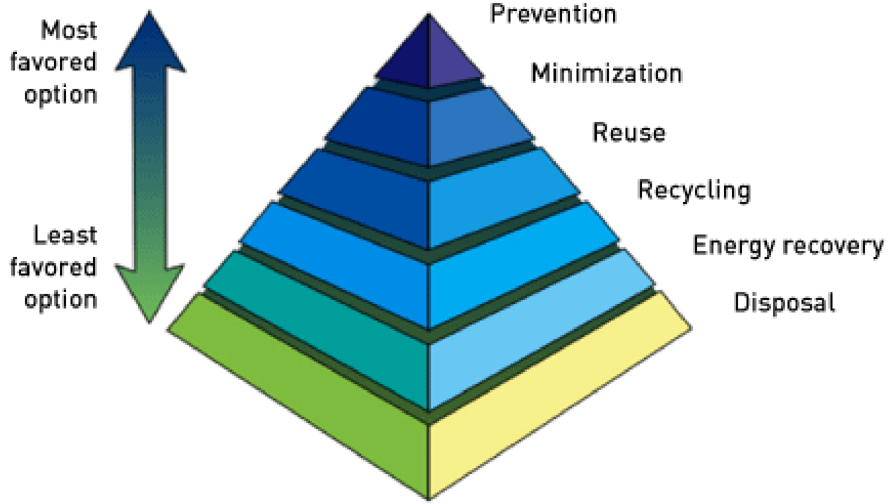
INTRODUCTION - Still Landfilling?..

- 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.



The solid waste management hierarchy

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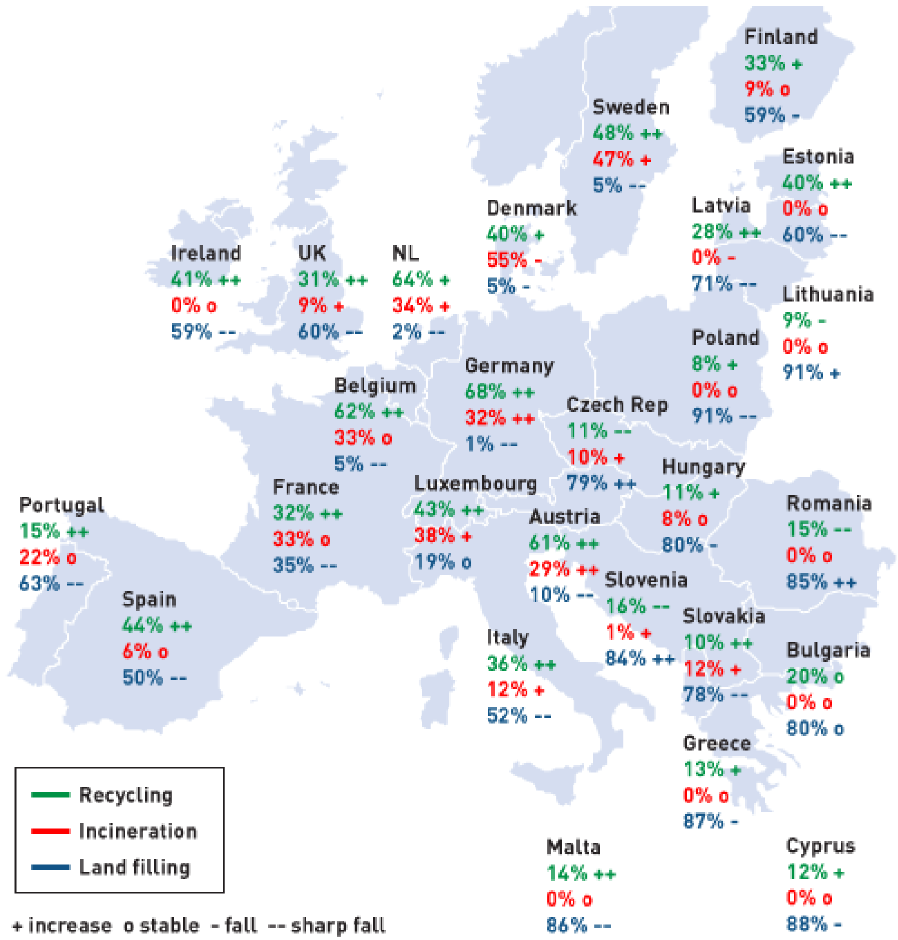

Distribution of solid waste management methods in Europe (Eurostat 2010)

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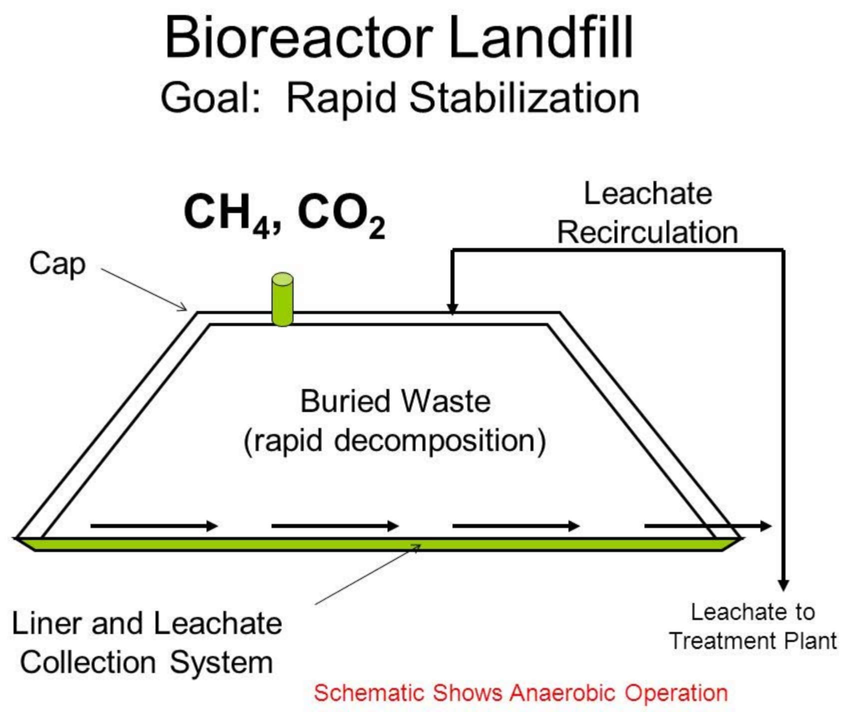
INTRODUCTION - Landill Bioreactor (LBR) Technology

- 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.
- It has been known that anaerobic bioreactor is the most common and economically preferable one as compared to aerobic, facultative and hybrid ones.



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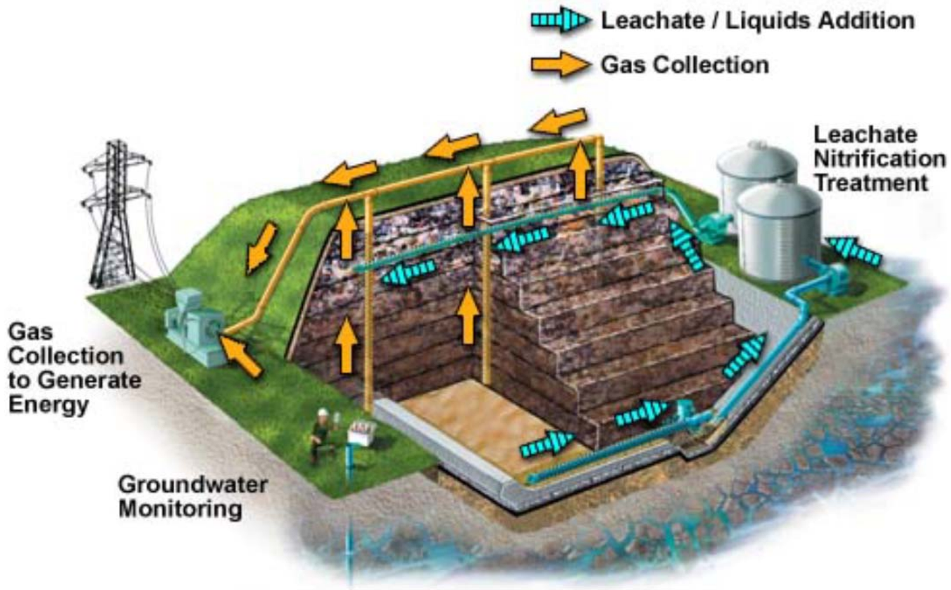

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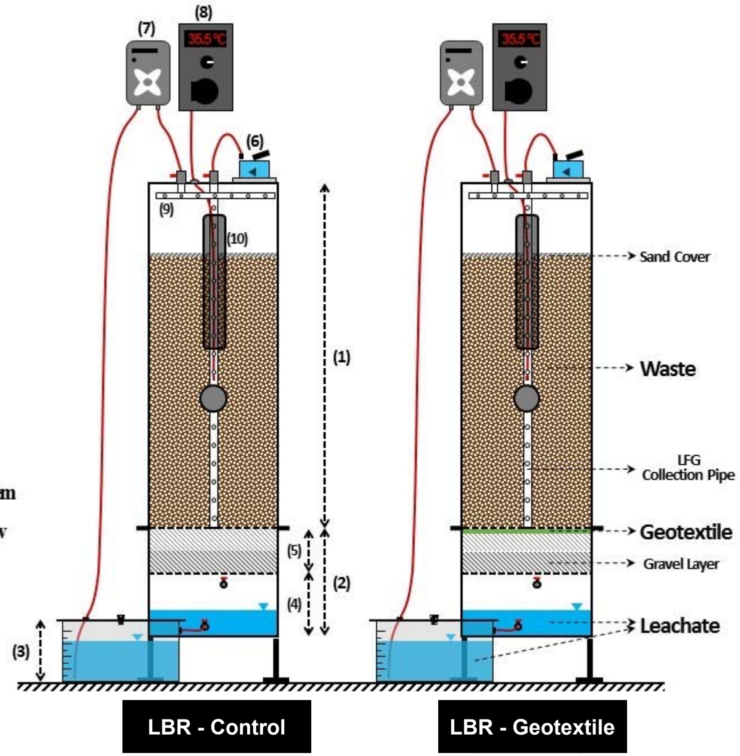
INTRODUCTION - Geotextile Material

- 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.

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

(1) Upper Compartment
(2) Lower Compartment
(3) Exterior Leachate Tank
(4) Interior Leachate Tank
(5) Drainage System
(6) Wet-Type Gas Meter
(7) Peristaltic Pump
(8) Thermocouple
(9) Leachate Distrubition System
(10) Waste Monitoring Window



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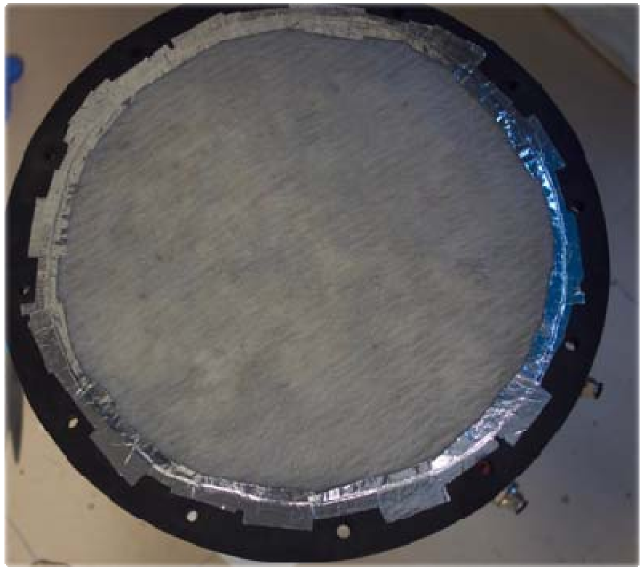
- The simulated landfill bioreactor with geotextile layer was operated under mesophilic conditions (33-37 °C)



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METHODOLOGY - Characterization

- 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**

Parameters	Value (%)
Water Content	62
Total Solids (TS)	38
Volatile Solids (VS)	71
Fixed Solids	29

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

Waste Component	Value (%)
Food (Organic part)	62
Paper	16
Plastic	8
Other all	14

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METHODOLOGY – Operational Procedure

- 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.

Parameter	Unit	Control	w/ Geotextile
MSW Wet Quantity	kg	30.8	30.8
MSW Volume	L	44	44
MSW Density	kg/m^3	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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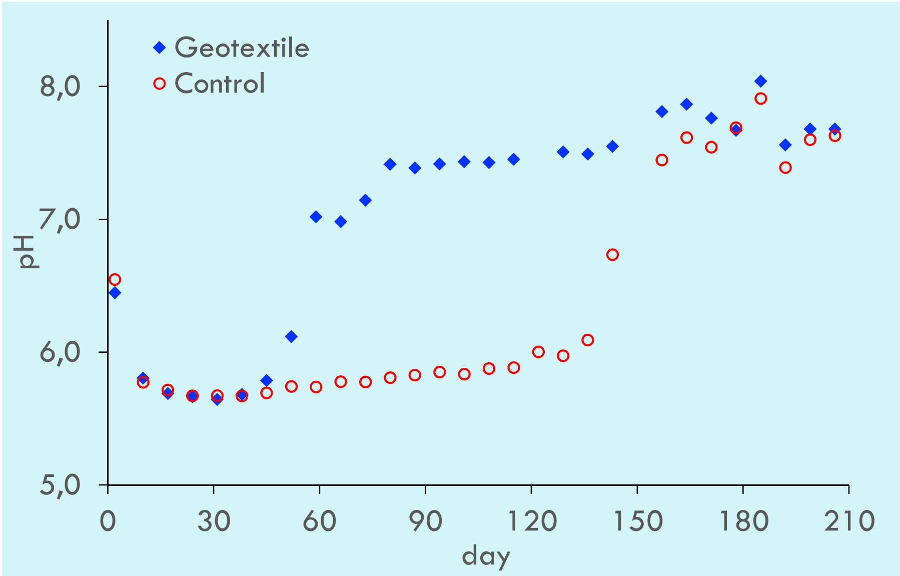
RESULTS&DISCUSSION - pH

- 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.**

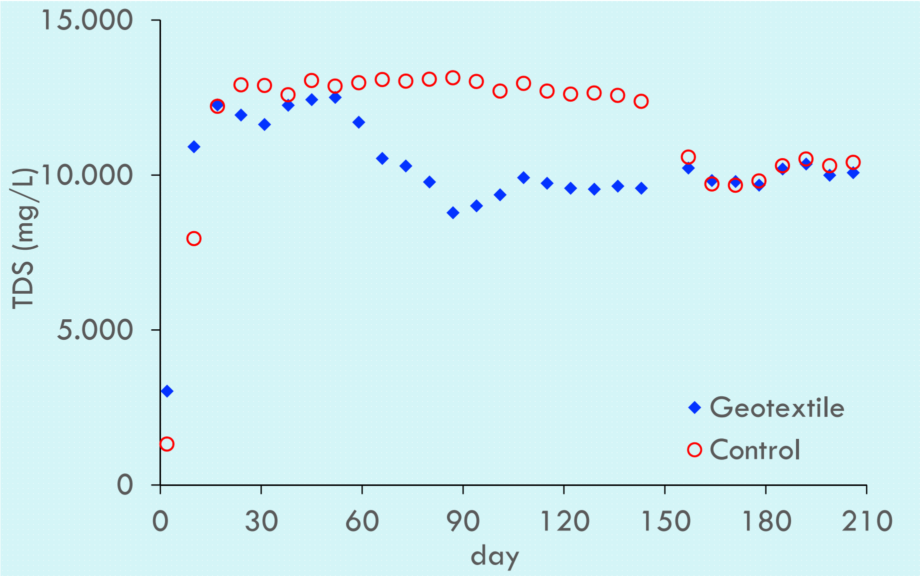
RESULTS&DISCUSSION - Total Dissolved Solids (TDS)

- 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.**

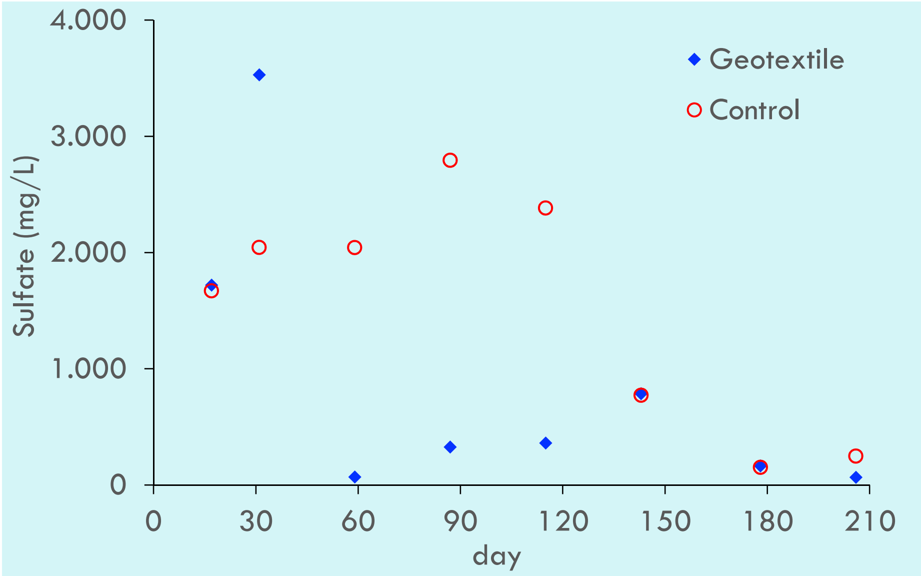
➢ **Rapid decrement as compared to control.**



RESULTS&DISCUSSION - Sulfate (SO4)

- 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.

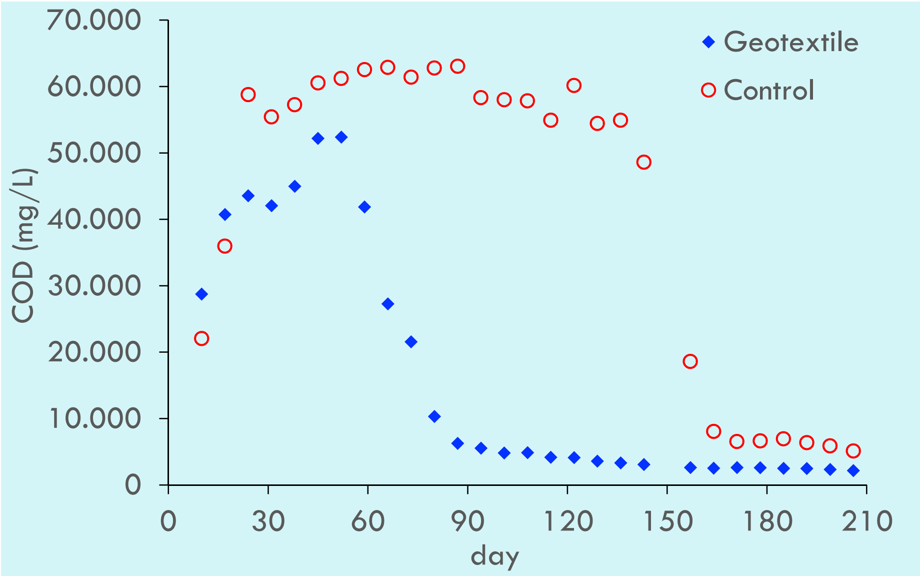


- **Higher and great removal efficiency.**
- **Rapid removal of sulfate.**

RESULTS&DISCUSSION - Organic Content (as COD)

- 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 anaeorobic LBR.**

➢ **High COD removal in much shorter time obviously showed that GT has enhanced the biodegradation of organics.**

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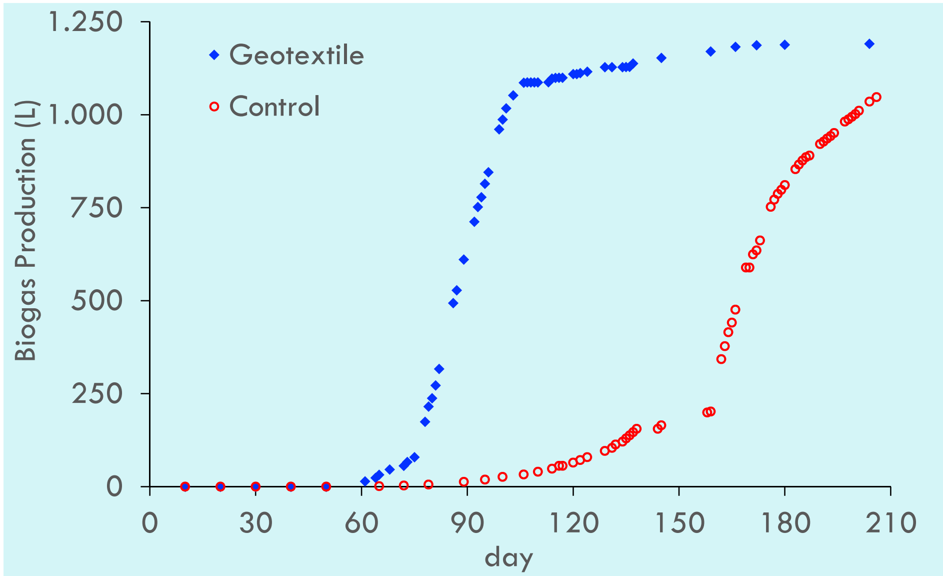
RESULTS&DISCUSSION - Total Biogas (LFG) Production

- 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.**

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RESULTS&DISCUSSION - Total Biogas (LFG) Production

Operation Time	Moisture Content	MSW Quantity		Organic Content	Cumulative LFG Volume	LFG Yield Wet Basis	LFG Yield Dry Basis	Study	
		Wet	Dry						
day	%	kg	kg	%	L	L/kg.OFSW	L/kg.OFSW		
210	62%	30.80	11.70	62%	1047	55	144	LBR-1	In this study
210	62%	30.80	11.70	62%	1191	62	164	LBR-2	
100	34%	1.50	0.98	54%	44	54	83	Harmankaya (2013)	
270	17%	26.50	22.05	69%	2011	110	132	Sandip et al. (2012)	
114	21%	19.50	15.50	42%	839	102	129	Hot (2012)	
600	51%	19.50	9.56	45%	1497	171	348	Erses (2008)	
105	54%	20.00	9.20	57.5%	621	54	117	He et al. (2005)	
275	80%	13.00	2.60	76%	269	27	136	San and Onay (2001)	

- **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 (164 Liters of LFG produced per kilogram of dry organic solid waste) compared to similar studies.**

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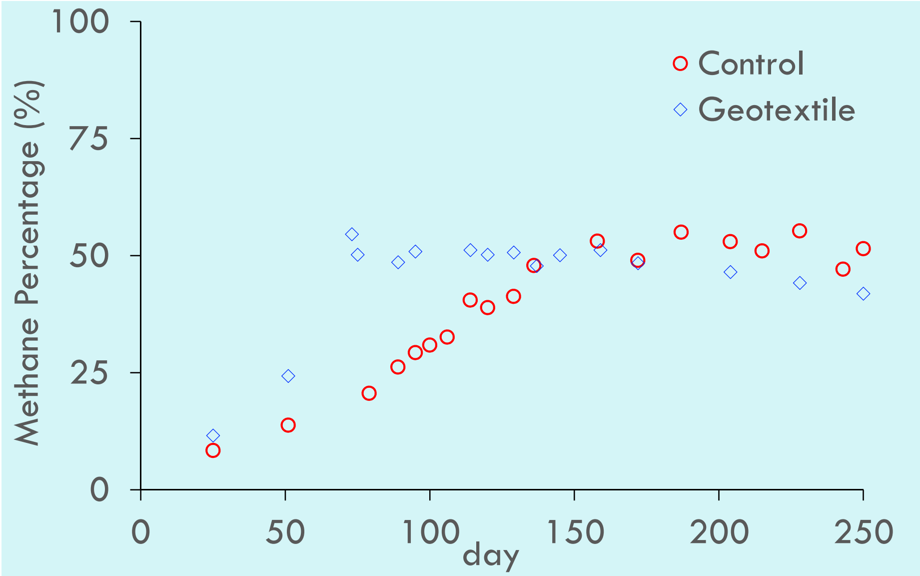
RESULTS&DISCUSSION - Methane Content in LFG

- CH_4 and CO_2 are the main gases produced in consequence of the anaerobic waste degradation.
- After the initialization of methanogenic conditions in a landfill site, CH_4 and CO_2 are typically present around 45 65% and 35-55%, respectively.

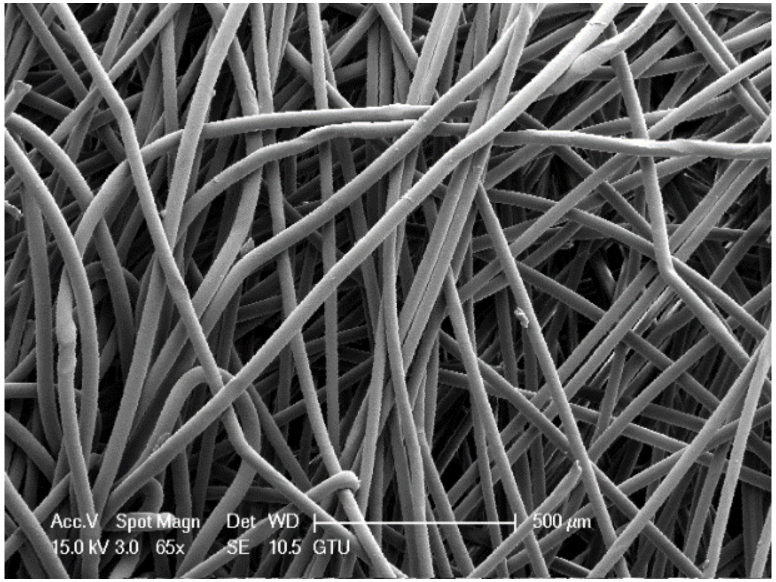
- Maximum Methane content r-Control: 55.0%
- Reached maximal value at 187th day.
- Maximum Methane content in r-GT: 54.6%
- Reached maximal value at 73rd day.

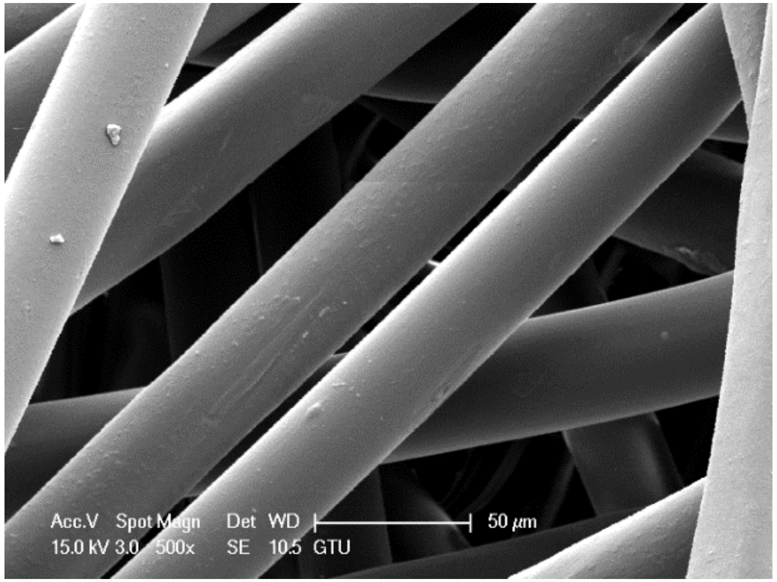


➢ **Reached the typical methane content of biogas concentrations which is around 50%, in first couple of months.**

➢ **Little decrease in methane percentage by time, even after the LFG production rate was highly decreased.**

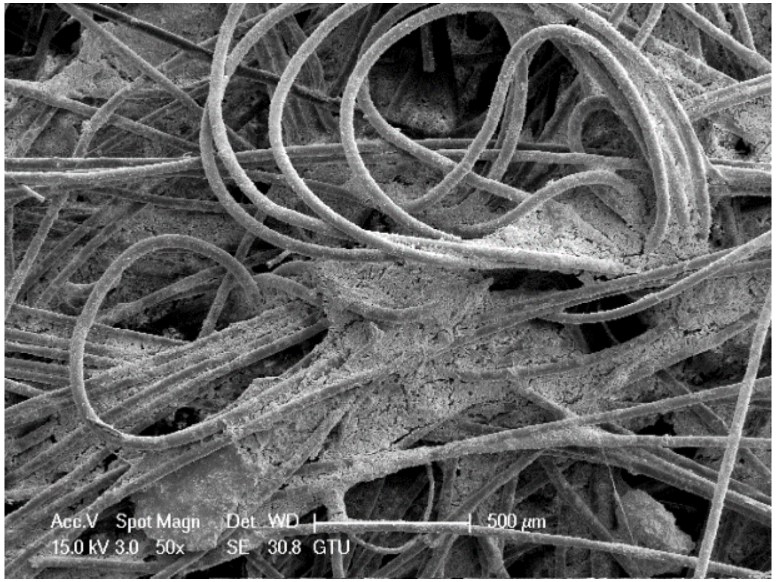
RESULTS&DISCUSSION - Biomass Formation in GT Filter

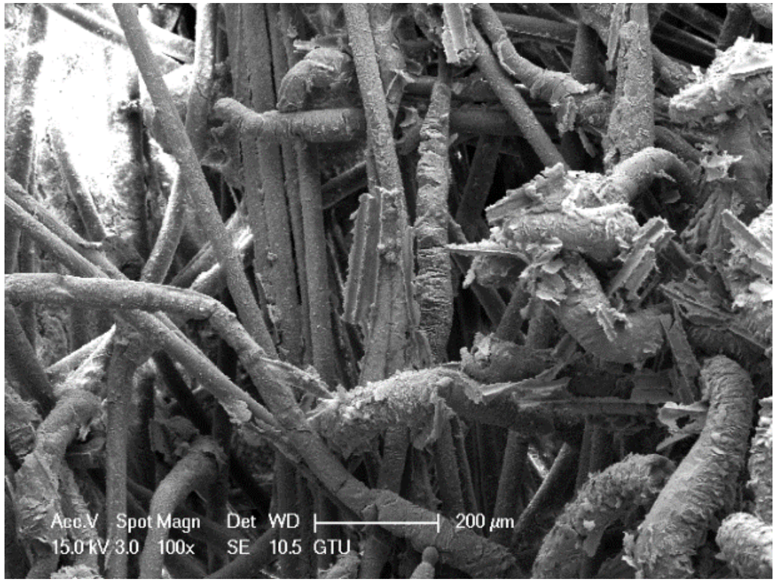




- **Before the geotextile material was not used as a filter media, there are almost no particles on complex fabric structure.**
- **The complex biomass structure between the widely spaced fibers of the geotextile sample is shown.**

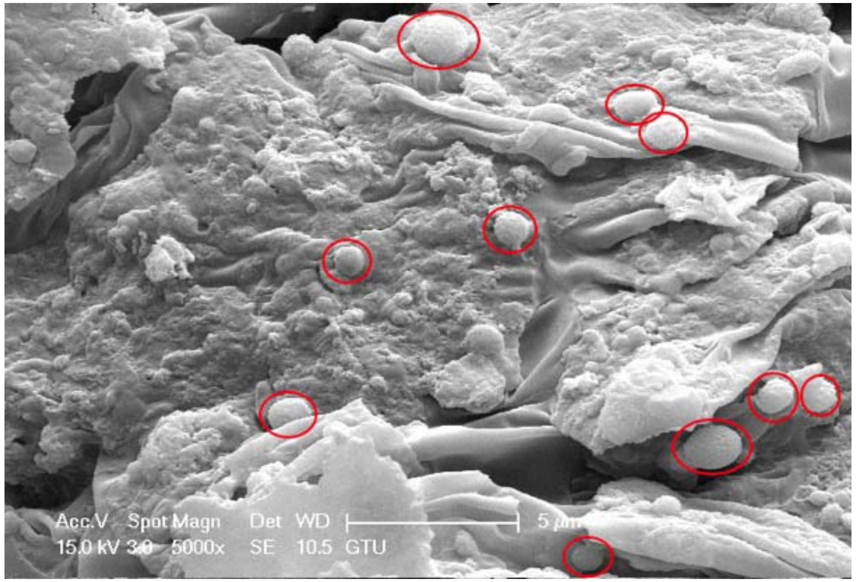
RESULTS&DISCUSSION - Biomass Formation in GT Filter

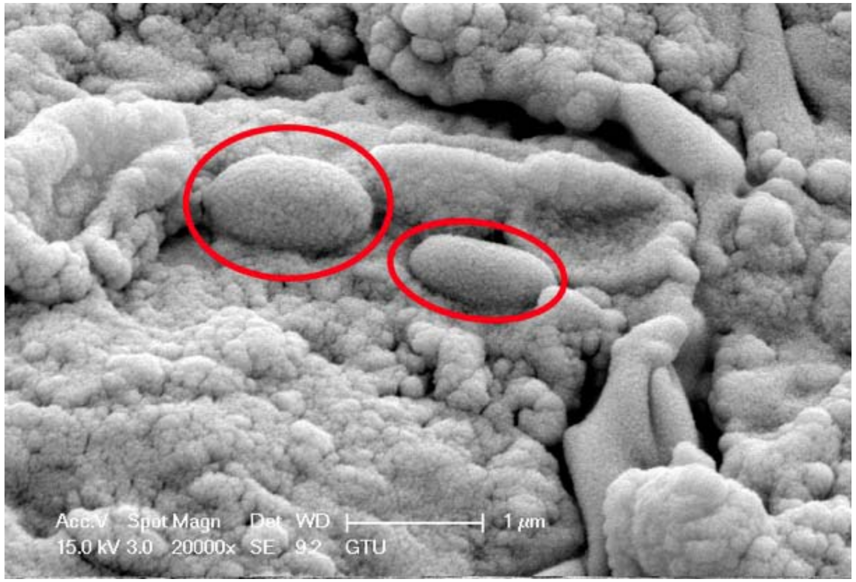




- **Clearly shows that, there are some attached formations on fibers, which is a verification of biofilm growth.**
- **In addition, there are some visible trapped particles between pores of the material in Figure 4.22.a, which resembles suspended growth as in activated sludge process.**

RESULTS&DISCUSSION - Biomass Formation in GT Filter





- **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)**

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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.**

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THANK YOU.

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