

Using Landfill Gas Condensate as a Carbon Source for Landfill Leachate Denitrification

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Background Information

Microorganisms perform
denitrification in BNR

BNR fed with external
carbon sources

Carbon sources affect
microorganism's activity

Carbon sources affect
denitrification

Table 1. Yearly landfill leachate generation,
treatment, and denitrification cost in the USA

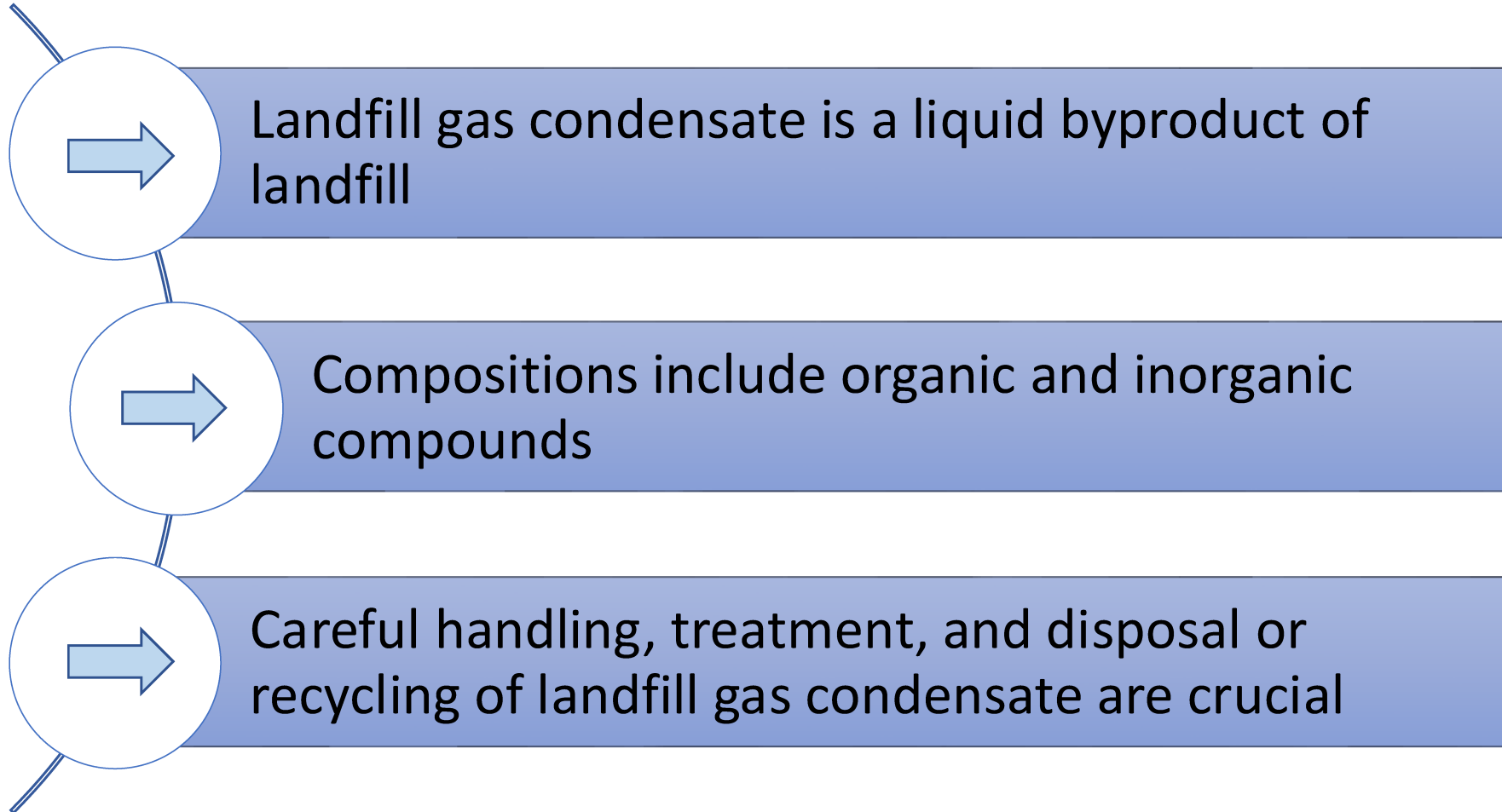
Landfill leachate generation	16.1~16.9 Billion Gallons/year
Landfill leachate treatment	10.9~11.5 Billion Gallons/year
Denitrification Cost	\$520~\$600 Million/year as of methanol cost

Commonly Used Carbon Sources:

1. Methanol
2. Ethanol
3. Acetate
4. Sodium
Acetate
5. Glucose
6. Glycerol
7. Volatile Fatty
Acids
8. Fermentation
Liquid



Landfill Gas Condensate



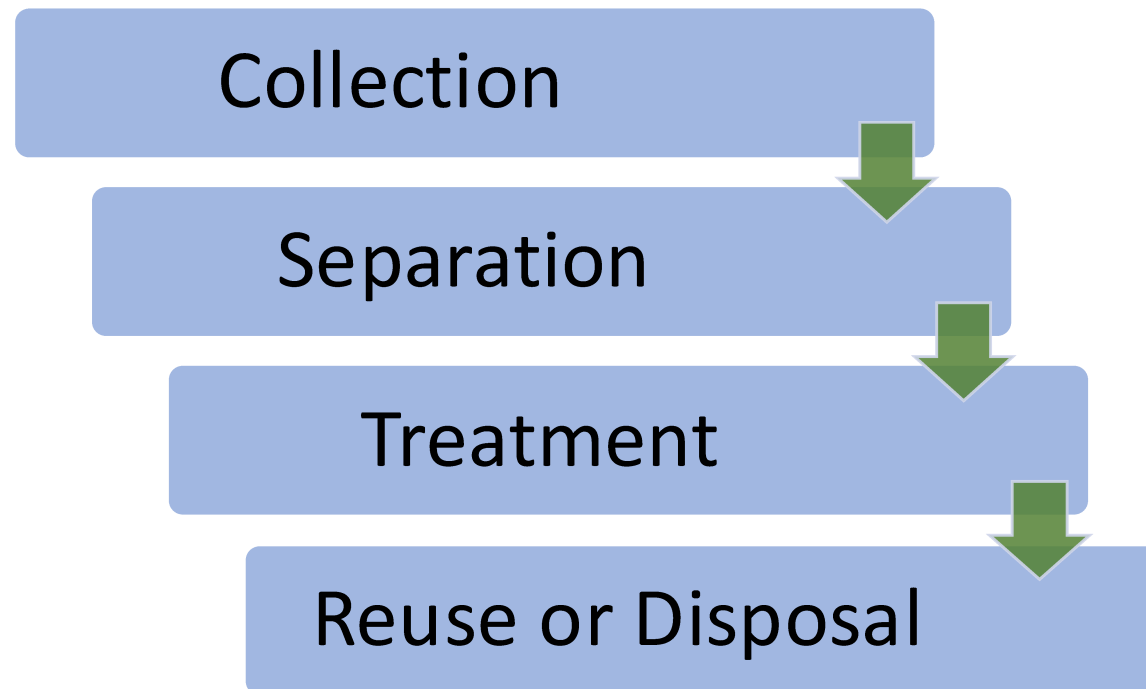
Landfill gas condensate



Why Landfill Gas Condensate?

- Typical U.S. landfills can produce significant amounts of gas condensate.
- Some estimates suggest daily condensate production in a landfill could surpass **5000** liters.

The landfill handles condensation as follows:



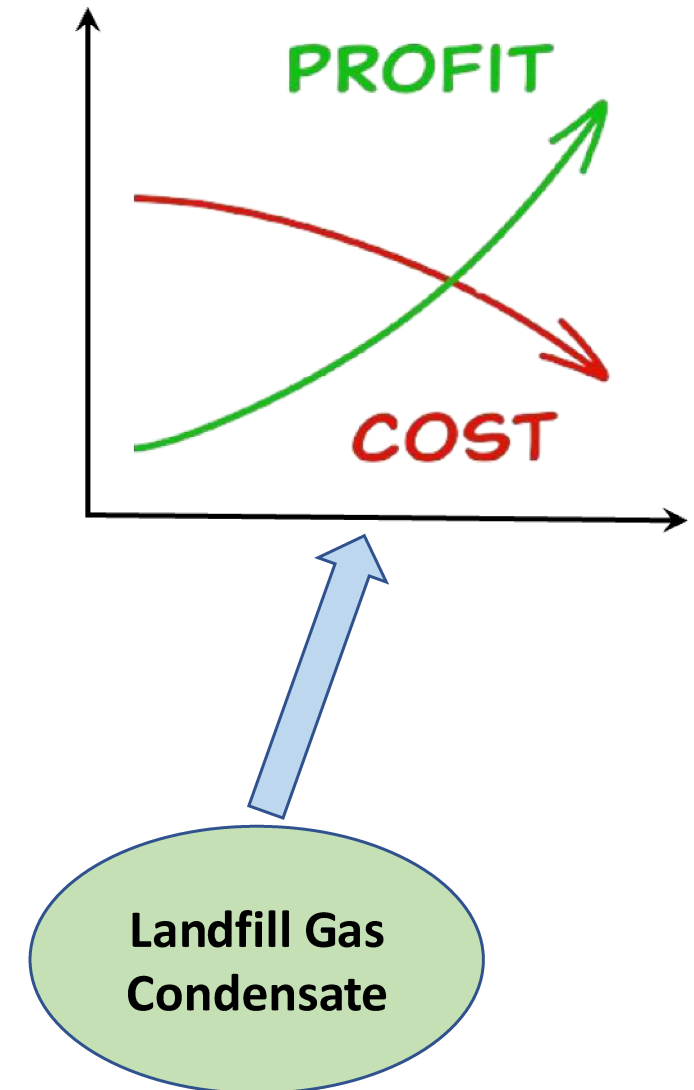
COST



Why Landfill Gas Condensate?

Table 2. Cost and Defects of Typical External Carbon Sources

Carbon Sources	Cost	Defects
Methanol	\$175 - \$250 /Ga	Biotoxicity
Ethanol	\$440 - \$520 /Ga	Inconvenient transportation
Sodium Acetate	\$180 - \$200 /Kg	Large dosage
Glucose	\$60 - \$70 /Kg	Low denitrification
Glycerin	\$570 - \$700 /Ga	Partial denitrification may observe
Volatile Fatty Acids	\$19 - \$25 /Kg	Pretreatment cost
Fermentation Liquid	Unspecified but costly	Energy consumed for pretreatment
Landfill Gas Condensate	Free	-





Objectives



To investigate denitrification of wastewater-landfill leachate blend with methanol, glycerin, sodium acetate, and condensate



To determine lowest effluent nitrate with varying external carbon dosage



To determine optimum external carbon dosage



To determine optimum denitrification time with optimum dosage

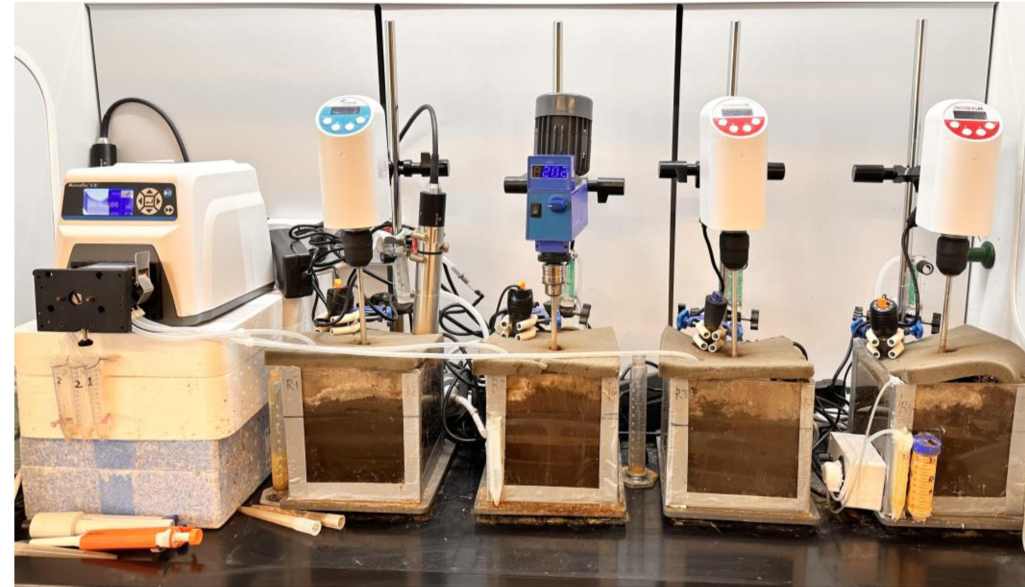
Note: This is the first study reporting condensate as an external carbon source for landfill leachate denitrification.



SBRs Operation Conditions

Table 3. General Information

Reactor Material	PMMA
Total Volume (L)	5
Working Volume (L)	3
Leachate Addition	Yes
Leachate Percentage (%)	1.5
HRT (Day)	1
Cycle/Day	2
Cycle Duration (h)	12
Aerobic (h)	6.5
Anoxic (h)	3.5
Post-aerobic (h)	1
Settle, Decant, Feeding, Idle (h)	1
SRT (Day)	15



Lab scale reactor setup

Table 4. Other Operation Conditions

Reactors	Mixing (RPM)	Temp. (°C)	MLSS (mg/L)	Airflow (L/min)	DO (mg/L)	External Carbon Sources
R1	200±6	20 ± 1	≈ 4,000	1.5	1~ 2	Methanol
R2						Glycerol
R3						Sodium Acetate
R4						Condensate



Wastewater and Leachate Characteristics

Table 5. Wastewater Characteristics

Sample	pH	Total Nitrogen (mg/L)	TKN (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N) (mg/L)	NH ₃ -N (mg/L)	COD (mg/L)	PO ₄ ³⁻ (mg/L)	Alkalinity (mg/L CaCO ₃)	BOD (mg/L)
Wastewater samples	7.5	40	39	1	0.05	32	260	17	186	124

Table 6. Leachate Characteristics

Sample	pH	Total Nitrogen (mg/L)	TKN (mg/L)	NH ₃ -N (mg/L)	COD (mg/L)	PO ₄ ³⁻ (mg/L)	BOD (mg/L)	TS (mg/L)	TSS (mg/L)	TDS (mg/L)
Landfill Leachate	8.1	3,370	3,353	2,350	4,880	1,770	1,680	12,050	250	11,800



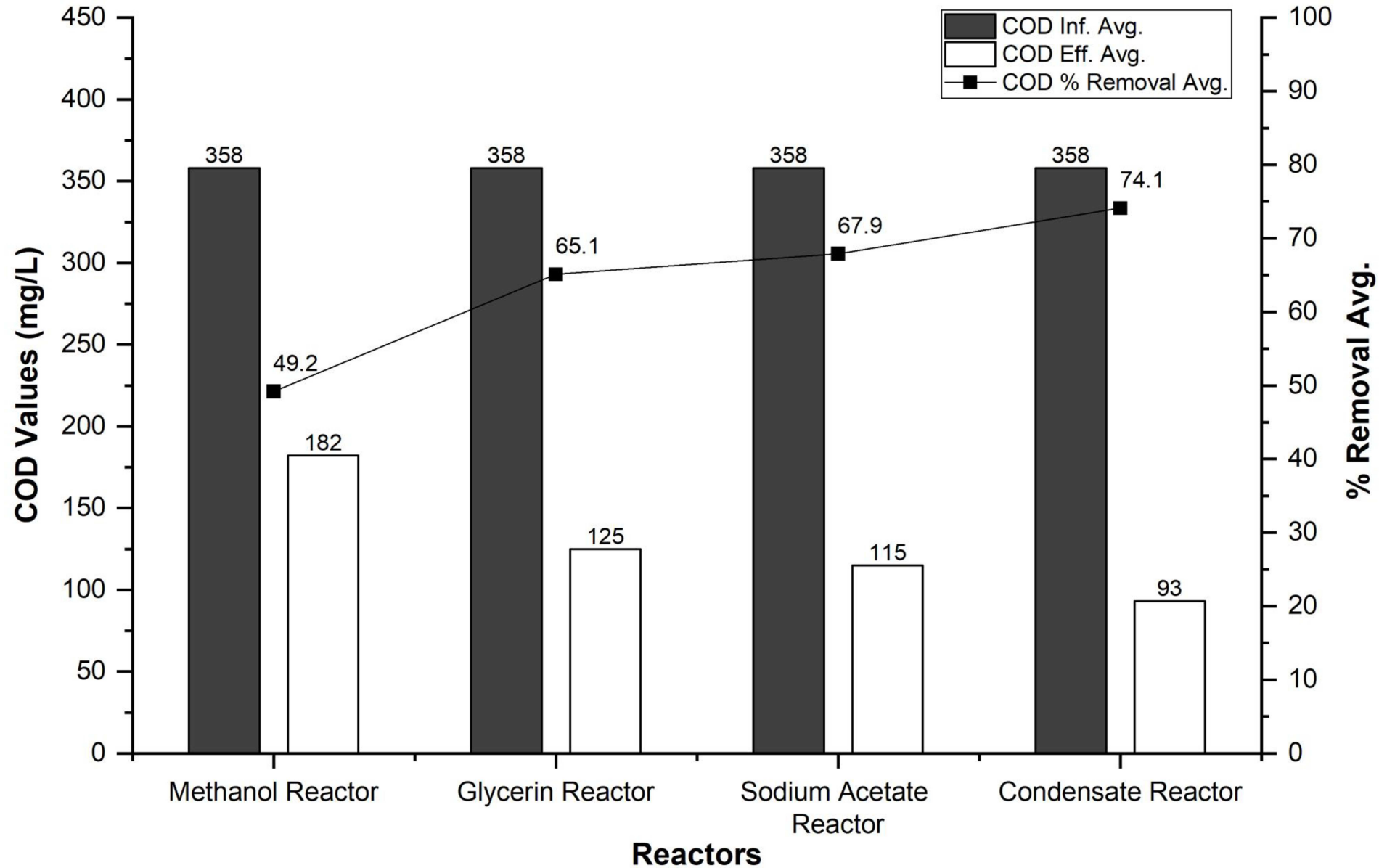
Effluent Characteristics

Table 7. Primary treated effluent characteristics.

Parameters	Influent	R1 Effluent	R2 Effluent	R3 Effluent	R4 Effluent
pH	7.70	8.00	7.90	8.00	8.00
TN (mg/L)	80.22	7.50	7.30	7.50	9.50
NH ₃ -N (mg/L)	65.01	0.14	0.05	0.11	0.11
NO ₃ -N (mg/L) (Before denitrification)	-	34.50	37.42	36.36	37.50
NO ₃ -N (mg/L) (After denitrification)	-	0.72	0.70	0.79	0.71
NO ₂ -N (mg/L)	0.05	0.01	0.01	0.01	0.01
COD (mg/L)	358	182	125	115	93
BOD (mg/L)	147	60	49	47	41

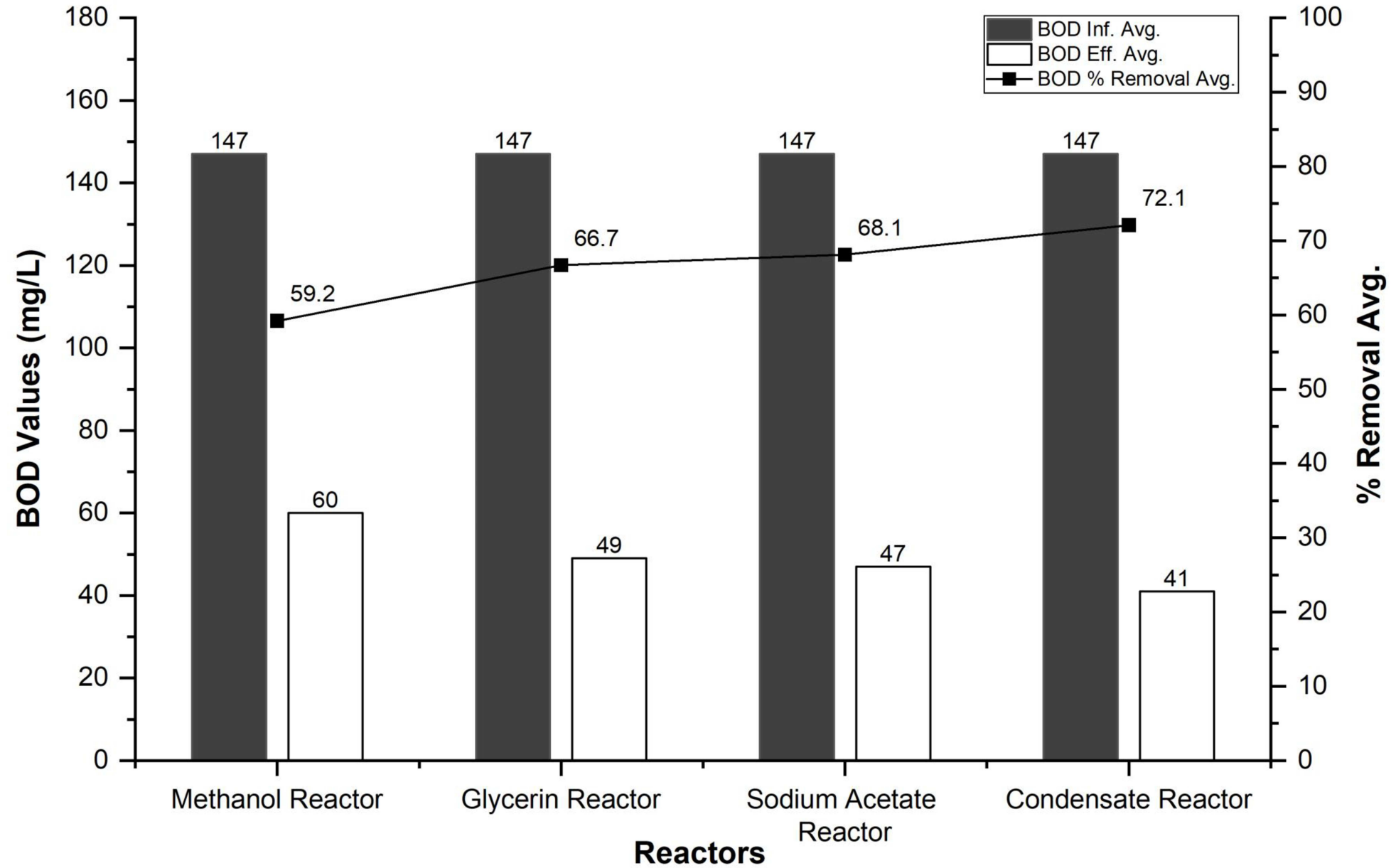


Influent and Effluent COD



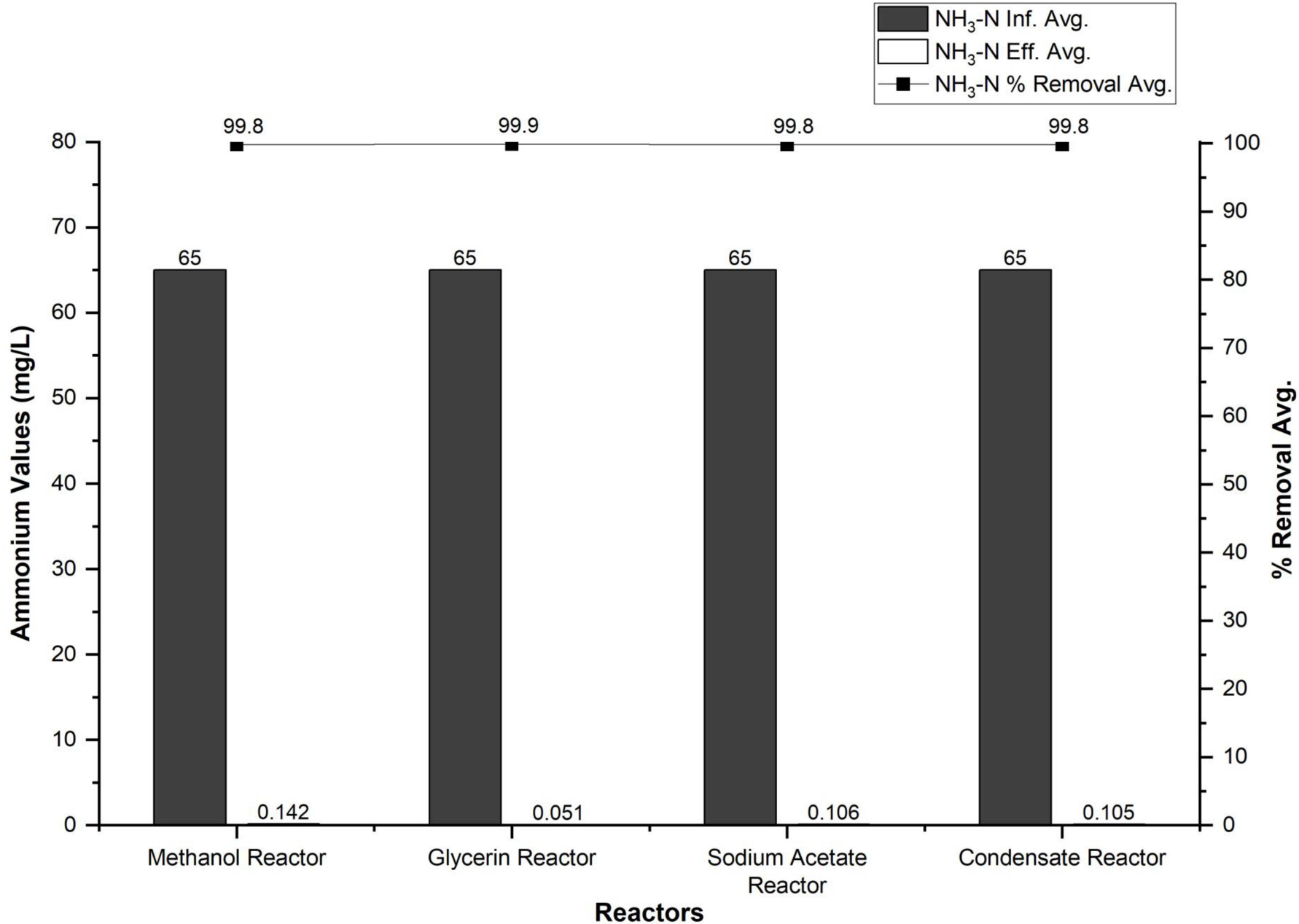


Influent and Effluent BOD



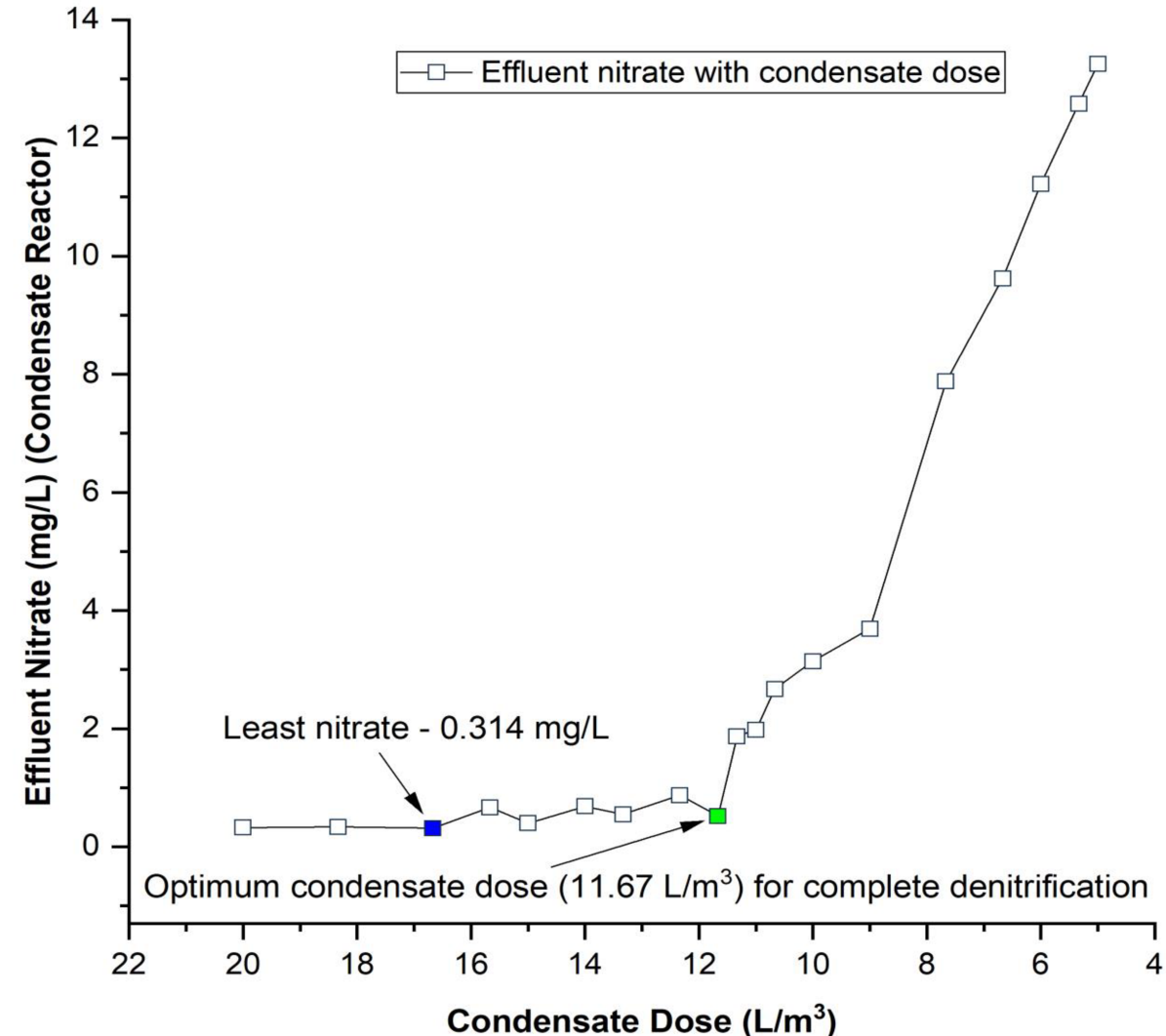
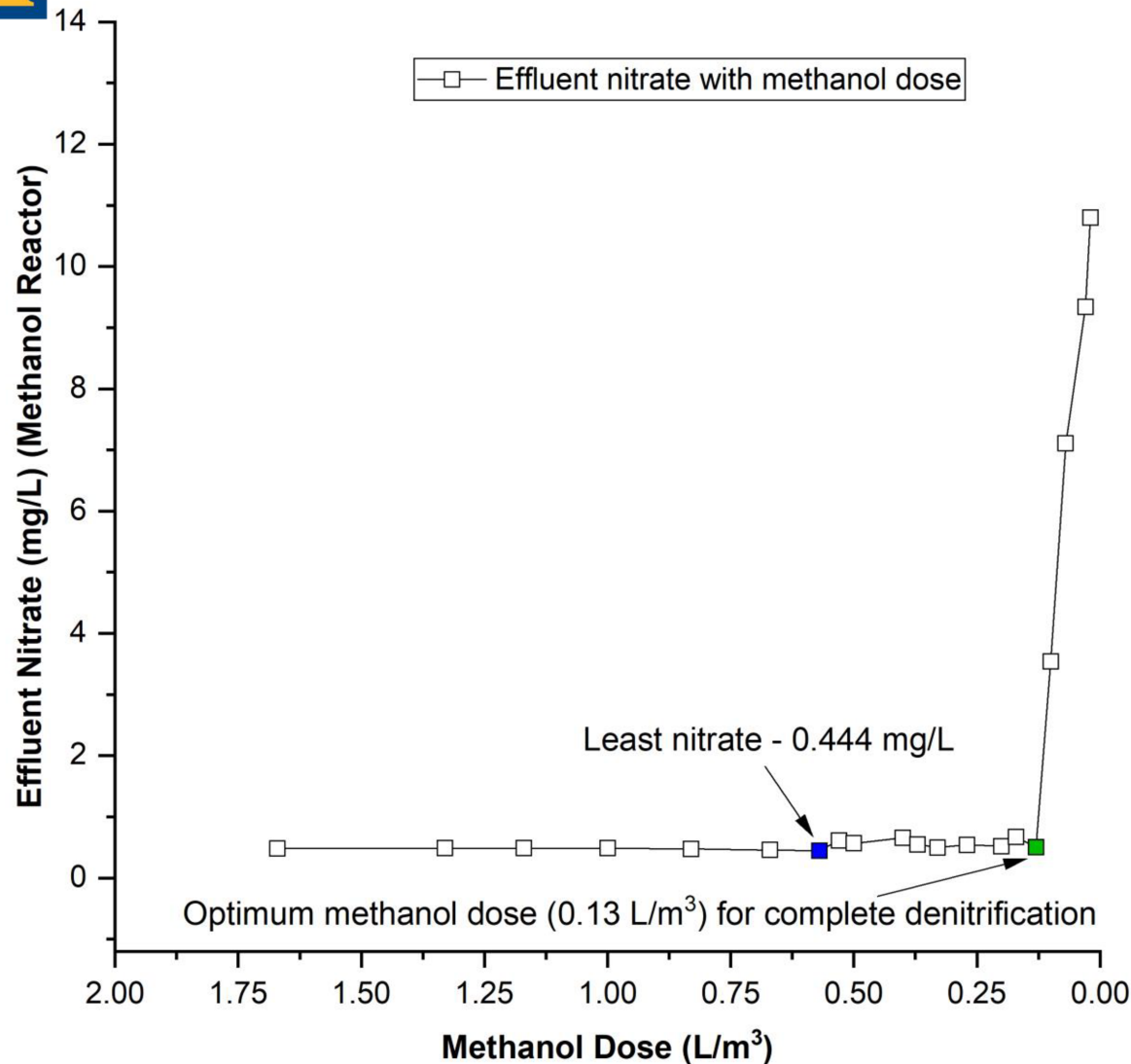


Influent and Effluent $\text{NH}_3\text{-N}$





NO₃-N Concentration with Different Dosage

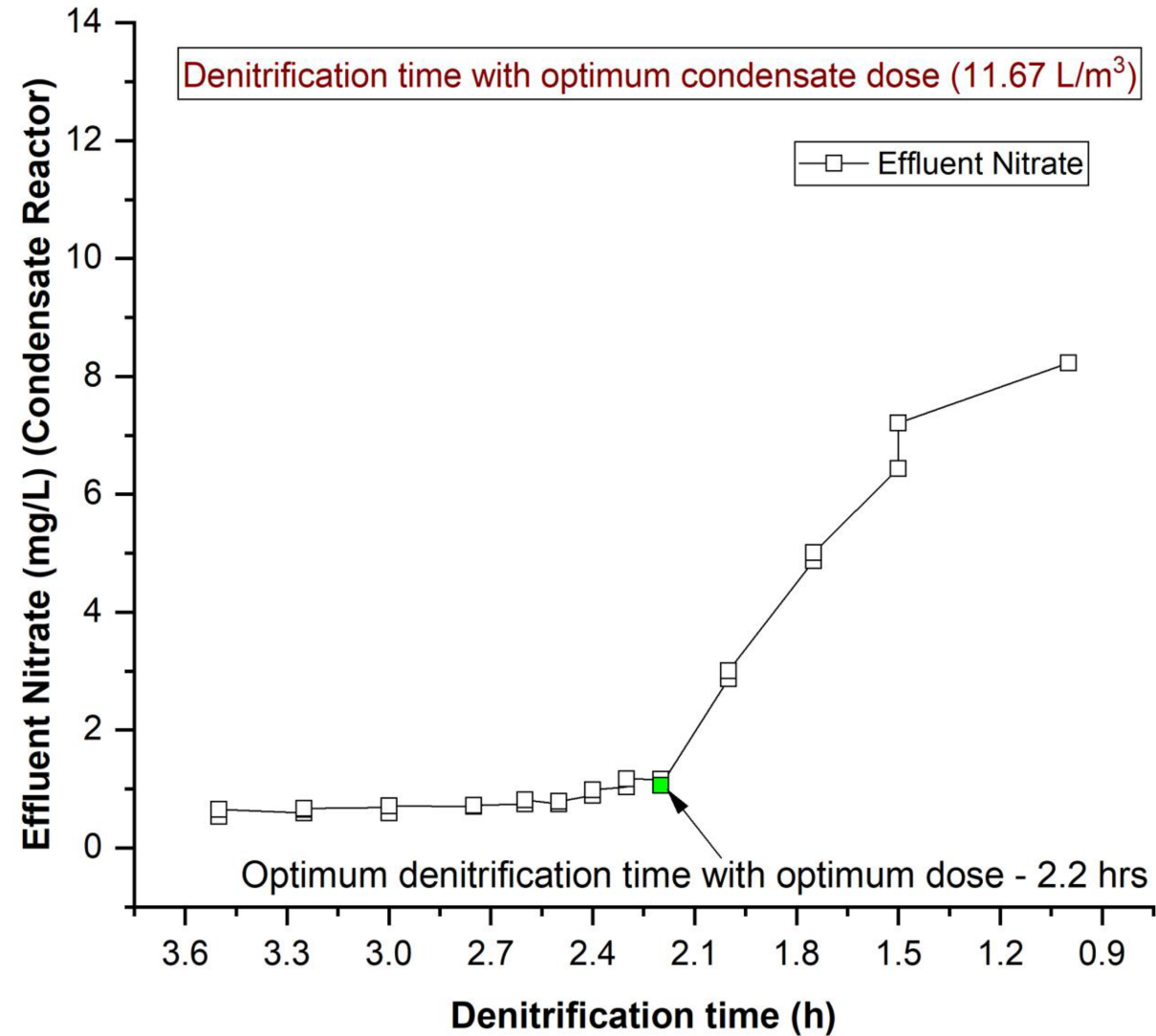
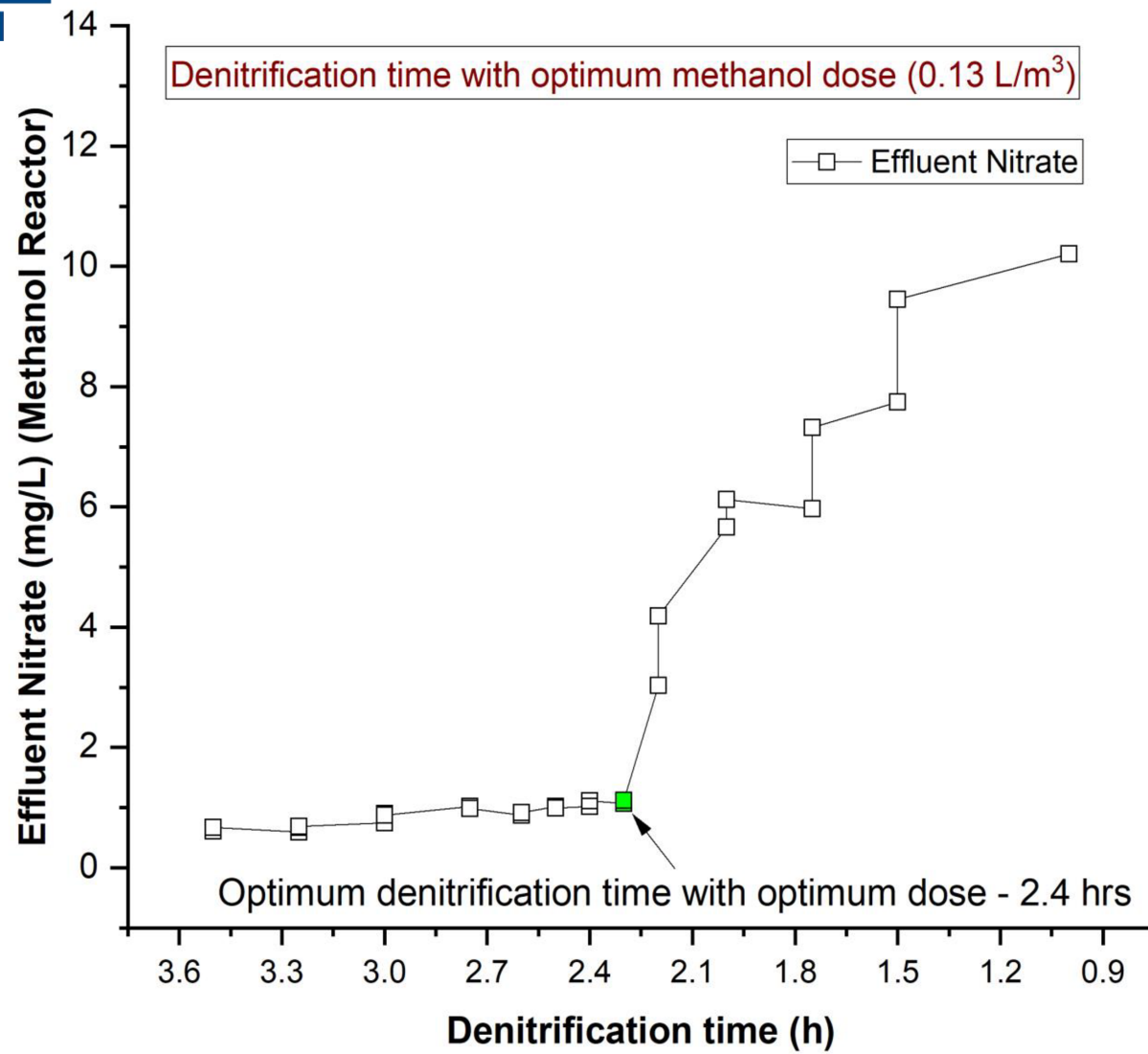


Carbon Sources	Methanol	Glycerin	Sodium Acetate	Condensate
COD (mg/L)	1,184,000	331,400	78,000	16,000

Carbon Sources	Methanol	Glycerin	Sodium Acetate	Condensate
Optimum Dose (L/m ³)	0.13	0.33	1.17	11.67



Optimum Denitrification Time



Reactors	Methanol Reactor	Glycerin Reactor	Sodium Acetate Reactor	Condensate Reactor
Optimum Denitrification time (h)	2.40	2.60	2.75	2.20



Least Denitrification Time and Respective $\text{NO}_3\text{-N}$

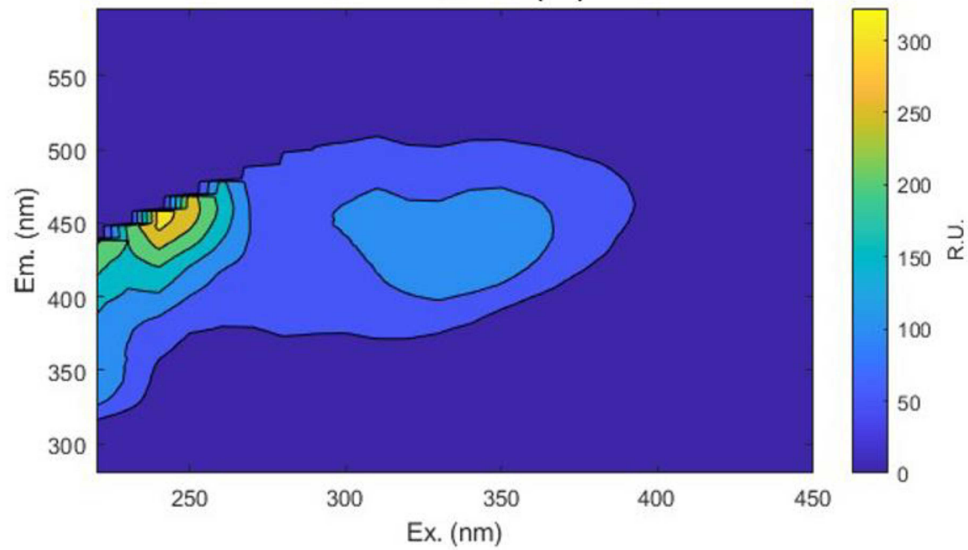
Table 8. The optimum time for complete denitrification with optimum external carbon dose and $\text{NO}_3\text{-N}$ concentration

Reactors	External Carbon Sources	Optimum Dose (L/m^3)	Respective Nitrate (mg/L)	Optimum Denitrification time (hrs)
R1	Methanol	0.13	1.02	2.40
R2	Glycerin	0.33	1.04	2.60
R3	Sodium Acetate	1.17	1.02	2.75
R4	Condensate	11.67	1.06	2.20

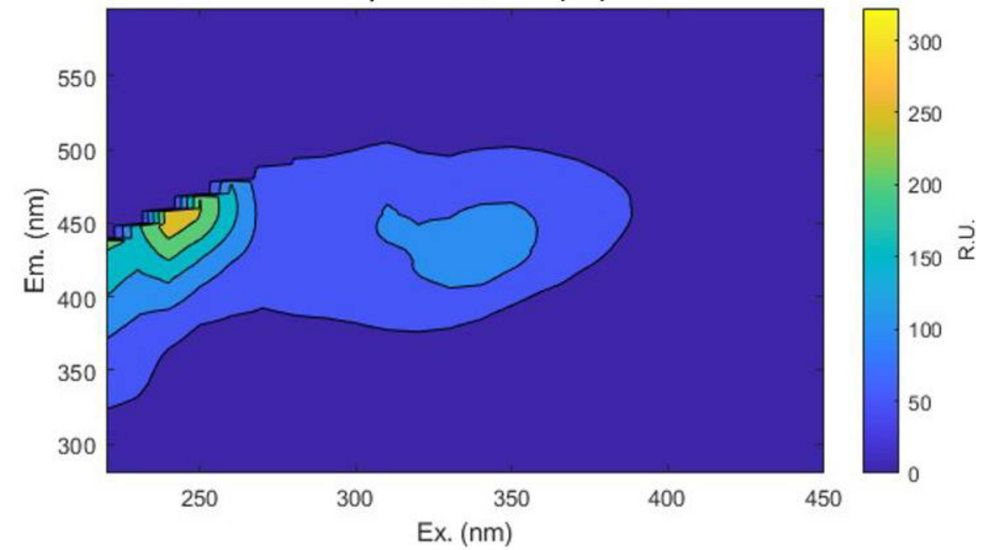


Molecular Characteristics of DOM: EEM

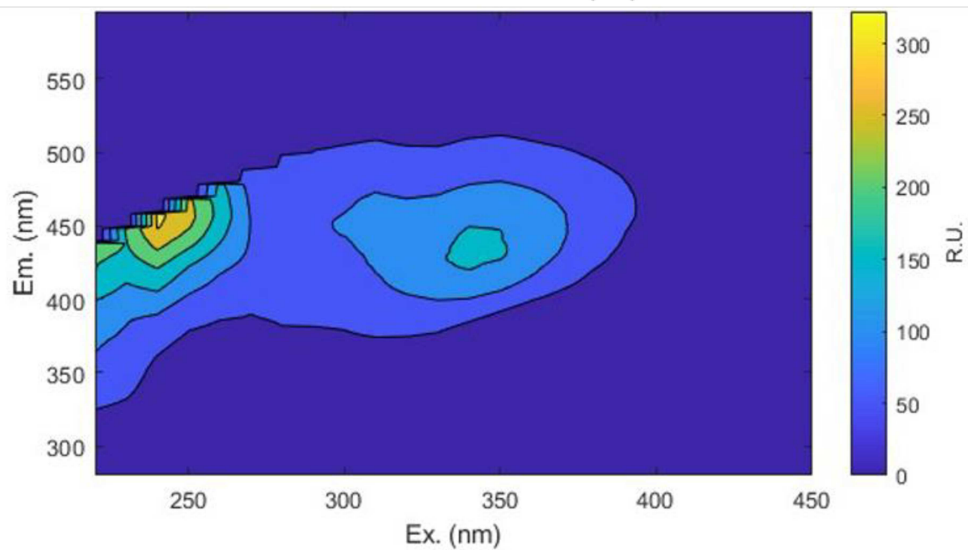
Methanol Reactor (R1)



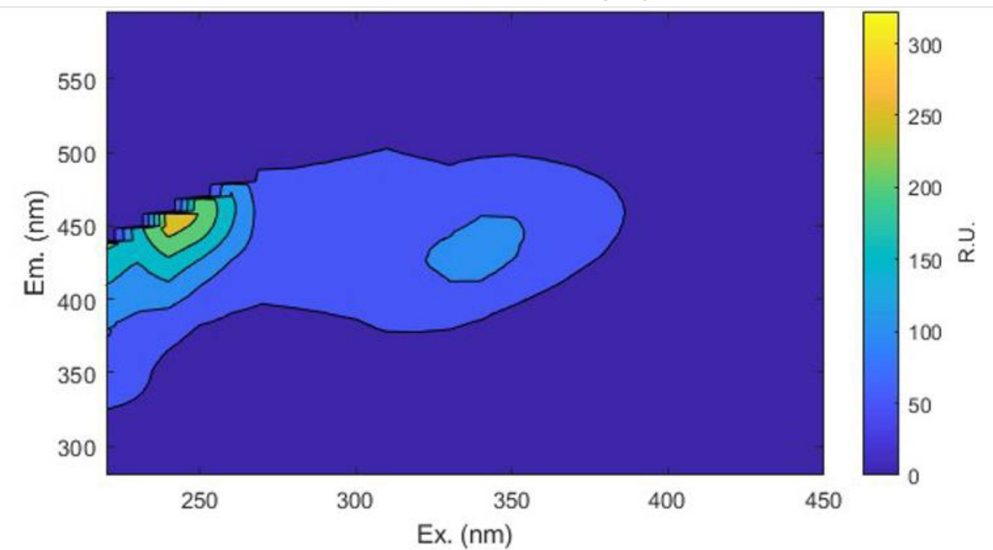
Glycerin Reactor (R2)



Sodium Acetate Reactor (R3)



Condensate Reactor (R4)





Molecular Characteristics of DOM: PARAFAC

Table 9. Different components in the effluent from PARAFAC analysis

Component 1	Humic-like compounds
Component 2	Humic-like compounds and Fulvic-like compounds
Component 3	Aromatic proteins II (Lignin)
Component 4	Humic-like compounds

Table 10. Component intensities in samples

	Component 1 Humic-like compounds	Component 2 Humic-like compounds and Fulvic-like compounds	Component 3 Aromatic proteins II (Lignin)	Component 4 Humic-like compounds
R1	93.70	55.66	86.74	17.81
R2	79.36	48.84	42.11	16.51
R3	110.42	48.26	36.21	18.12
R4	74.55	45.83	41.69	14.87



Conclusions



External carbon sources significantly improved denitrification



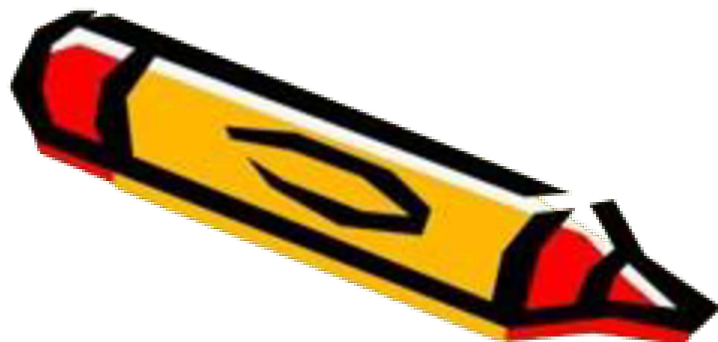
Condensate is effective in denitrification compared to others
and free to use



Condensate introduced no residual/recalcitrant toxicity in the
system



Condensate required elevated volume helps to reduce the load



Thank you for your
time.

Any questions?

