A Solution for Microelectronics Manufacturing Wastewater Treatment

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Outline

- **Context**
- **Drivers**
- **Objectives**
- **Process Development**
  - Waste Characteristics
  - Biodegradability Test
  - Processes Selection
- **Experimental Results**
  - Biodegradability Test
  - Waste Stream #1
  - Waste Stream #2
- **Findings**

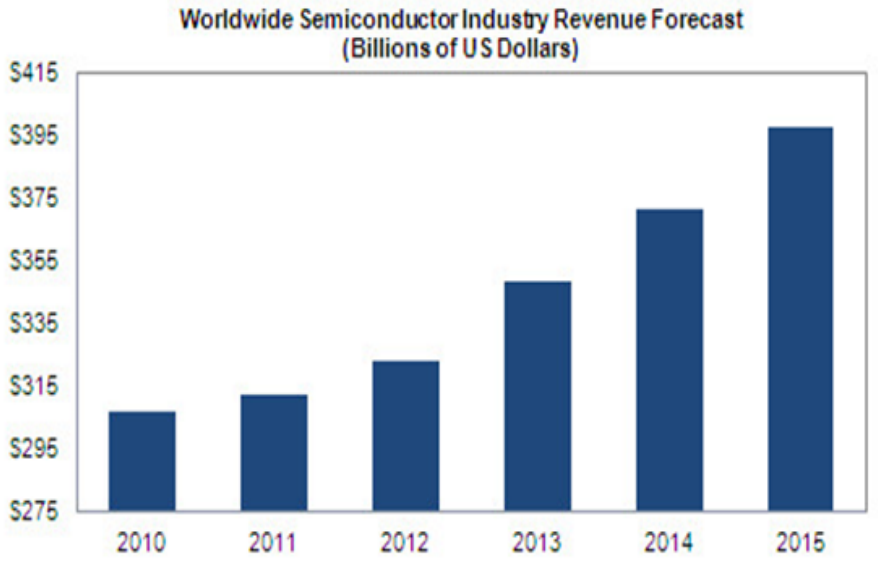
Context

- Microelectronics manufacturing is one of the fastest growing industries

- A typical semiconductor manufacturing facility consumes 6.7 MGD water

- Manufacturing process uses toxic and recalcitrant chemicals

- Industries are looking for water reuse technologies.



Source: IHS iSuppli Research, January 2012

(American Water Intelligence, 2012).

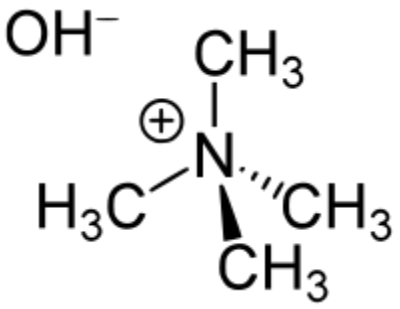
Chemicals/Contaminants

Parameter	Concentration (mg/L)
Tetra-methyl ammonium hydroxide (TMAH)	**5,000-60,000**
Di-methyl sulfoxide	<2000
Glycerol	5,000-66,000
Pyrazole	50-2,000
N-methyl pyrrolidone (NMP)	0-23,000
Triethanolamine (TEA)	0-10,000
Ethylene glycol (EG)	0-10,000
Morpholinopropylamine	0-3,000
Formaldehyde	60-700
Acetone	100-200
Methanol	300-400
Methyl methacrylate	600-700
Calcium fluoride	700-800
Potassium hydroxide	50-1000

Drivers

- **Increased pollutants** loading limits POTWs' ability to treat industrial discharges

- **Difficult to treat complex water matrix**
  - Corrosive, alkaline wastewater (pH ~12)
  - Toxic and persistent organic compounds
  - Inhibitory to biological processes



(e.g. **TMAH**).

- Limited information on pilot/full scale demonstration of >95% TOC and TN removal from high strength microelectronics WW.

Objectives

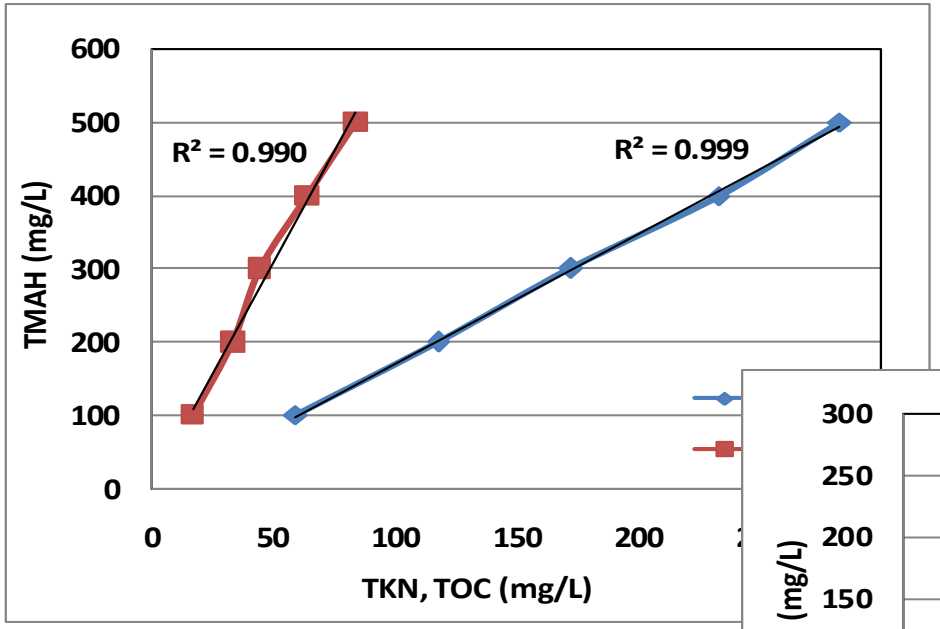
- Develop a sustainable solution for microelectronics WW treatment
  - Investigate biodegradability of toxic substances (e.g. TMAH)
  - Evaluate nitrification and denitrification options
  - Achieve >98% TMAH degradation, >95% TOC and TN removal
  - Develop design, operational and kinetic parameters.

Waste Characteristics

- **Waste stream #1: Organic rich combined waste**
- **Waste stream #2: Segregated waste (TMAH only)**

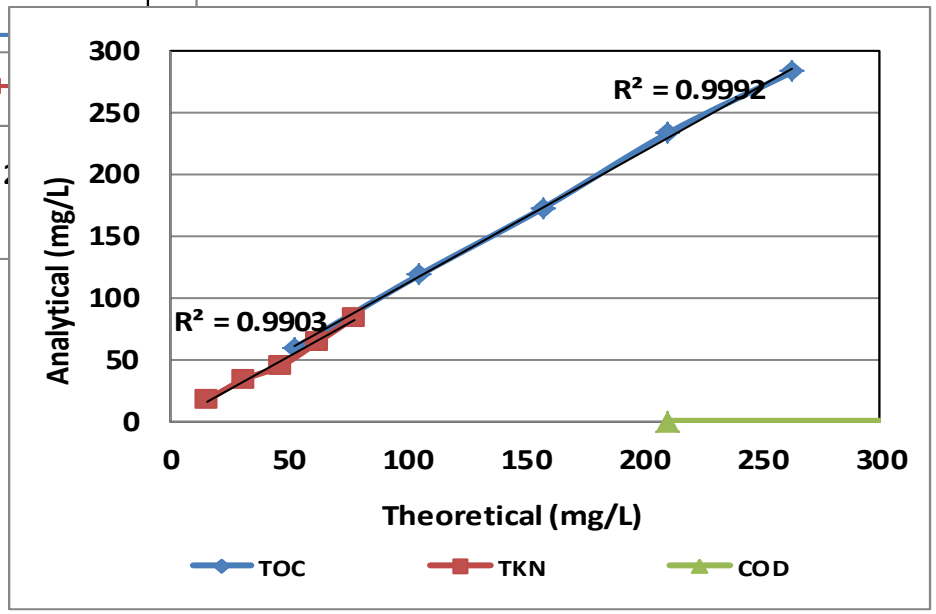
Parameter	Waste Stream #1	Waste Stream #2
pH	>12	>12
TMAH (mg/L)	49,762	23,000
TOC (mg/L)	79,528	17,561
TN (mg/L)	9,311	4,675
COD (mg/L)	174,024	n/a

TOC, TKN Correlation with TMAH

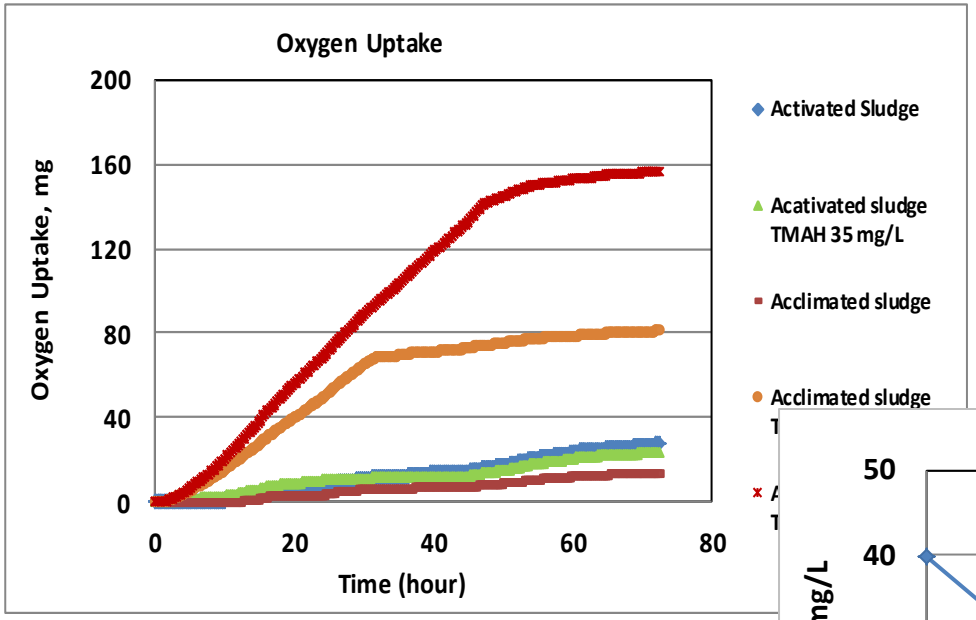


Analytical correlations:

TOC/TMAH = 0.527
TKN/TMAH = 0.154

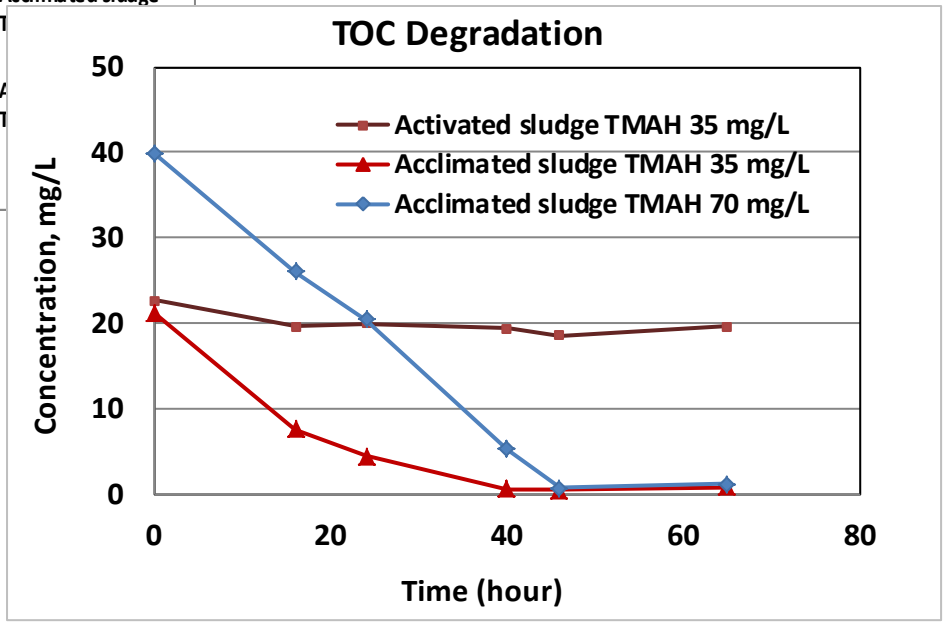


TMAH Biodegradation



Respirometer testing: biodegradation of TMAH using AS and acclimated biomass

OU for degradation of TOC/TMAH and formation of ammonia-nitrogen

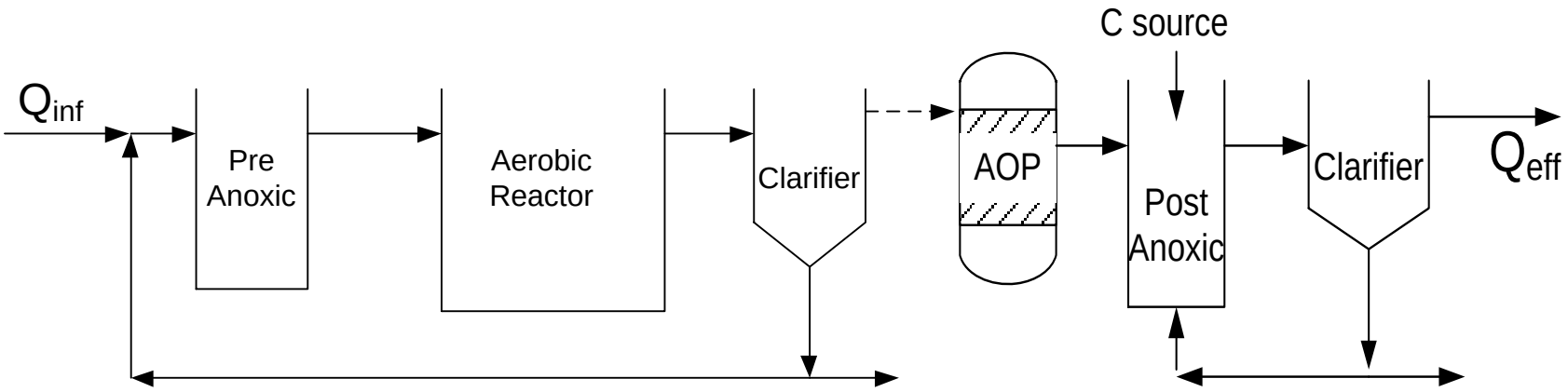


Waste Stream #1

Pre-Anoxic + Aerobic + Clarifier + Aerobic + Clarifier

or

Pre-Anoxic + Aerobic + Clarifier + AOP + Post-Anoxic + Clarifier

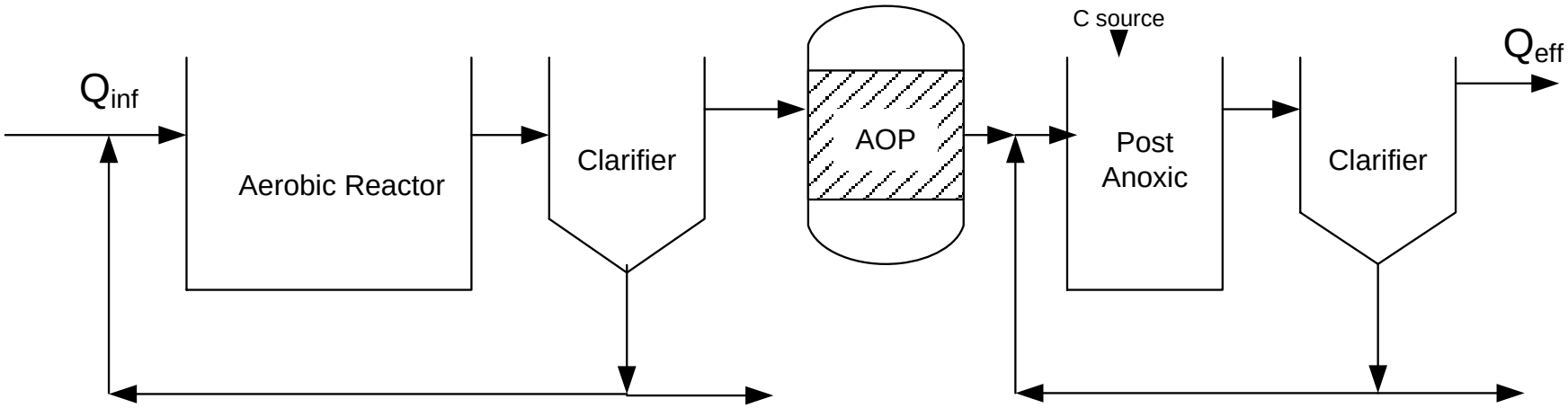


Waste Stream #1: Lab-scale Test Data

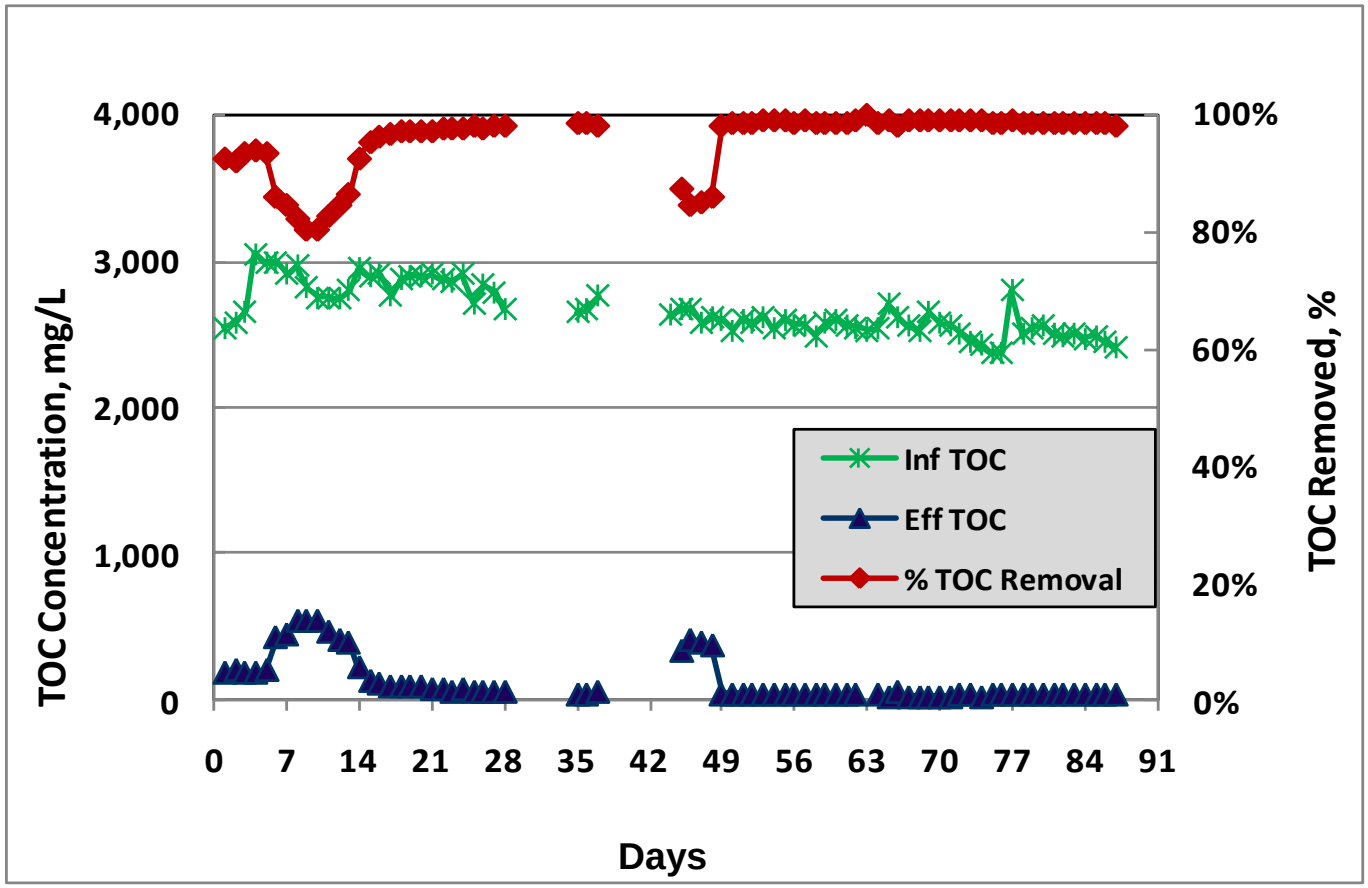
	Influent	Anoxic	Aerobic	AOP	Post Anoxic	Effluent	Removal
COD (mg/L)	2,600	925	85	<30	n/a	n/a	**>98%**
TOC (mg/L)	1,350	450	60	<30	n/a	n/a	**>98%**
NH_4-N (mg/L)	14	56	106	<1.0	n/a	3	**>98%**
NO_3-N (mg/L)	<0.4	<0.4	<0.4	97	<0.4	<0.4	**n/a**
TKN (mg/L)	165	141	118	33	n/a	27	**>80%**

Waste Stream #2

Aerobic + Clarifier + AOP + Post-Anoxic + Clarifier



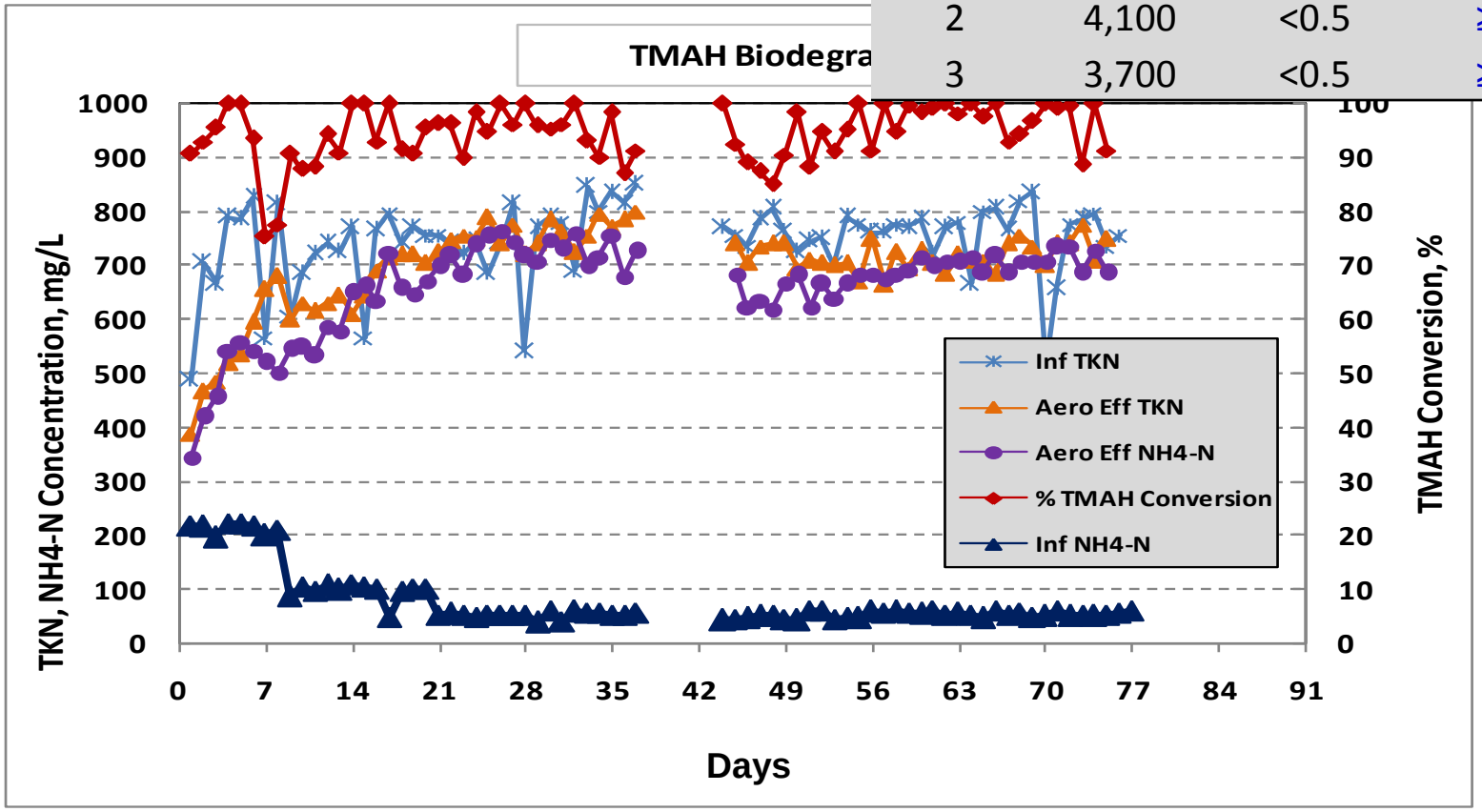
West Stream #2: Bench-scale Test Results



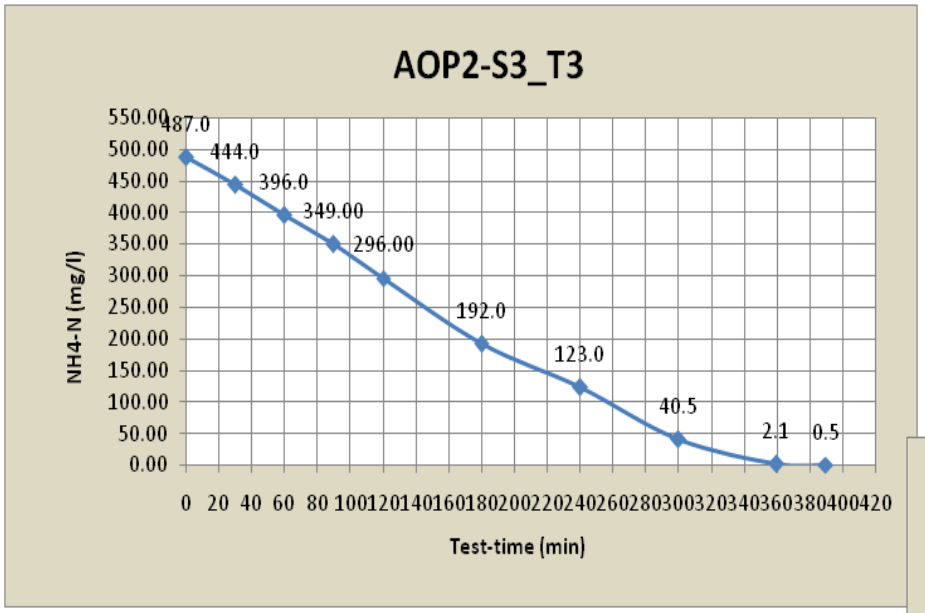
West Stream #2: Bench-scale Test Results

Influent TN 750 mg/L
Aerobic effluent NH_4-N 670 mg/L
Effluent TN <30 mg/L

Sample	Influent TMAH (mg/L)	Effluent TMAH (mg/L)	% Removal
1	4,000	39	≥99%
2	4,100	<0.5	≥99%
3	3,700	<0.5	≥99%

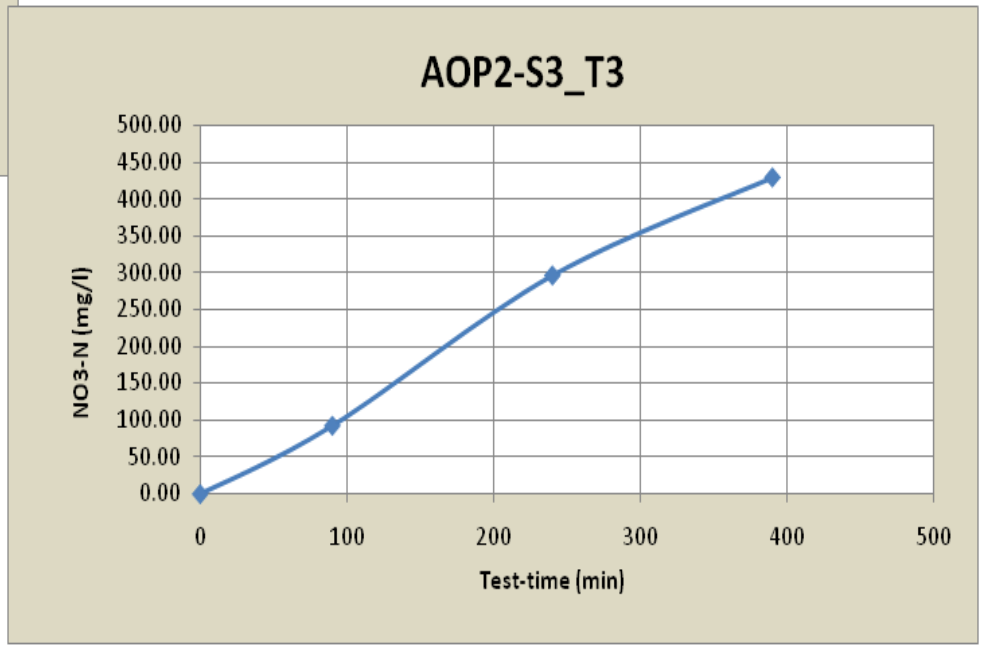


West Stream #2: Bench-scale Test Results



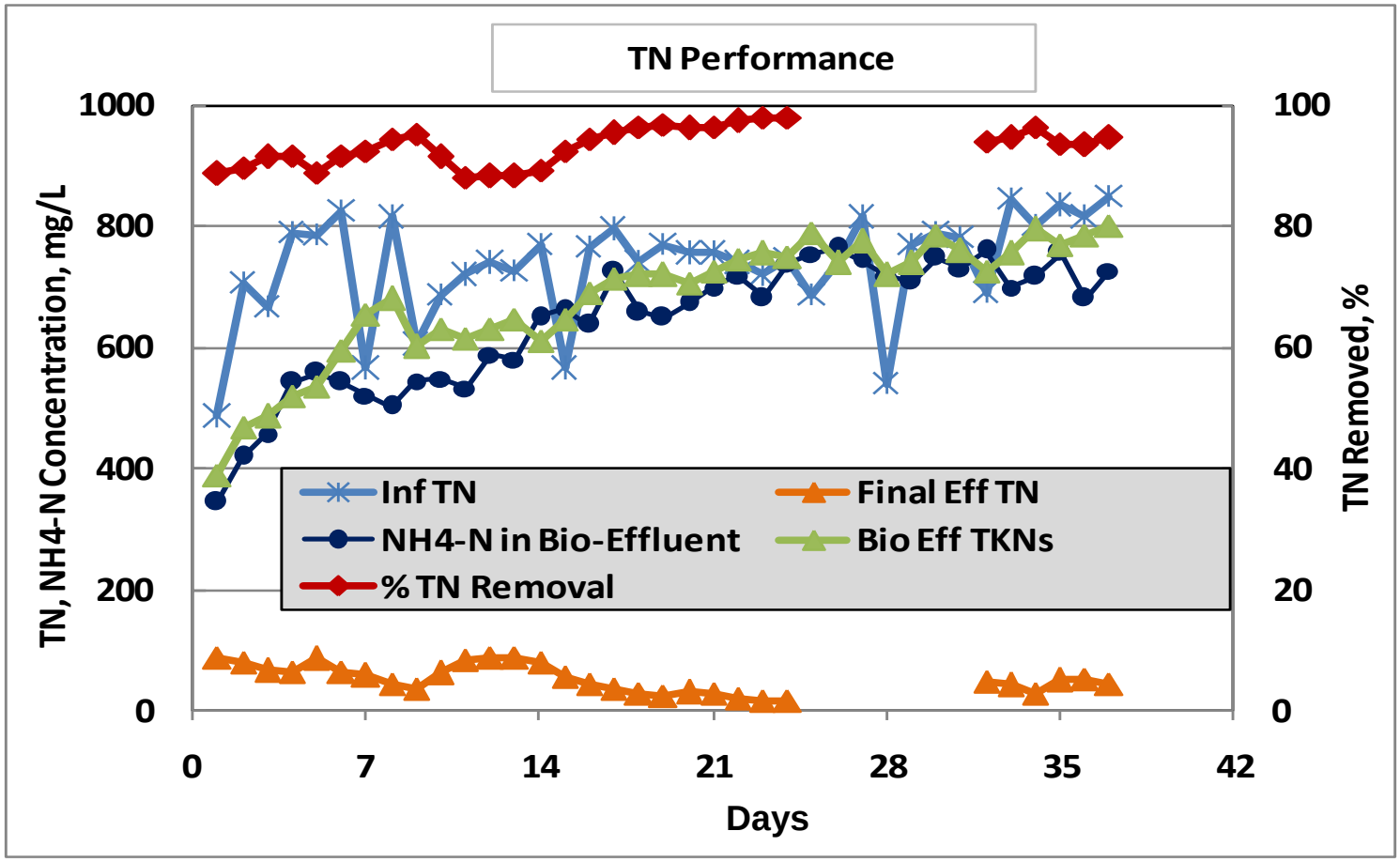
AOP: Ozonation

NH_4-N ⟶ NO_3-N



West Stream #2: Bench-scale Test Results

Aerobic degradation – AOP (nitrification) – Anoxic (biological de-nitrification)



West Stream #2: Bench-scale Test Results

Aerobic-AOP-Anoxic for TMAH treatment

	Influent	Aerobic	AOP	Anoxic	Effluent	Removal
COD (mg/L)	<30	201	67	n/a	n/a	n/a
TOC (mg/L)	2,800	80	n/a	n/a	n/a	>98%
NH_4-N (mg/L)	7	690	8	n/a	6.4	n/a
NO_3-N (mg/L)	<0.4	<0.4	610	<0.4	<0.4	n/a
NO_2-N (mg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	n/a
TKN (mg/L)	750	715	30	n/a	26	>95%
TMAH (mg/L)	4,000	n/a	n/a	n/a	BDL	>99%

Findings

- **Combination of AOP and Biological treatment** provides a complete treatment solution for microelectronics wastewater

  - Aerobic biodegradation of TMAH generated ammonia-nitrogen even at TMAH of 4000 mg/L. Biological nitrification was not observed throughout the study

  - Ozonation (AOP) completely nitrify ammonia-nitrogen generated from the aerobic biodegradation of TMAH

  - >98% TMAH degradation, and >95% TOC and TN were achieved.

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Thank You!

Questions & Answers

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