

ESAA Remediation Technologies Symposium

Solar Detoxification – Treatment of Contaminated Groundwater

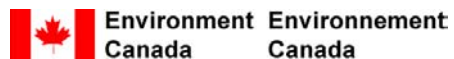
Bill Wong, P.Eng. SAIC Canada

R&D Performed by: SAIC Canada

**Financial Support by: PERD, Environment Canada and
Natural Resources Canada**

Technical Support by: Natural Resources Canada

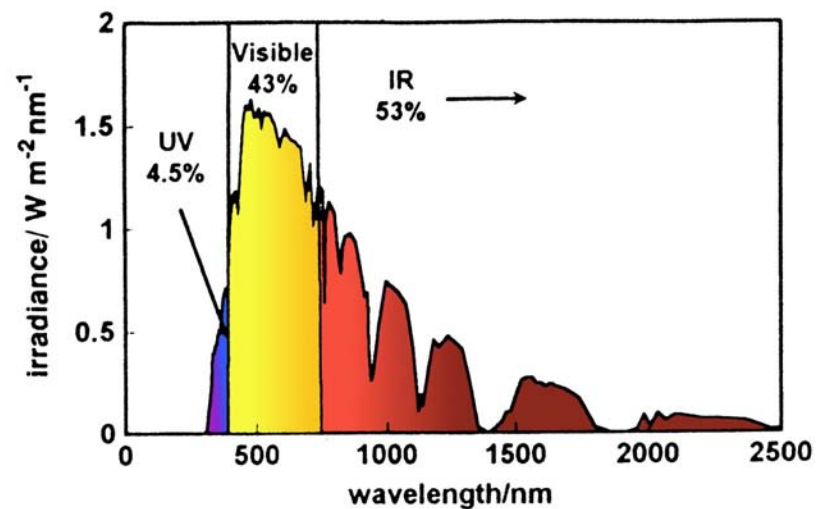
Industrial Partner: Trans Mountain Pipeline Company Ltd.



Conventional Photo-oxidation: Hydrogen Peroxide + UV*

—————> **iOH** Radicals

* UV < 300 nm



Solar Spectral Irradiance Distribution

**Solar Radiation +
Hydrogen Peroxide + Catalyst** —————> **iOH** Radicals

Solar Detoxification – Solaqua® Process

(Bolton, Cater, Safarzadeh)

- Uses ferrioxalate as a photochemical agent
- Ferrioxalate absorbs UV and visible light up to 500 nm
- Ferrioxalate: complex of iron(III) and oxalic acid

- Photolysis of ferrioxalate generates iron(II)
- Iron(II) reacts with peroxide to generate hydroxyl radical
- Hydroxyl radical breaks down organic contaminants

Solar Detoxification – R&D Activities

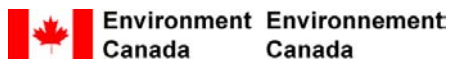
**1992 Developed at University of Western Ontario
(Bolton, Cater, Safarzadeh)**

2000 Bench-scale testing at SAIC Canada (spiked solution)

2001 Field-scale testing at a landfill site

2001 Bench-scale testing treating BTEX, MTBE and MMT

2002 Field demonstration treating benzene and MTBE





Landfill Site (Ottawa, Ontario)



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Objective:

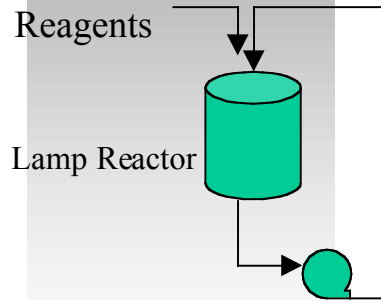
- Continue development of solar detoxification process for the treatment of Contaminated Groundwater

Scope:

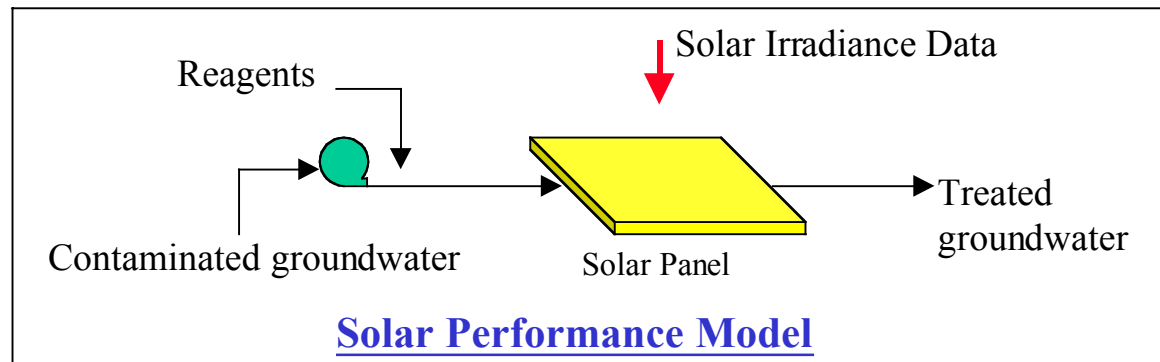
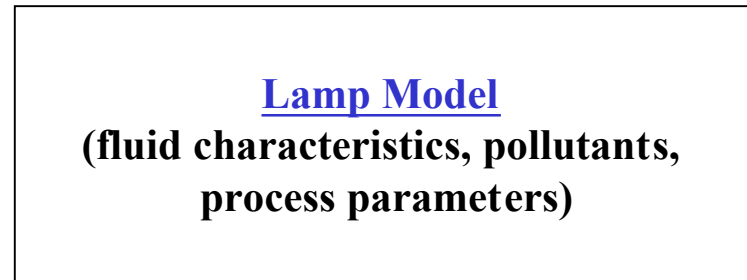
- Bench-scale testing (process optimization)
- Process Model Development
- Pilot-scale testing at National Solar Testing Facility
- Field Demonstration

Researchers: Dr. Shamil Cathum / Dr. Kostantin Volchek
Dr. Stephen Cater
Bill Wong

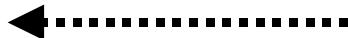
Solar Detoxification R&D Approach



Bench-scale Equipment
with artificial photon source
treating contaminated water



System Design and Performance Prediction



Check Process
Model at NSTF

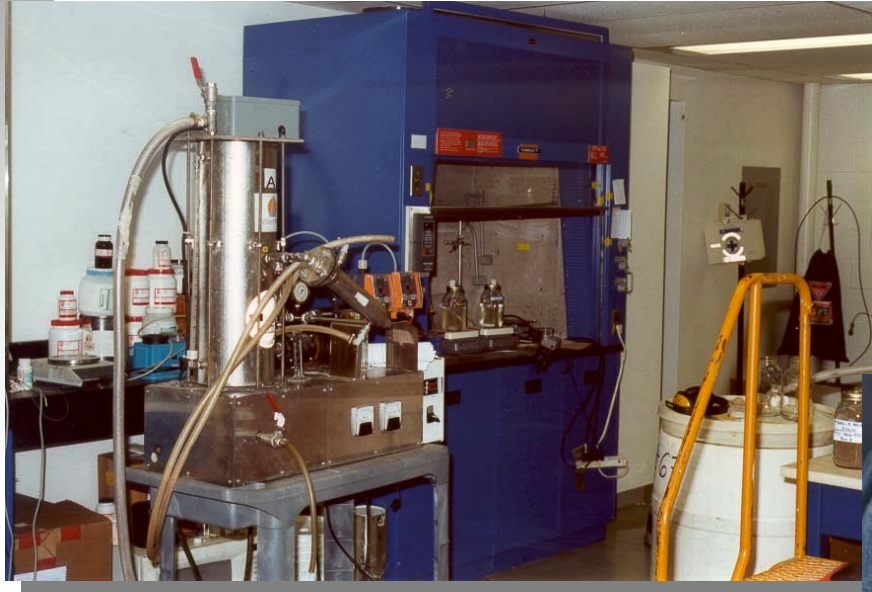


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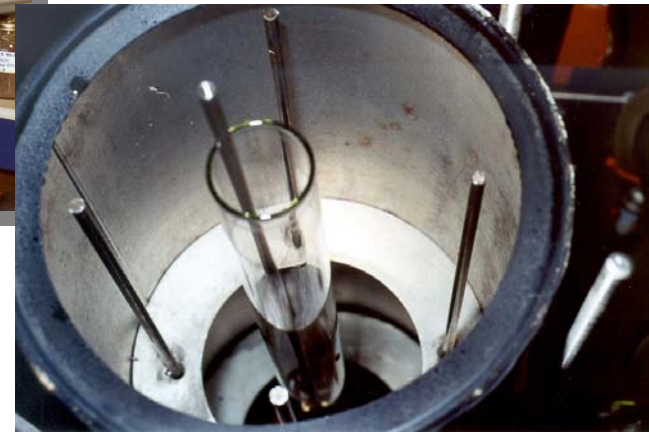
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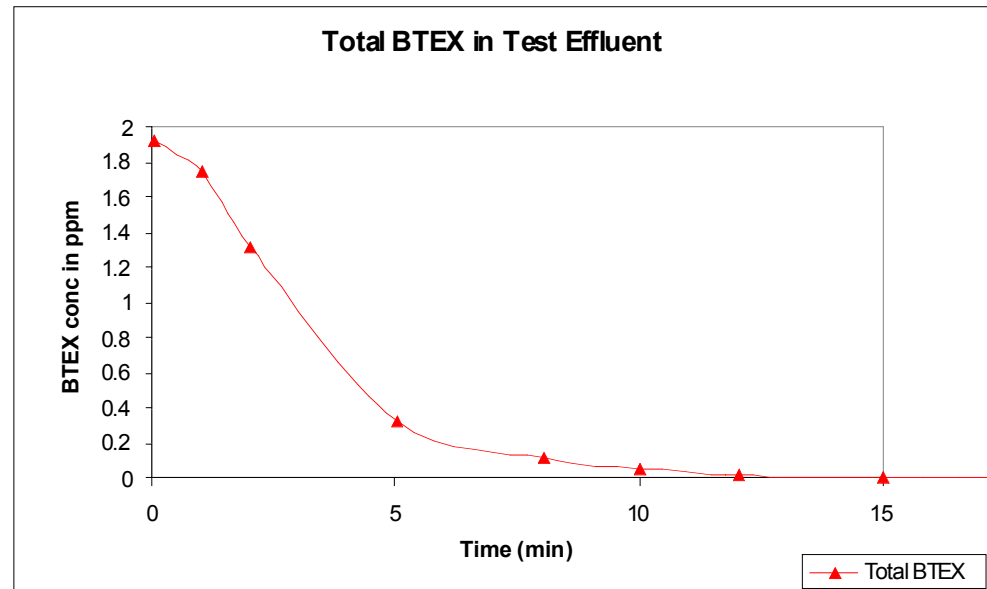
Compounds Tested:

- BTEX
- MTBE
- MMT



Bench-scale Advanced Oxidation Process (AOP) system
Pyrex sleeve over mercury vapour lamp
pH control, recirculation pump, plumbing, sampling port

Typical BTEX concentration vs. exposure time



Process Parameters: 25 ppm FeOx, 350 ppm hydrogen peroxide at pH 4

SAIC SOLAQUA SIZING MODEL		<i>CONFIDENTIAL: LAMP OUTPUT NOT TO BE DISCLOSED</i>				Author:	SRC
Example	MTBE in Groundwater	<i>Inputs are in yellow, outputs are in red</i>				Version:	1.4
						Date:	3/19/2002
Ferrioxalate (ppm Fe):	25	ppm	Material:	2	<i>1=quartz, 2 = pyrex</i>		
Pathlength:	10	cm					
Volume:	12	L	Abs Type:	2	<i>1=tap, 2=ground, 3=waste, 4=leachate, 5=user</i>		
pH:	4						
Pollutant Concentration:	1	ppm					
Pollutant Molecular Wgt:	88		Pollutant Concentration:	1.14E-05	moles/L		
Peroxide Concentration:	350	ppm	<i>(choose a value = COD of water, min = 25 ppm)</i>				
Pollutant Type:	1	1,2, or 3	<i>1=fast=BTEX,TCE; 2=med=MEK,MTBE; 3=slow=DCA,CHCl3, acetone</i>				
Water Type:	2	1,2, or 3	<i>1=low=spiked tap water, 2=med=ground, 3=high=leachate</i>				
Absorbed 1 kW Lamp Flux:		2.75E-03	ein/min/L	3.31E-02	ein/min		
Reactivity Factor:		0.0006	0.0003				
Pollutant Factor:		1					
pH Factor:		0.8					
Pollutant Removal Rate:		27.93	%/min	<i>(for first 90% removal only)</i>			

Lamp Model Output



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SAIC SOLAQUA SIZING MODEL

Solar Panel Sizing Model

CONFIDENTIAL

Inputs are in yellow, outputs are in red

Author: SRC
Version: 1.2
Date: 2/25/2002

Ferrioxalate (ppm Fe):	25	ppm	Cover:	2	1=nothing, 2 = acrylic
Pathlength:	2.5	cm	Area:	2.97	m ²
Volume:	74.25	L	Abs Type:	2	1=tap, 2=ground, 3=waste, 4=leachate, 5=user
pH:	4		Flow rate:	100	L/min
Pollutant Concentration:	1	ppm	UV Source:	S	S=sun, L=lamp
Pollutant Molecular Wgt:	88		Pollutant Concentration:	1.14E-05	moles/L
Peroxide Concentration:	350	ppm	<i>(choose a value = COD of water, min = 25 ppm)</i>		
Pollutant Type:	1	1,2, or 3	1=fast=BTEX, TCE; 2=med=MEK, MTBE; 3=slow=DCA, CHCl3, acetone		
Water Type:	2	1,2, or 3	1=low=spiked tap water, 2=med=ground, 3=high=leachate		
City Code:	C		Date:	12-Feb	43
City Name:	Calgary, AB		Time:	8	8-16 hrs
Latitude:	51.02	degrees	Daily Zenith Angle:	71.97	avg for day
Elevation:	3439	feet	Hourly Zenith Angle:	86.99	approximate instantaneous angle
Lamp incident irradiance:	1000	w/m ²	Average Zenith Angle:	59.77	avg for year
Average, daily or hourly:	A	A,D or H	Zenith Angle Used:	59.77	
Absorbed Flux:		5.98E-04	ein/min/L	4.44E-02	ein/min
Reactivity Factor:		0.0008	0.0003		
Pollutant Factor:		1			
pH Factor:		0.8			
Average Pollutant Removal Rate:		50.0	%/min	<i>(for first 90% removal only)</i>	
Removal Rate per pass:		37.2	%		

Solar Performance Model Output



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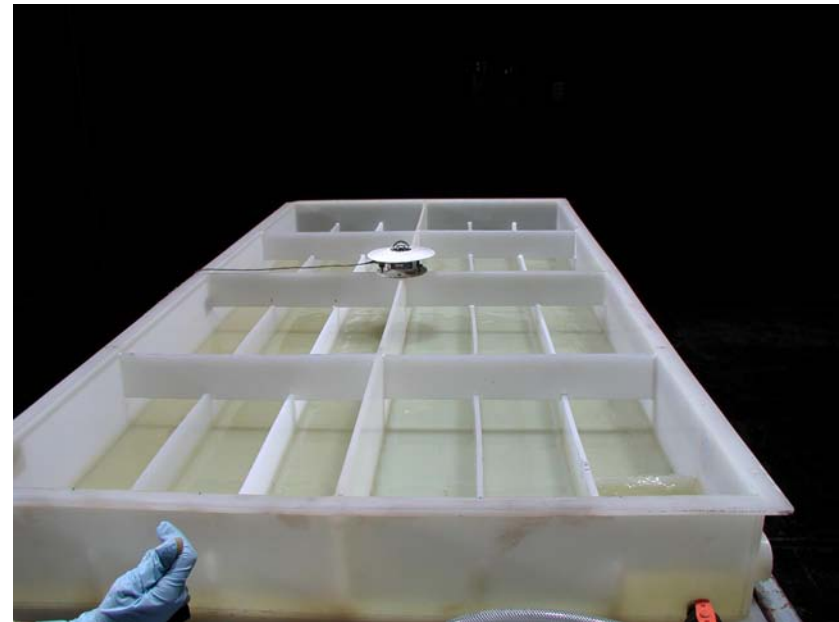
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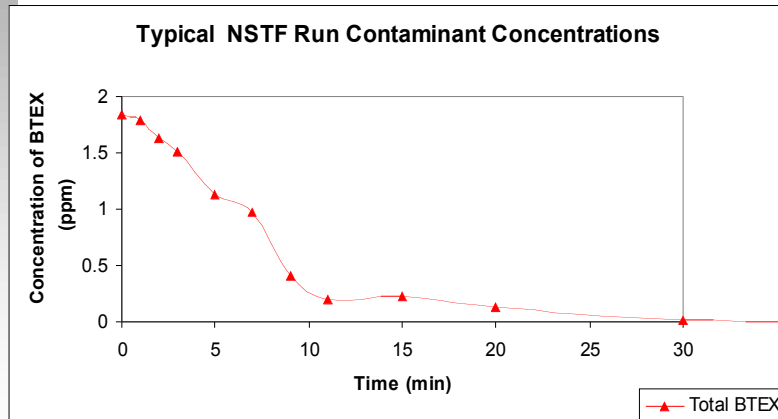
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National Solar Testing Facility (NSTF)
150 kW Vortek solar simulator
(150-1120 watts per square meter)





Run #	Bench-scale Degradation Rate	Lamp Model Degradation Rate	Pollutant Factor	Solar Model Predicted Degradation Rate	Measured Degradation Rate at NSTF
A	20%	21%	0.0002	25%	21%
B	10%	10%	0.0004	13%	10%
C	20%	21%	0.0035	27%	10%

Field Demonstration

Trans Mountain Pipeline Company Ltd. Sumas Pump Station
Abbotsford, British Columbia (August-September 2002)



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Implications for Industry :

- Renewable energy based technology for contaminant destruction

Future Work:

- Complete analysis and field demonstration report (winter 2002)
- Solar panel design and prototype testing
- Design notes

Other environmental applications:

- Remediation of industrial wastewater



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