

# HUMASORB®

*Solution To Pollution*

**Low Cost for Simultaneous Cleanup of Heavy  
Metals, Radionuclides and Organics**

**Metals, Radionuclides, Organics**

**Multi-Purpose Adsorber**

**High Cation-Exchange Capacity**

**Can Be Regenerated**

**Cost-Effective**

**Environmentally Friendly**

**January 2023**

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**ARCTECH, Inc.**

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**[www.arctech.com](http://www.arctech.com)**



*Preserving tomorrow's world... today*

# ARCTECH Corporate Profile

- Established in 1988 as Spin-Off Company
  - From a Major US Aerospace Company
- Corporate Headquarters & Technical Research Center
  - Chantilly, Virginia
- Manufacturing Plant
  - South Boston, Virginia
- Market Profile: Develop Innovative Solutions from Concept to Implementation for the Energy, Environmental, and Agricultural markets
- Commercial Products Applications in the US, Egypt, Gulf Countries, & South Korea
- Creating Biotechnology Solutions since Mid 70's
- Selected as One of the Top Six Bio-Processing Firms in the United States
  - By Ernst & Young in 1989
- Founding Member of *Humic Products Trade Association (HPTA)* in 2011



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# WATER & SOCIETY ISSUES

- 💧 Water, organic matter and heat energy are absolute essentials for sustaining life
- 💧 Water is controlled and uncontrolled resource on our planet
- 💧 Clean water must be available at affordable cost for everyone

**WATER QUALITY TODAY IS A MAJOR ISSUE**



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# CONTAMINANTS OF CONCERN IN WATER

- 💧 Suspended Solids – Insoluble metal salts, soil and sludge particles
- 💧 Organics – Petroleum and chlorinated hydrocarbons, pesticides
- 💧 Metals – Heavy metals and radionuclides
- 💧 Anions – Nitrate, phosphate, sulfate
- 💧 Microbes – Coliform, Cryptosporidium sp. , Giardia sp.
- 💧 Viruses – Norwalk



# STATE-OF-THE- ART Water Treatment Technology

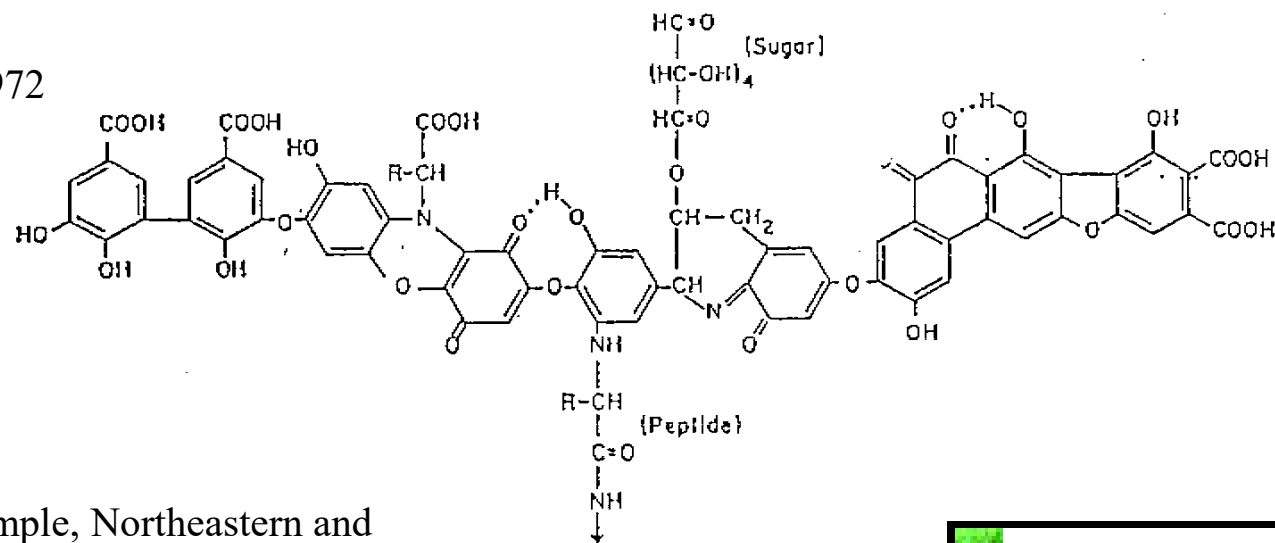
- 💧 Filtration – Charcoal, activated carbon, sand
- 💧 Resins – Cation and anion exchange
- 💧 Membrane Separation - Reverse Osmosis, hollow fibers
- 💧 Chemical Oxidation – Peroxide, ozone, chlorination, UV
- 💧 Chemical Reduction
- 💧 Chemical precipitation – Lime addition
- 💧 Biological – Aerobic and anaerobic



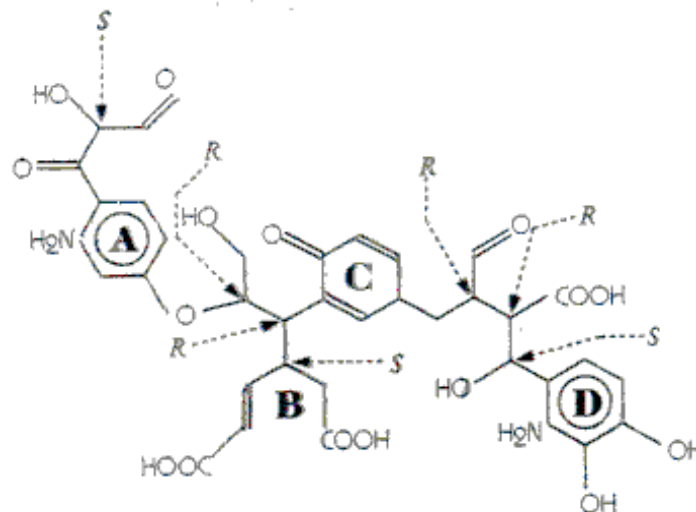
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# MODELS OF HUMIC ACID MOLECULE

A. Stevenson, 1972

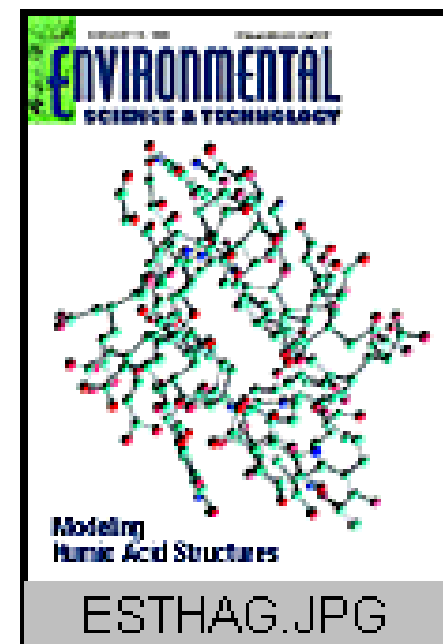


B. TNB, 1998 (Temple, Northeastern and Birmingham)



Empirical Formula:  $C_{36}H_{30}O_{15}N_2 \cdot xH_2O$

$x=0-15$



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# Why HUMASORB® for Water Application?

## *Issues of Today*

- ❖ 122 Trillion Gallons of Wastewater Per Year Need to be Treated
- ❖ Large Undergrounds Watersheds Remain Contaminated Because of High Costs
- ❖ Safe Drinking Water Becoming Scarce and Costly
- ❖ Impaired Irrigation Water Supply

## *HUMASORB® Solutions*

- ❖ HUMASORB® can Cost-Effectively Treat Toxic Organic, Metals, Radionuclides and Pathogens
- ❖ HUMASORB® for Cost- Effective Subsurface Barrier Treatment
- ❖ HUMASORB® Effective for Removing Toxic Contaminants from Drinking Water
- ❖ HUMASORB® can Recycle Wastewaters into Organic Fertilizers.



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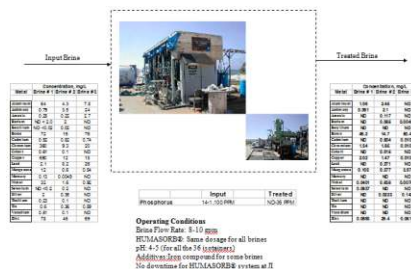


# HUMASORB® Product and Technology Applications Proven in Multiple Markets

## Military Wastes Applications

### HUMASORB® TREATED AND DISPOSED SPENT DECONTAMINATION SOLUTION FROM US ARMY CHEMICAL WEAPONS DEMIL FACILITY AT JOHNSTON ATOLL

US ARMY



- Successfully completed treatment of approximately 24,000 gallons of Spent Decontamination Solution (SDS) that contained RCRA hazardous levels of arsenic, lead and mercury.

### DESTRUCTION OF LEWISITE IN TON CONTAINER SLUDGE AND ONSITE SECONDARY WASTE MANAGEMENT AT PINE BLUFF ARSENAL WITH HUMASORB® TECHNOLOGY

US Army Chemical Material Agency and EAI Corporation

- Pine Bluff Arsenal (PBA) has approximately 4,400-Ton Containers (TCs) requiring final disposal. The ton containers were originally used to store variety of chemical agents since almost World War I.
- The micro-scale destruction experiments were conducted by EAI Corporation in 15-mL glass vials with TFE/silicone lined phenolic caps. A total of 24 decontamination reagents were evaluated by EAI, including five (5) HUMASORB decontamination reagents. Only HUMASORB reagents included hydrolysis, oxidation and adsorption mechanisms.
- HUMASORB decontamination reagents were effective even at 100°F compared to other reagents, which required higher temperatures (150 or 180°F).
- The results from the secondary waste minimization tests show that after the HUMASORB® treatment, arsenic levels are reduced to non-detect levels (Detection Limit: 0.6 ppm). The Resource Conservation and Recovery Act (RCRA) limit for arsenic is 5 ppm.

### HUMASORB® and Advanced Actodemil® Neutralization Technology for Safe Destruction of Picric Acid and Arsenic

KOBE STEEL, LTD

Table 1. Results of Analyses for Contaminants in the Treated Sample

Compound	Concentration	Regulatory Limit
Arsenic	ND	5.0 mg/L TCLP
Barium	1.3 mg/L TCLP	100 mg/L TCLP
Cadmium	ND	1.0 mg/L TCLP
Chromium	1.3 mg/L TCLP	5.0 mg/L TCLP
Lead	ND	5.0 mg/L TCLP
Mercury	ND	0.2 mg/L TCLP
Selenium	ND	1.0 mg/L TCLP
Silver	ND	5.0 mg/L TCLP
Semivolatile Organic Compounds – None Detected		
Volatile Organic Compounds – None Detected		

- Using the Actodemil® technology for destruction of the explosive material picric acid from aqueous solution and the HUMASORB® technology for the removal of As (V) from an aqueous solution.
- initial concentration of picric acid of 6,600 mg/L. However, picric acid was not detected after treatment with the a-HAX reactant. A summary of the results from the TCLP analyses are presented in Table 1. No organic compounds were detected.

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# HUMASORB® Product and Technology Applications Proven in Multiple Markets

## Industrial Wastes Applications

**HUMASORB® REMOVING MERCURY <5 ppt AND PCB NON-DETECT FROM STORM WATER AT A SCRAP METAL YARD IN MICHIGAN**

- To date over 3 million gallons of wastewater has been treated without requiring HUMASORB® replacing.



**HUMASORB® TECHNOLOGY DEMONSTRATED FOR REMEDIATION OF METAL-CONTAMINATED TANNERY AND ELECTROPLATING WASTE STREAMS IN INDIA**

- For treatment of waste streams containing multiple metals in India. The results with the streams from the tannery showed chromium removal of more than 93-99% and with electroplating streams containing multiple toxic metals, the removal of metals was more than 95%.

National Association of State Development Agencies, Washington, D.C.

**Technical Feasibility of Polychlorinated Biphenyls (PCBs) Removal from Liquids by HUMASORB®-CS**

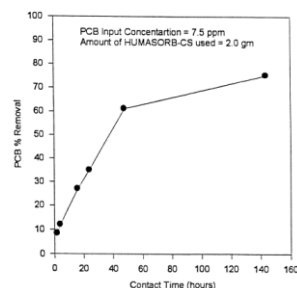


Table 1. PCBs Removal with HUMASORB®-CS

Contact Time, hours	Input concentration, ppm	Output concentration, ppm	Removal %
24	7.511	4.9	35
48	7.511	2.95	61
144	7.511	1.87	75
168	7.511	2.03	73

Table 2. Extraction of PCBs from Spent HUMASORB®-CS

Contact Time, hours	PCBs concentration, ppm	Recovery %
1	5.81	52
24	8.22	73
48	8.76	78
72	8.81	78

- HUMASORB® technology successfully adapted to provide a solution to Mason & Hanger at the Iowa Army Ammunition Plant for the simultaneous destruction of M30 propellant and recovery of Depleted Uranium (DU) contamination.

**Feasibility Tests with HUMASORB® for Removal of Ba and Sr from Frac Wastewater**

Sample ID		Sample C F Sure only*		Frac Water NY	
Contaminants		Ba ppm	Sr ppm	Ba ppm	Sr ppm
Provided Data		1520	3120	13.7	50.8
HUMASORB®-CS	Untreated	1313.2	2762.4	5.7	44.0
	Treated	797.7	2177.5	0.318	7.0
	Reduction %	39.26	21.17	94.39	84.06



HUMASORB®-CS Treated and Untreated Frac Wastewater



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# HUMASORB® Product and Technology Applications Proven in Multiple Markets

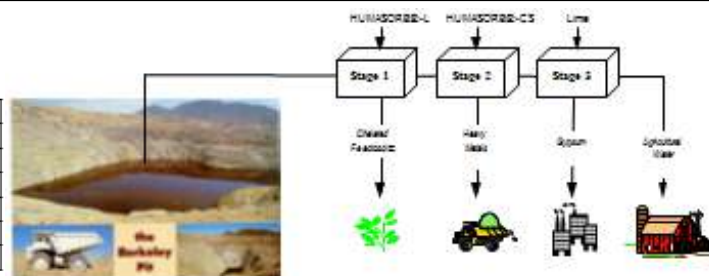
## Mining Industry Wastes Applications

### HUMASORB® TECHNOLOGY DEMONSTRATED FOR RESOURCE RECOVERY FROM BERKELEY PIT ACID WATERS IN BUTTE, MONTANA

U.S. Department of Energy/MSE Technology Applications, Inc.

#### PILOT TESTING RESULTS

METALS	DEMONSTRATION OBJECTIVES	PROCESS PERFORMANCE
Arsenic	< 0.5 ppm in product	0.294-0.481 ppm in product
Cadmium	< 0.5 ppm in product	0.280-0.360 ppm in product
Cadmium	> 70% Removal in Stage 2	67.56-98.93 % Removal in Stage 2
Copper	> 70% Removal in Stage 2	85.44-99.96 % Removal in Stage 2
Iron	> 70% Removal in Stage 2	73.15-99.97 % Removal in Stage 2
Zinc	> 70% Removal in Stage 2	48.02-99.90 % Removal in Stage 2

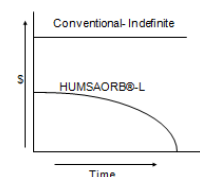


- ARCTECH's HUMASORB® process is an effective approach for economically viable treatment of acid mine waters such as Berkeley Pit water.

### Demonstration of HUMASORB® Technology for In-situ Treatment of Acid Mine Drainage in the Abandoned Tide Mine Site, Indiana County, PA

Pennsylvania Department of Environmental Protection (PA DEP) and Blacklick Creek Watershed Association, Inc.

- HUMASORB®-L treatment meets the success criteria for removing metals to > 90% and raising the pH to more than two units, criteria set forth for this project by the PA DEP.
- The HUMASORB®-L treated acid mine water enhances growth of SRB which can lead to improving the operation of the passive treatment system.
- HUMASORB®-L system can be easily deployed at mine sites.
- HUMASORB®-L can be utilized as active treatment for metal recovery as a micronutrient fertilizers.
- HUMASORB®-L Offers Lower Life Cycle Costs for AMD Treatment



### HUMASORB®-CS Feasibility Test for Selenium and Other Toxic Chemicals from the Runoff Water from Coal Waste Pile at Mammoth Coal Co., Montgomery, WV

- Selenium and Other Toxic Chemicals are Removed from the Runoff Water from Coal Waste Pile.

Toxic Metal	Untreated, ppb	HUMASORB Treated, ppb	NPDES Permit Limit
As	24	n.d.	n.a.
Cd	n.d.	n.d.	n.a.
Cr	n.d.	n.d.	n.a.
Hg	n.d.	n.d.	n.a.
Pb	n.d.	n.d.	n.a.
Se	13	n.d.	8 ppb

n.d. = not detected  
n.a. = not available  
Sample Submitted by SNF Flomin, Inc.



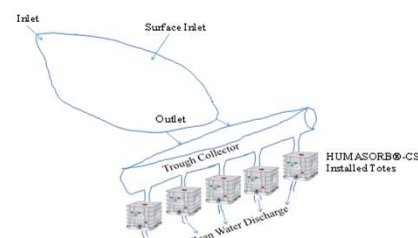
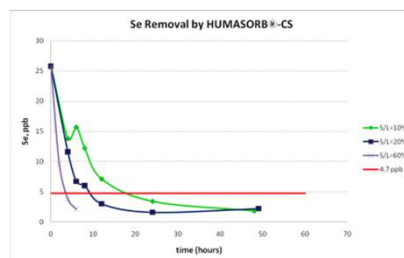
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# HUMASORB® Product and Technology Applications Proven in Multiple Markets

## Mining Industry Wastes Applications

### HUMASORB® Treatment for Selenium Removal from Coal Mine Discharge Water in West Virginia

- HUMASORB®-CS had good capability to remove Se in the WV Coal Mine Discharge water that can meet the more stringent NPDES regulation. About three hours contact time with 60% of S/L loading, selenium went down less than 4.7 ppb.

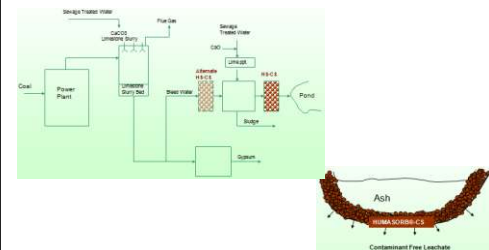


HUMASORB®-CS Implementation Approach for Removal of Selenium from Coal Mine Discharge Wastewater.

## Power Plant Wastes Applications

### HUMASORB®-CS Feasibility Test Showed that Toxic Metals are Removed from Spent Scrubber Wastewaters at Dominion Resources Chesterfield Power Plant-Virginia

#### Dominion Resources



Toxic Metals (mg/L)	Chesterfield Units Bleed Slurry (2/25/2010)		Chesterfield WWTP Effluent (2/25/2010)		Regulatory Limit	HUMASORB® Compliance
	Initial	HUMASORB® Treated	Initial	HUMASORB® Treated		
As	0.598	nd	0.696	nd	0.20	Yes
Ba	0.427	0.33	0.416	0.303	3.00	Yes
Cd	0.108	nd	0.119	nd	0.05	Yes
Cr	0.175	nd	0.150	nd	0.60	Yes
Hg	0.735	nd	0.674	nd	0.05	Yes
Pb	6.966	nd	5.832	nd	0.10	Yes
Se	1.030	0.133	1.070	0.103	2.00	Yes
Ag	nd	nd	nd	nd	0.10	Yes
Cu	nd	nd	nd	nd	0.10	Yes
Fe	nd	nd	0.155	nd	1.00	Yes
Ni	1.084	nd	0.143	nd	0.50	Yes
Ti	0.87	nd	0.799	0.011	0.50	Yes
Zn	1.801	nd	0.067	nd	0.10	Yes

nd: not detected

scrubber waste water

Toxic Metals (mg/L)	Ash Pond Leachate (mg/L)			HUMASORB® Treated (mg/L)			TCLP Hazardous Waste Limit, mg/L
	pH3	pH5	pH6.5	pH3	pH5	pH6.5	
As	1.163	1.135	1.580	nd	nd	nd	5.0
Ba	1.220	0.608	0.680	0.011	0.006	0.003	100.0
Cd	0.193	0.183	0.183	nd	nd	nd	1.0
Cr	0.090	0.090	0.095	nd	nd	0.006	5.0
Hg	nd	nd	nd	nd	nd	nd	0.2
Pb	1.055	1.118	1.028	nd	0.052	0.037	5.0
Se	1.165	1.215	1.585	nd	nd	nd	1.0
Ag	nd	nd	nd	nd	nd	nd	5.0
Cu	9.023	nd	nd	nd	nd	nd	
Fe	0.633	nd	nd	nd	nd	nd	
Ni	2.315	1.258	0.193	0.045	0.072	0.011	
Ti	1.345	1.208	1.238	nd	nd	0.045	
Zn	1.003	0.143	nd	nd	nd	nd	

nd: not detected

TCLP: Toxicity Characteristic Leaching Procedure

ash pond leachate



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# HUMASORB® Product and Technology Applications Proven in Multiple Markets

## Municipal Wastes Applications

### HUMASORB®-CS Amended Smart Sponge® Feasibility Proven For Removal of Toxic Metals, PCB and Oils

AbTech Industries Inc.

- All RCRA heavy metal mix (As, Ba, Cd, Cr, Pb, Hg, Se and Ag) and Cu are removed completely to 100% by HUMASORB®-CS amended Smart Sponge® except As. Removal % of As was 95.7%.

- The result of TCLP test shows that heavy metal leaching complies with the TCLP Regulatory Level.

Metal	Leachate, ppm	TCLP Regulatory Level, ppm	Compliance
Ag	ND	5	Yes
As	0.074	5	
Ba	0.034	100	
Cd	ND	1	
Cr	ND	5	
Cu	ND	Not Listed	
Hg	0.006	0.2	
Pb	0.92	5	
Se	ND	1	

- PCB removal was 43.75%.
- Phosphorus was removed 97.56 % by HUMASORB®-CS Amended Smart Sponge®.

## Drinking Water Applications

### HUMASORB® MATKA UNIT FOR SAFE DRINKING WATER

- MATKAs, a common word from the Hindi language and Kolshi in Bangladesh, are in common use in rural and poor households on the Indian subcontinent.



Tests conducted in Prototype HUMASORB® Matka System

Contaminant	Untreated Water, ppm	Treated Water, ppm	WHO Guideline for Drinking Water System, ppm
Lead	5-20	ND	0.01
Arsenic	5-20	ND	0.01
Chromium	5-20	ND	0.05
Fluoride	5-20	ND	1.50
Hardness	451	19.75	NE
Nitrate	95.54	ND	50

ND: Not Detected, NE: Not Established

ECO-FRIENDLY

- Total System under 300-500 Rupees for a 3-gallon (11 litres) MATKA
- Provide 300-360 gallons ( 1,130-1,360 litres of drinking water
- HUMASORB® recharge cost : less than 500 Rupees



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# HUMASORB® System is Robust to Treat Brines of Varying Characteristics Generated at Chemical Agent Disposal Sites

## Successful Operations with Brines of Varying Characteristics at JI

Input Brine

Metal	Concentration, mg/L		
	Brine # 1	Brine # 2	Brine # 3
Aluminum	64	4.3	7.8
Antimony	0.79	3.5	24
Arsenic	0.25	0.22	2.7
Barium	ND < 2.0	2	ND
Beryllium	ND < 0.02	0.02	ND
Boron	72	16	76
Cadmium	0.52	0.82	0.74
Chromium	360	9.3	20
Cobalt	0.61	0.1	ND
Copper	650	12	18
Lead	2.1	8.2	26
Manganese	12	0.6	0.54
Mercury	0.13	0.0049	ND
Nickel	32	1.6	0.92
Selenium	ND < 0.2	0.2	ND
Silver	2	0.35	ND
Thallium	0.23	0.1	ND
Tin	0.6	0.36	0.59
Vanadium	0.51	0.1	ND
Zinc	78	46	69



Treated Brine

Metal	Concentration, mg/L		
	Brine # 1	Brine # 2	Brine # 3
Aluminum	1.06	2.45	ND
Antimony	0.061	2.1	ND
Arsenic	ND	0.117	ND
Barium	ND	0.065	0.00433
Beryllium	ND	ND	ND
Boron	46.2	14.7	50.4
Cadmium	ND	0.504	0.0103
Chromium	1.84	1.65	0.0105
Cobalt	ND	0.015	ND
Copper	2.02	1.47	0.0105
Lead	ND	0.271	ND
Manganese	0.108	0.377	3.97
Mercury	ND	ND	ND
Nickel	0.0401	0.636	0.00766
Selenium	0.0637	ND	ND
Silver	ND	0.0223	0.143
Thallium	ND	ND	ND
Tin	ND	ND	ND
Vanadium	ND	ND	ND
Zinc	0.0693	29.4	0.0518

	Input	Treated
Phosphorus	14-1,100 PPM	ND-36 PPM

### Operating Conditions

Brine Flow Rate: 8-10 gpm

HUMASORB®: Same dosage for all brines

pH: 4-5 (for all the 36 isotainers)

Additives: Iron compound for some brines

No downtime for HUMASORB® system at JI

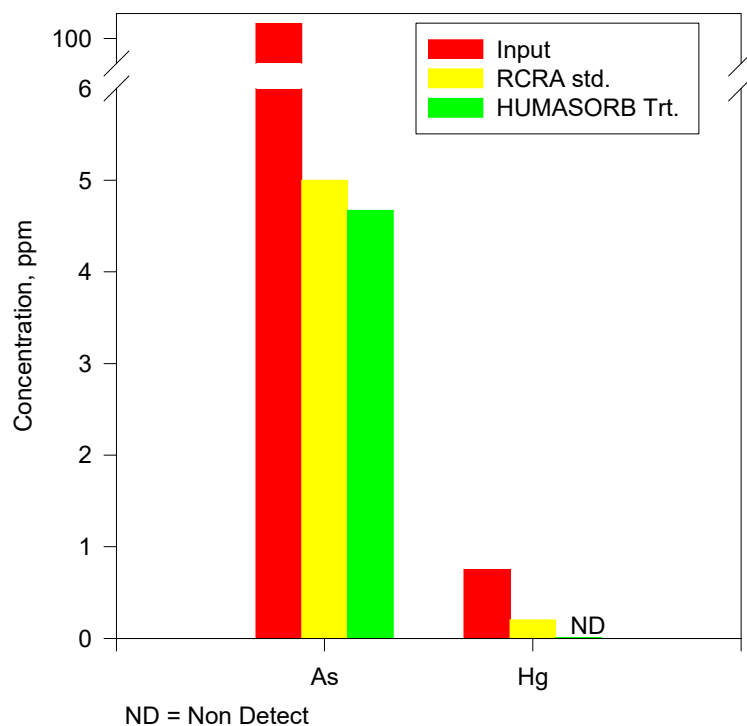


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# HUMASORB® Technology is Effective for Treatment of Waste Brines at Johnston Island Atoll

Concentration of metals in a composite sample collected at the end of 145 bed volumes



**Arsenic was present as an uncharged species, while mercury was present as cationic in the brine water**



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# HUMASORB® Mobile Unit at Army's Johnston Island Chemical Weapons Destruction Facility



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# HUMASORB® TECHNOLOGY DEMONSTRATION UNIT



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# HUMASORB® Removing Mercury and PCB from Storm Water In Michigan





# HUMASORB® Removing Zinc and Toluene to Compliance Level from a Factory Drain Effluent Water In Massachusetts

HUMASORB® -CS



Installation of HUMASORB® -CS  
in Drain System



contaminant	untreated	treated
Zinc	3.14 ppm	0.317 ppm
Toluene	2,200 ppb	N.D
Copper*	0.616 ppm	0.092 ppm
Lead*	0.109 ppm	N.D
Nickel*	0.103 ppm	0.012 ppm
Phthalate*	120 ppb	26 ppb
Phenol*	21 ppb	17 ppb
Oil & Grease*	61 ppm	25 ppm
Xylene*	430 ppb	N.D
Acetone*	7400 ppb	150 ppb

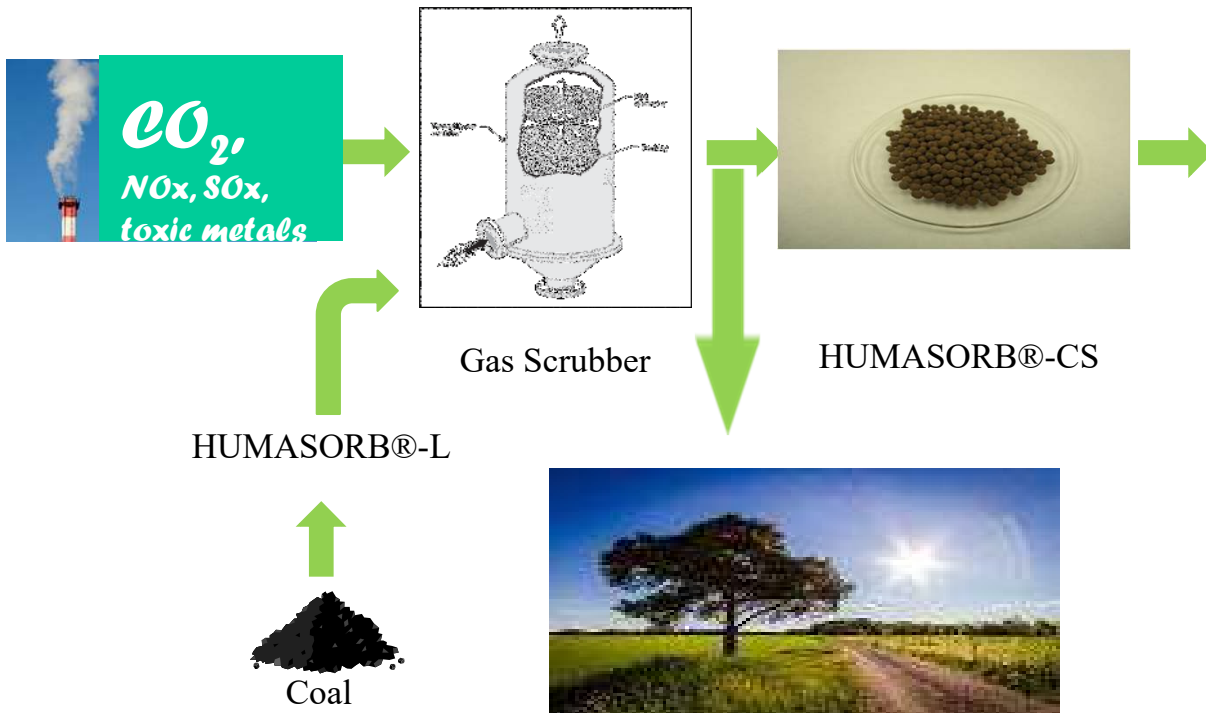
\* Not regulated but removed



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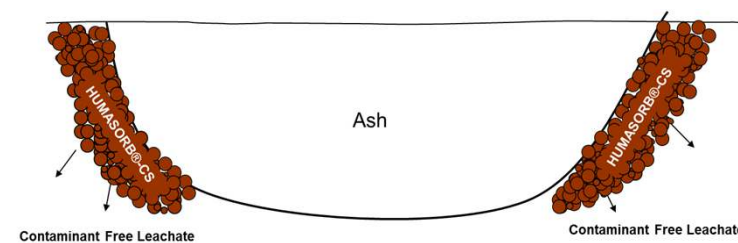
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# HUMASORB-L Capture CO<sub>2</sub> Along with Other Contaminants are Recycled into HUMASORB®-CS Water Filter and Soil Fertility



## HUMASORB®-CS Feasibility Test for Contaminant of Toxic Chemicals form Ash Pond Leachate

Toxic Metals (mg/L)	Ash Pond Leachate (mg/L)			HUMASORB Treated (mg/L)			TCLP Hazardous Waste Limit, mg/L
	pH3	pH5	pH6.5	pH3	pH5	pH6.5	
As	1.163	1.135	1.580	nd	nd	nd	5.0
Ba	1.220	0.608	0.680	0.011	0.006	0.003	100.0
Cd	0.193	0.183	0.183	nd	nd	nd	1.0
Cr	0.090	0.090	0.095	nd	nd	0.006	5.0
Hg	nd	nd	nd	nd	nd	nd	0.2
Pb	1.055	1.118	1.028	nd	0.052	0.037	5.0
Se	1.165	1.215	1.585	nd	nd	nd	1.0
Ag	nd	nd	nd	nd	nd	nd	5.0
Cu	9.023	nd	nd	nd	nd	nd	
Fe	0.683	nd	nd	nd	nd	nd	
Ni	2.315	1.258	0.193	0.045	0.072	0.011	
Tl	1.345	1.208	1.288	nd	nd	0.045	
Zn	1.003	0.143	nd	nd	nd	nd	

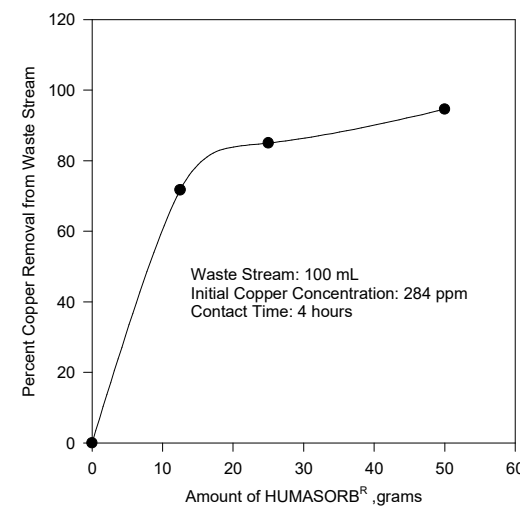
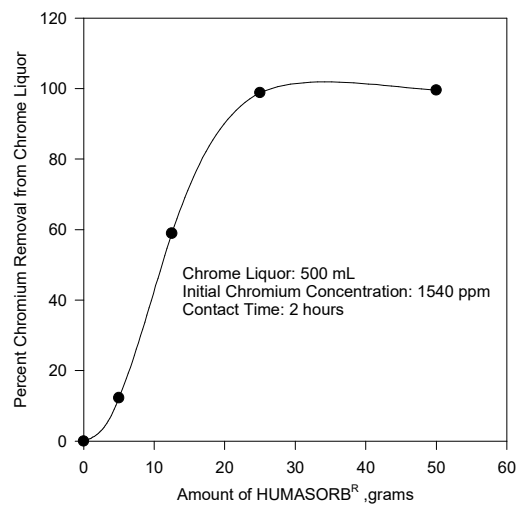


**Grand Challenge Awarded by Canada, 2014**



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# HUMASORB® DEMONSTRATION SETUP FOR TESTS IN INDIA



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## **HUMASORB® IS EFFECTIVE IN TREATMENT OF CONTAMINATED WATER IN MATKA TESTS**

Tests conducted in Prototype HUMASORB Matka System

Contaminant	Concentration in Untreated Water, ppm	Concentration in Treated Water , ppm	WHO Guideline for Drinking Water System,ppm
Lead	5-20	ND	0.01
Arsenic	5-20	ND	0.01
Chromium	5-20	ND	0.05

## **ECONOMIC FEASIBILITY**

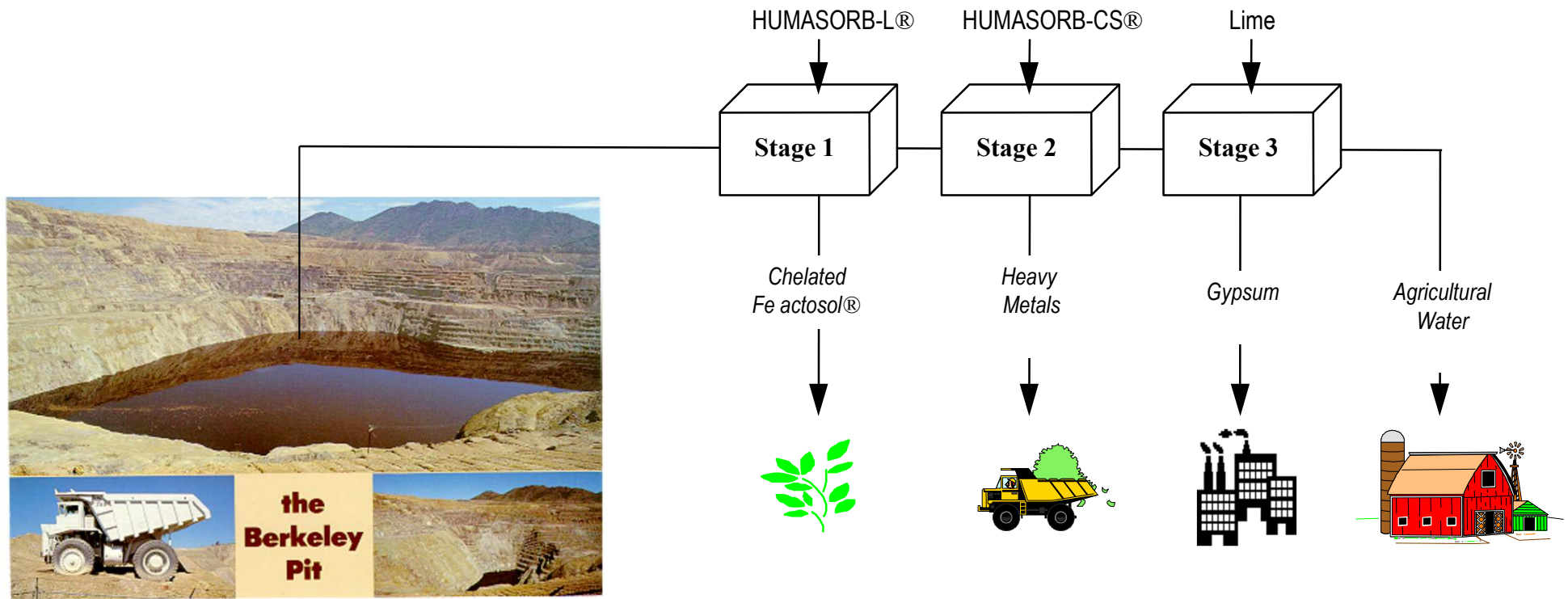
- **Total System under 300-500 Rupees for a 3-gallon (11 litres) MATKA**
- **Provide 300-360 gallons ( 1,1130-1,360 litres of drinking water**
- **HUMASORB® recharge cost : less than 500 Rupees**



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# Simplified Flow Diagram of the ARCTECH Process to Convert Berkeley Pit Water to Fertilizer and Agricultural Water



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# **Background-Hard Rock Mine-Berkeley Pit, Butte, Montana**

**Mined for gold, silver, and copper, the region of Butte, Montana, nicknamed "The Richest Hill on Earth" by the end of the 19th century.**

**The Berkeley Pit is a gigantic former open pit one mile wide and 900 feet deep mine.**

**Approximately 5-6 million gallons flows into the pit everyday from underground aquifers.**

**Water is acidic (pH~2) and laden with toxic metals such as As, Cd, Zn.**



**In 1995, a large flock of migrating snow geese landed on the Berkeley Pit water and were killed, most likely by the high concentration of acid.**



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# HUMASORB® Approach Proven Effective for Resource Recovery of AMD Waters

Metals	Untreated	treated
	ppm	
Al	224	0.428 (B)
Cd	1.82	0.0016 (B)
Cu	201	0.0437 (B)
Fe	660	75.1
Ni	1.02	0.124 (B)
Zn	626	26.2

B: Below method detection limit

## Economics

5 million gallon per day capital cost \$25 million

Revenues :\$106 million @\$2 per gallon fertilizer

Costs :\$89 million

Profit Before Tax :\$17 million

Potential Profit of \$10/1000 gallon AMD treated water

Micronutrient fertilizer contained  
Fe, Zn, Cu, Mn, Mg & Humic Acid

## Plant Growth Studies at Montana State Univ.

- actosol® enhanced the development and growth of wheat & alfalfa
- actosol® treatment increased yield of wheat & alfalfa by 40%
- actosol® increased micronutrient uptake by roots of wheat & alfalfa



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# Multi Site *In-Situ* Treatment Approach

HUMASORB®-L  
Formulation Facility  
In Pennsylvania



Periodic Treatments At  
Each Site



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## **HUMSAORB®-L Treatment Cost Is Function of pH of AMD Water**

<b>pH</b>	<b>Dosage Per 1000 Gallons</b>	<b>Cost, \$/1000 Gallons</b>
<b>High to Slightly Acidic</b>	<b>1 to 1.5</b>	<b>0.50 to 0.75</b>
<b>Near Neutral</b>	<b>0.5</b>	<b>0.25 to 0.35</b>

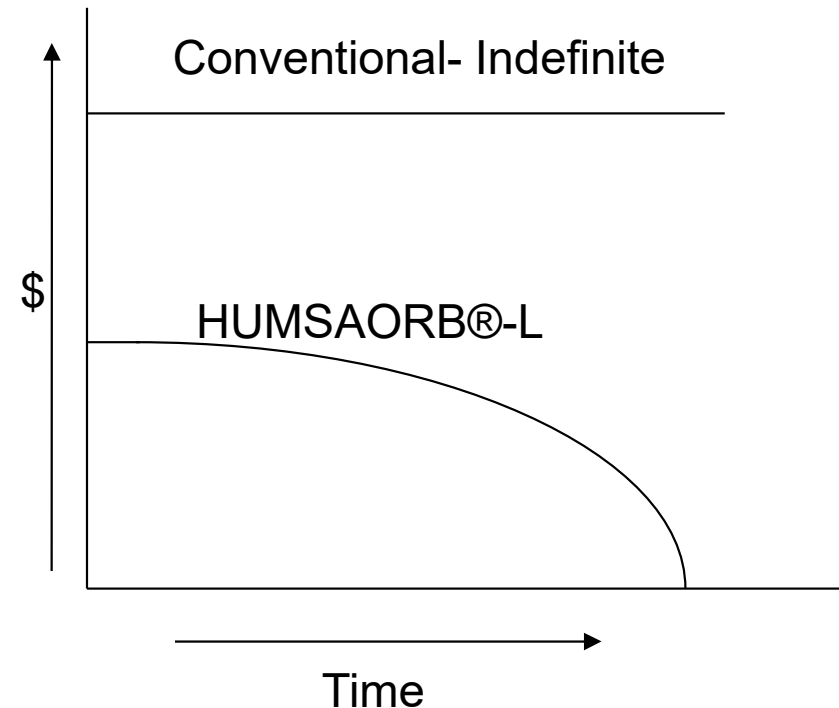
Commercial experience of lime treatment cost for active treatment is estimated at \$1.6-2.00/1000 gallons



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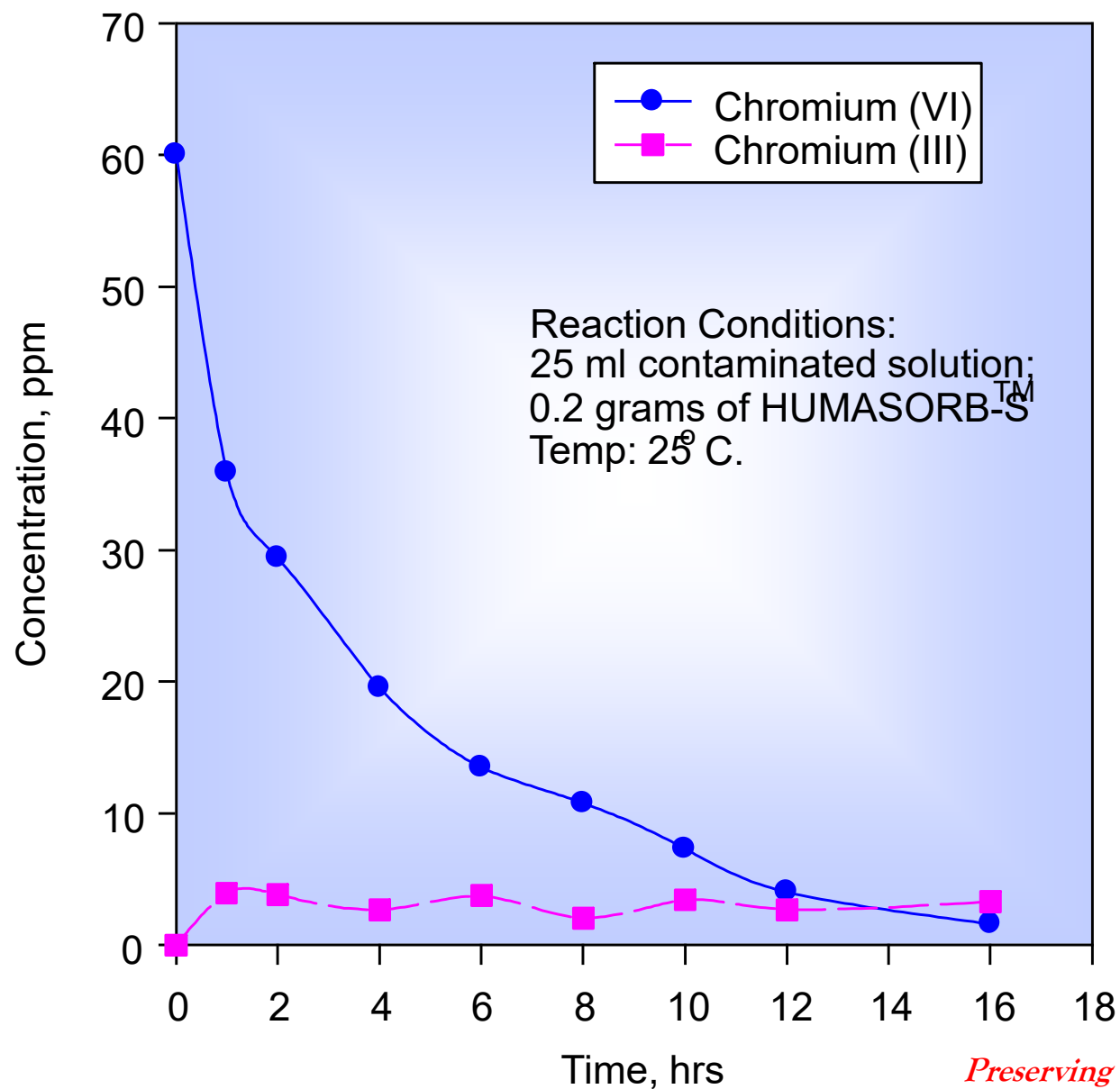
# HUMASORB®-L Offers Lower Life Cycle Costs for AMD Treatment

- Current average cost of \$0.50/1000 gallons results in total cost of \$12 million per year for treating 23 billion gallons of AMD in Pennsylvania (PADEP Jan. 2006 Press Release)
- At this rate Life Cycle costs will exceed \$1.2 billion over next 100+years
- HUMASORB®-L Life Cycle cost will be only \$24-60 million over 2-5 years Treatment



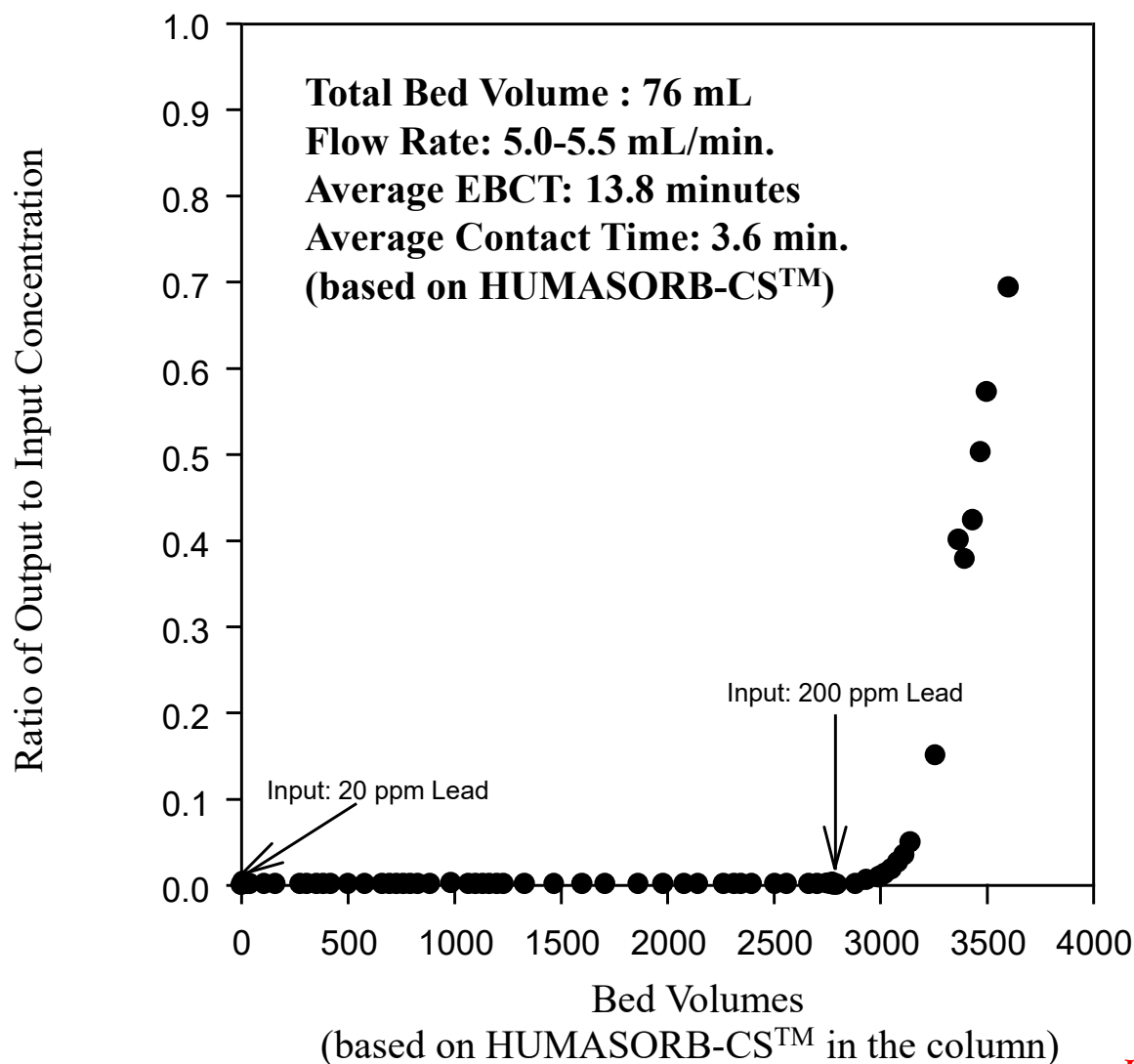
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# HUMASORB-CS Reduced Chromium (vi) to Chromium (iii) and Removed Chromium from Solution



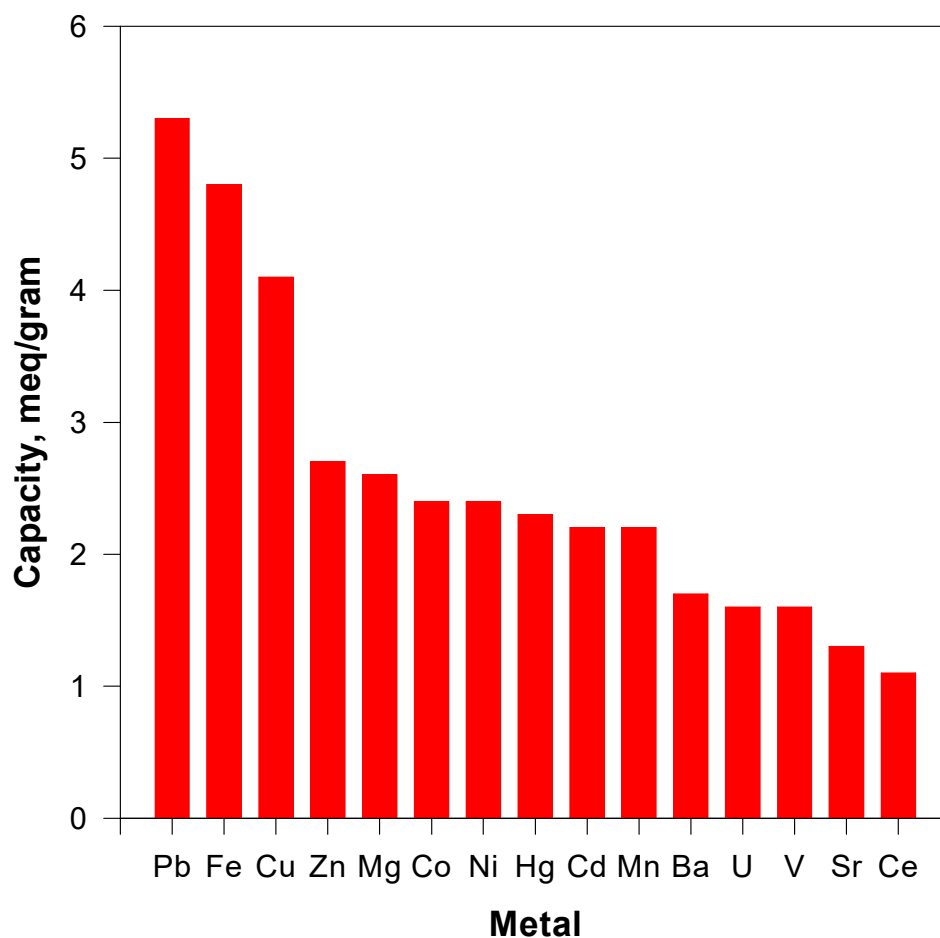
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# Breakthrough Curve for Lead in a Column Packed with HUMASORB® -CS (20%) and Sand (80%)



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## HUMASORB® HAS HIGH CAPACITY FOR METAL REMOVAL



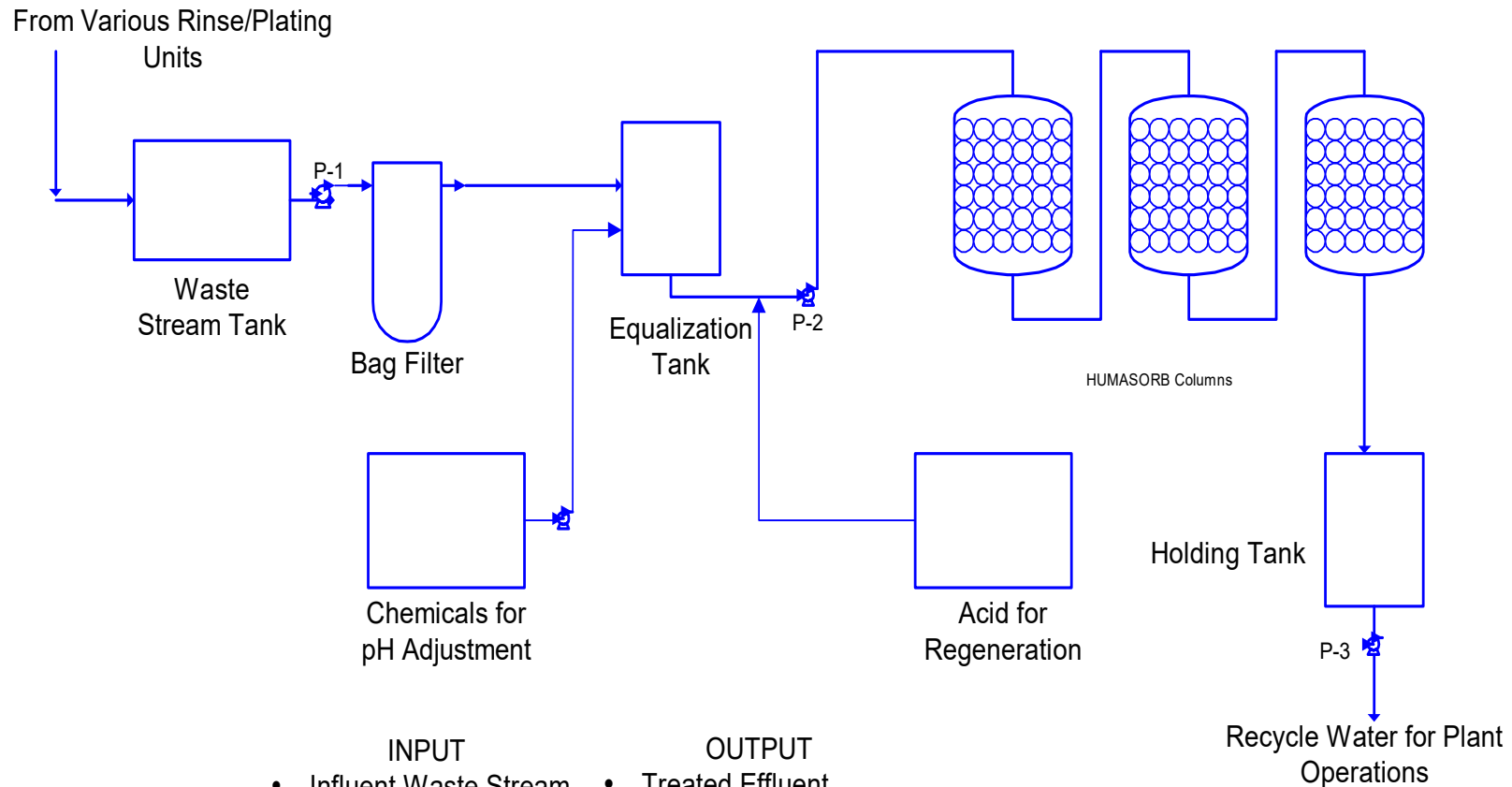
\*\*:

Capacity Estimated from Langmuir Model and/or  
Experimental Observation



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# Simplified Flow Scheme for the Proposed ARCTECH System



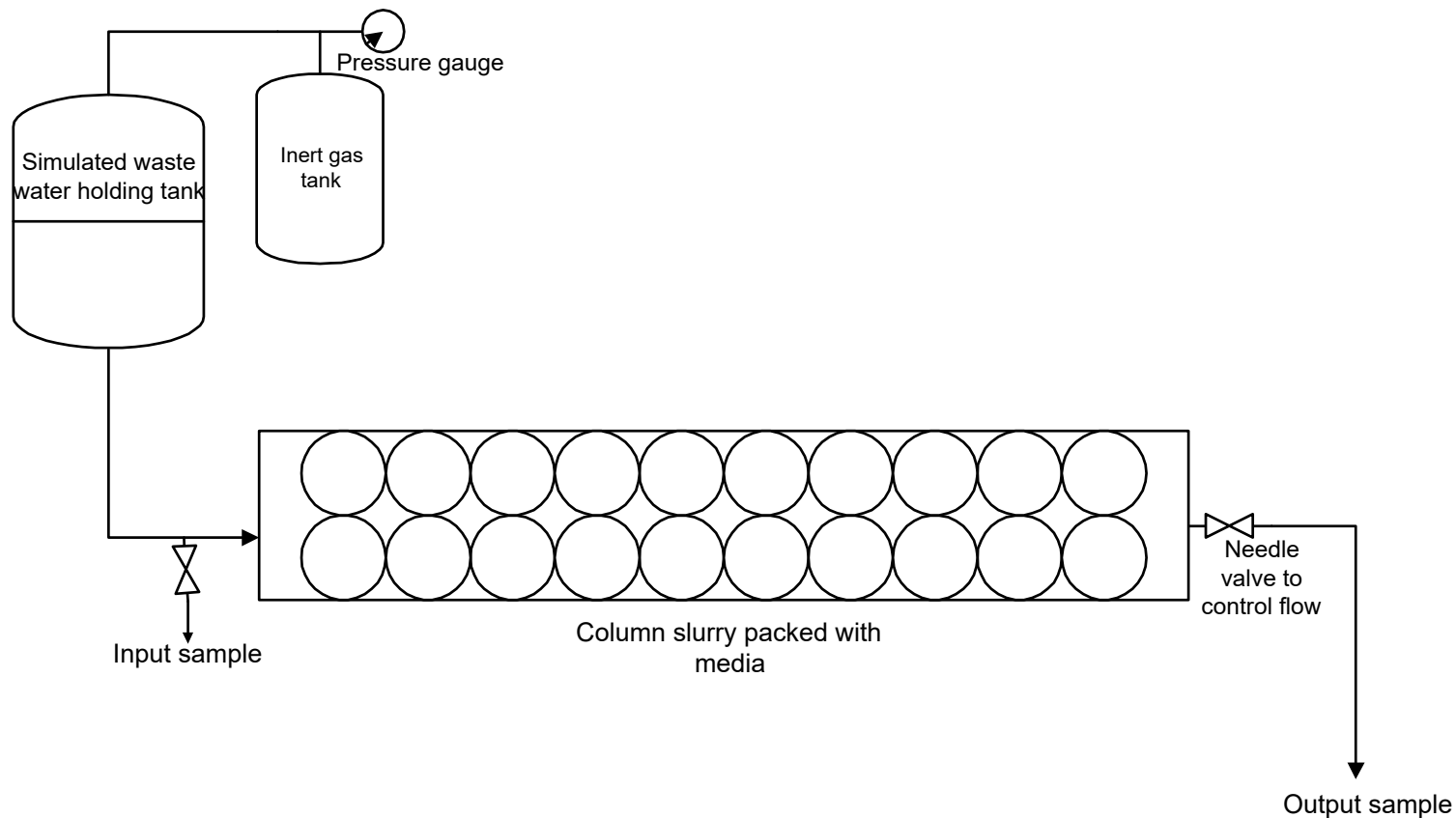
- | INPUT                     | OUTPUT                  |
|---------------------------|-------------------------|
| • Influent Waste Stream   | • Treated Effluent      |
| • HUMASORB                | • Spent HUMASORB        |
| • Acid for Regeneration   | • Spent Regenerant Acid |
| • pH Adjustment as Needed |                         |



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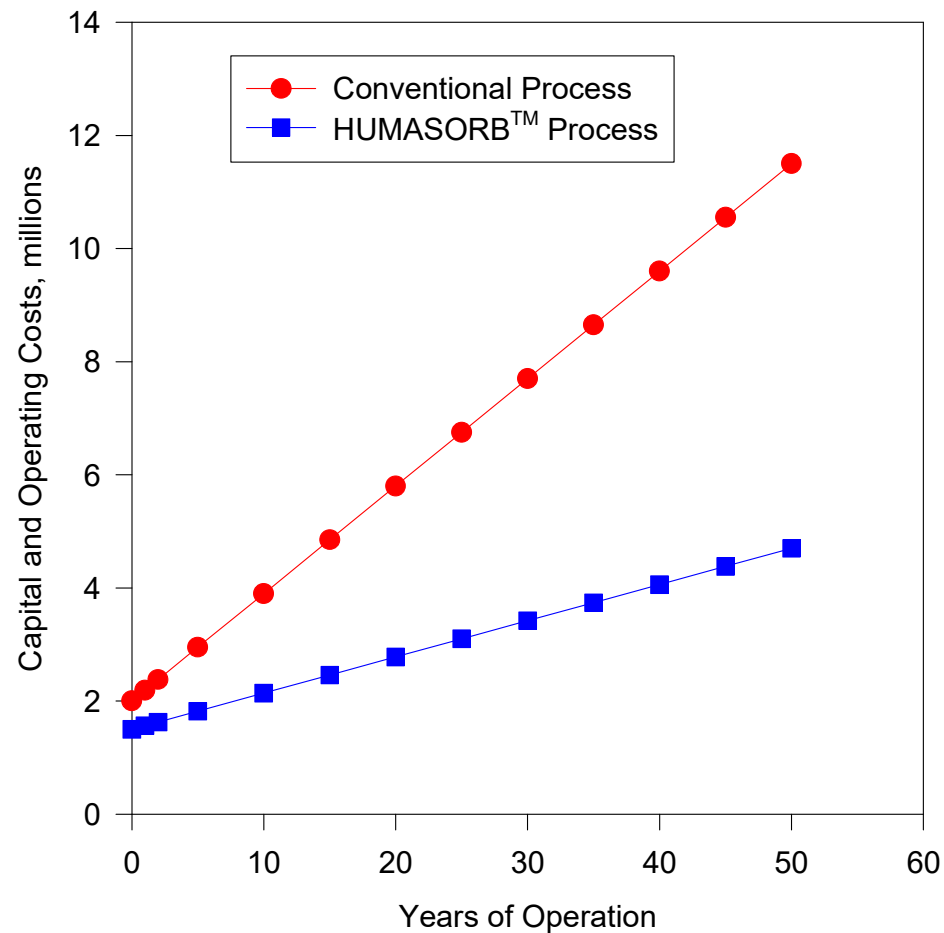
# Simulated Barrier Experimental Setup



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# HUMASORB® HAS LOWER LIFE-CYCLE COST

**Treatment Rate: 30 million gallons per year**

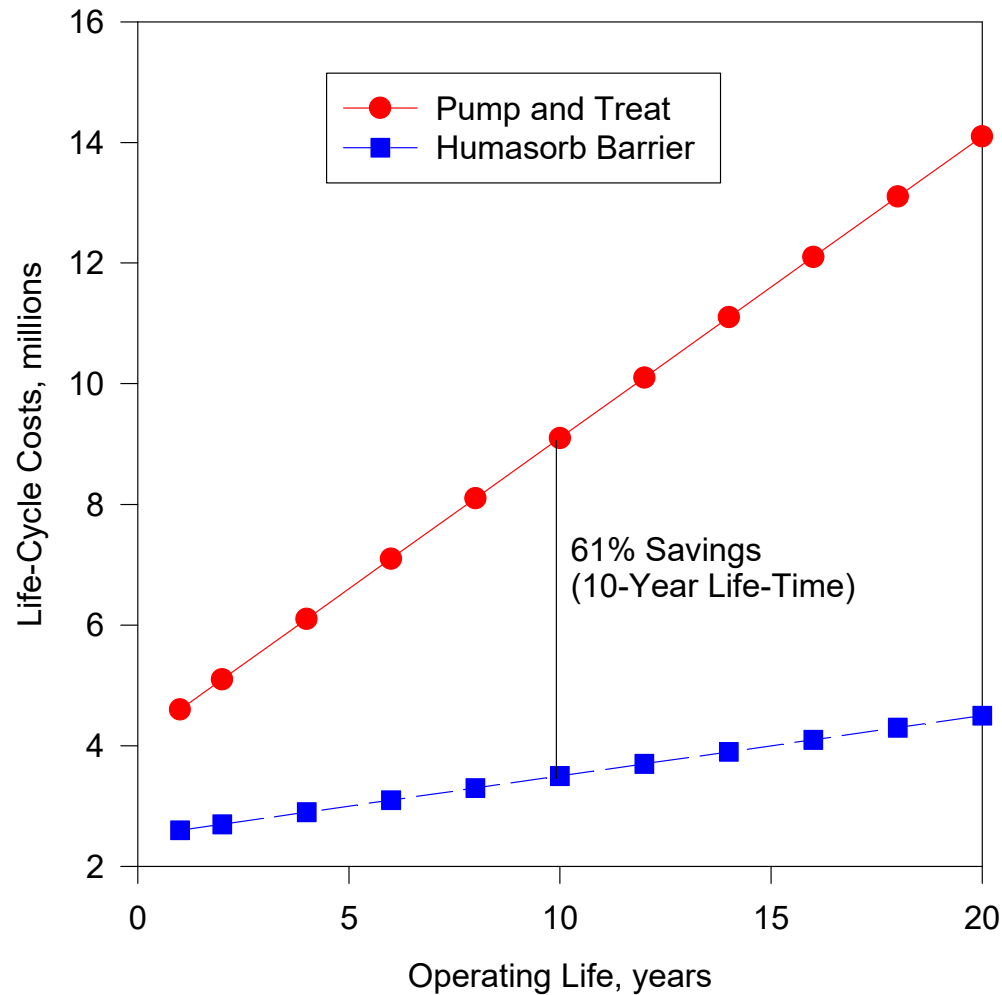


**Conventional Process:** Electrochemical treatment, filtration and clarification. Costs based on EPA Report 542-R-99-006  
**HUMASORB™ Process:** Estimated Costs for water contaminated with multiple metals and organic compounds



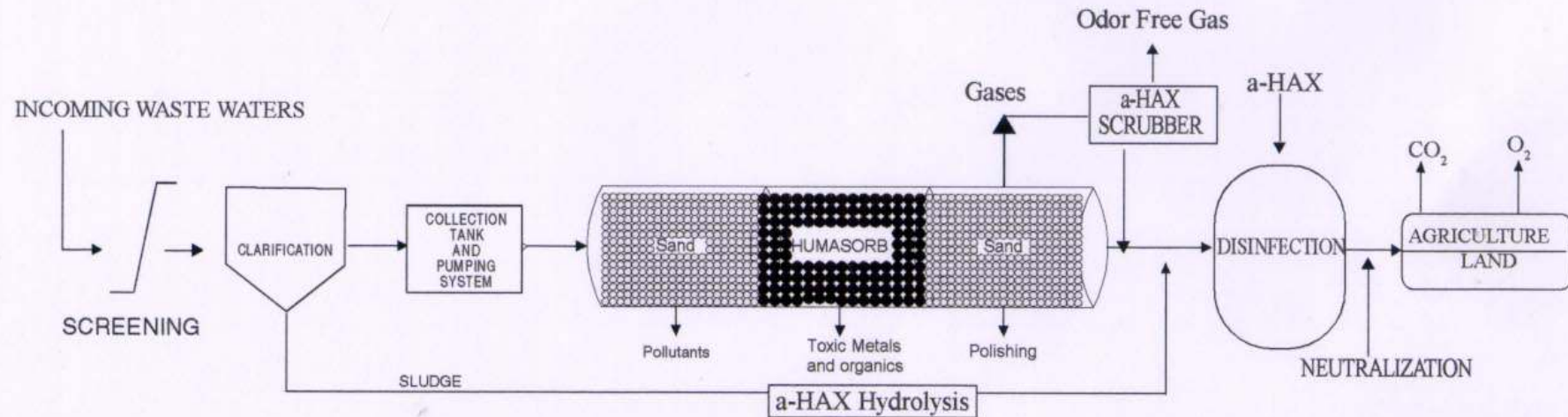
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# HUMASORB® BARRIER HAS LOWER LIFE-CYCLE COST COMPARED TO A PUMP AND TREAT SYSTEM



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# HUMASORB® SYSTEM WILL CONVERT WASTEWATER INTO AGRICULTURAL WATER AT SADAT CITY, EGYPT



## Per Annum Costs \$, million

1. Operating costs-raw materials, chemicals	4.9
2. O & M	<u>1.0</u>
Total	5.9

### Costs:

□ a-HAX, HUMASORB® and Chemicals and supplies delivered cost at Sadat City (assumes 18,000 m³ per day treatment rate)

## Per Annum revenues \$, million

1. Tipping fee charge	1.6
2. Crops	5.4
3. CO <sub>2</sub> credit	<u>0.1</u>
Total	7.1

### Revenues:

□ Tipping fee charges \$0.25/ m³ average of today's rates in Egypt.

Net profit of \$1,500 /acre/year from combined forests and edible crops on 3,600 acres. CO<sub>2</sub> credit at average \$10/ton of CO<sub>2</sub> based on 3 tons of capture per acre per year from 3,600 acres of cultivated area



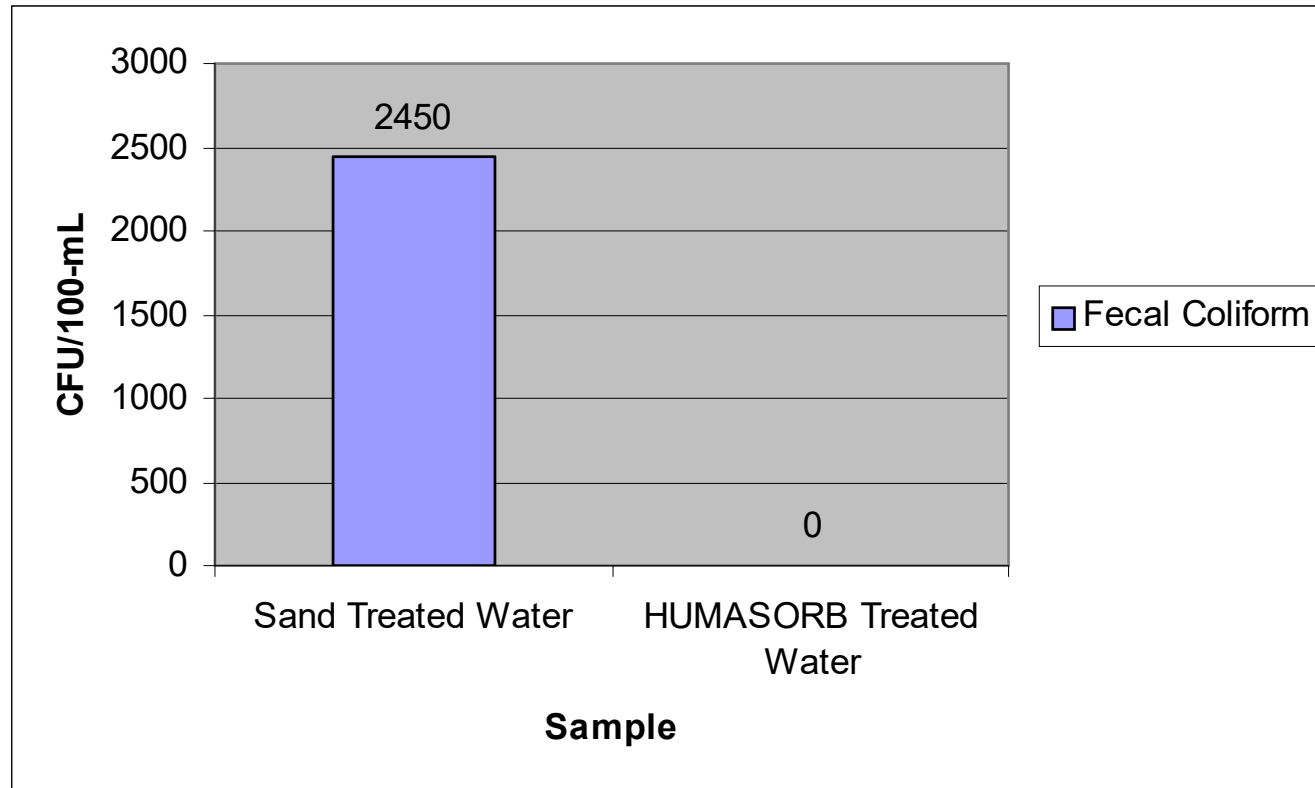
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# HUMASORB® UNIT AND STORAGE TANK AT SADAT CITY PROJECT SITE



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# HUMASORB® SYSTEM IS EFFECTIVE FOR PATHOGEN REMOVAL FROM WASTEWATER AT SADAT CITY



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# HUMASORB® TREATMENT MEETS FAO AND EGYPTIAN NATIONAL LIMITS OF TOXIC METALS IN IRRIGATION WATERS

	FAO Limit	Egypt Limit	Pond Water	Meet Criteria	HUMASORB <sup>R</sup> Treated Water	Meet Criteria
	Concentration in ppm					
Al	5		0.19	Y	0.18	Y
<b>As</b>	<b>0.1</b>	<b>0.1</b>	<b>0.23</b>	<b>N</b>	<b>0.08</b>	<b>Y</b>
Ba			3.80		0.07	
B			0.27		0.21	
Cd	0.01	0.01	0.00	Y	0.00	Y
Ca			49.20		86.73	
Cr	0.1	0.1	0.02	Y	0.00	Y
Co	0.05	0.05	BDL	Y	0.00	Y
Cu	0.2	0.2	BDL	Y	0.07	Y
Fe	5	5	0.53	Y	0.21	Y
Pb	5	5	0.03	Y	0.00	Y
<b>Li</b>	<b>2.5</b>		<b>3.70</b>	<b>N</b>	<b>0.02</b>	<b>Y</b>
Mg			39.10		19.21	
Mn	0.2	0.2	0.20	Y	0.02	Y
Mo	0.01	0.01	BDL	Y	0.01	Y
Ni	0.2	0.2	0.03	Y	0.01	Y
Se	0.02		0.02	Y	0.00	Y
Sn					0.00	
Ti			0.01		0.01	
W			0.00		0.00	
V	0.1		0.05	Y	0.03	Y
Zn	2	2	0.16	Y	0.02	Y



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# ORGANIC FERTILIZER WATER PRODUCED BY HUMASORB® TREATMENT CONTAINS SIGNIFICANT QUANTITIES OF PLANT NUTRIENTS

Nutrient	Concentration, ppm	Total Available <sup>+</sup> , kgs
Nitrogen	6.7	32,660
Phosphorus	23.7	264,600 (as P <sub>2</sub> O <sub>5</sub> )
Potassium	910	5,350,000 (as K <sub>2</sub> O)
Humic Acid	25	121,500



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# HUMASORB® TREATED WATER ENHANCES COTTON PLANT GROWTH



**Control Area**  
(with sand treated water)



**Test Area**  
(with HUMASORB® treated water)



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# Organic Fertilizer Water Produced by HUMASORB® Treatment Increased in Height, Weight, Cone Length and Cone Weight of Sorghum Plants

Treatment	Plant Height	Plant Weight	Cone Length (cm)	Cone Weight
<b>SAND</b>	212.833± 1.58 <b>b</b>	736.50 ± 24.71 <b>b</b>	22.567 ± 0.79 <b>b</b>	20.833 ± 0.569 <b>b</b>
<b>HUMASORB</b>	214.733± 2.10 <b>a</b>	970.83 ± 28.98 <b>a</b>	26.367 ± 0.80 <b>a</b>	23.90 ± 0.69 <b>a</b>
<b>LSD</b>	5.277	76.252	2.259	1.799



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# Organic Fertilizer Water Produced by HUMASORB® Treatment Increased in Height of *cupressus* sp. Trees

Treatment	At Cultivation (Height 1)	At 4 Months (Height 2)	H2 – H1 (cm)	Growth Rate
SAND	59.02075	71.7915	12.77075± 0.511b	19.5681 ± 0.985 b
HUMASORB	55.5285	70.5835	15.055 ±0.216 a	23.89606± 0.497 a
LSD	1.36			2.70



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# Economic Analysis of HUMASORB® Technology for Wastewater Facility at Sadat City

Per Annum Costs \$, million	Per Annum revenues \$, million
Total treatment operation, raw materials, chemicals and agriculture costs 7.5	1. Tipping fee charge 3.2
	2. Crops 5.8
	3. CO <sub>2</sub> credit <u>0.04</u>
<b>Total</b> 7.5	<b>Total</b> 9.0
<b>Costs:</b> ❖ a-HAX, HUMASORB® and Chemicals and supplies delivered cost at Sadat City (assumes 18,000 m <sup>3</sup> per day treatment rate)	<b>Revenues:</b> ❖ Tipping fee charges \$0.5/ m <sup>3</sup> ❖ Revenues of \$2,099 /feddan/year from combined intercropping trees, and crops on 2,770 feddans ❖ CO <sub>2</sub> credit at average \$5/ton of CO <sub>2</sub> based on 3 tons of capture per feddan per year from 2,770 feddans of cultivated area



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# **HUMASORB® TECHNOLOGY ENHANCES ENVIRONMENT**

- ❑ Eliminates discharge of untreated or partially treated wastewater on land / or and water bodies**
- ❑ Frees up fresh water for drinking water purposes from requirements of irrigation**
- ❑ Eliminates Landfills, Waste Impoundments and Associated Environmental Problems**
- ❑ Enhances soils and agricultural productivity**
- ❑ Facilitates capture of greenhouse CO<sub>2</sub> gases**

***CREATES TOTAL SOLUTION FOR RECYCLING OF  
WASTEWATER AND SOLID WASTES***



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