



# Axine Pharma Wastewater Services: Automated, on-site treatment of APIs & solvents in rinse water and plant effluent

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Axine Water Technologies

[www.axinewater.com](http://www.axinewater.com)



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# Treating Pharma Wastewater

Automated, On-Site Solutions for Rinse Water/Effluent

- Axine specializes in **on-site treatment of pharma wastewater** contaminated with APIs and solvents
- Our **automated systems** treat rinse water on-site to eliminate off-site trucking and incineration, ensure compliance and treat APIs in plant effluent
- Our unique **service model** enables plants to automate treatment, **reduce opex**, improve safety, eliminate off-site trucking risk and achieve ESG goals – with minimal capex investment
- Our solutions provide **guaranteed treatment** of the widest range of organic pollutants to the most **stringent treatment** requirements so plants can focus on manufacturing medicines
- If your plant is trucking CIP rinse water off-site or discharging APIs in wastewater, **we can help**





# Pharmaceutical Pollution is a Risk

## A Strategic Issue for the Pharma Industry



- In recent years, pharma wastewater contaminated with APIs has become the focus of global attention as a risk to human health & the environment
- Pharma companies are now faced with managing the risks of environmental and health impacts due to discharging untreated APIs, damage to corporate reputation, restrictions on market access, supply chain disruption, higher operating costs, new regulations & potential litigation
- To help address these issues, Axine has created a new standard of care for treating APIs and other toxic organic pollutants in pharma wastewater



# Incumbent Solutions are Ineffective

Axine's Solutions are Higher Performance & Lower Cost

## 1. Pharma plants **truck and burn** high volumes of **solvent & API-contaminated Rinse Water**

- **Expensive** – up to \$1M+/yr per plant
- **Dirty** – up to 5+ M lbs of waste incinerated
- **Safety** – Employee handling exposure risk
- **Energy Intensive** – trucking up to 100,000+ miles/yr
- **Business Interruption** – Loss of waste disposal outlets
- Can't be treated by incumbent technologies



## 2. Pharma plants also **discharge** high volumes of **API-contaminated effluent** to the environment

- **Environmental Risk** – API impact on aquatic ecosystems
- **Health Risk** – AMR, endocrine disruption, etc.
- **Reputational Risk** – C-level attention, investors, NGOs
- **Market Risk** – Emerging regs; supply chain scrutiny
- **Regulatory Risk** – Emerging API regulations
- Can't be treated effectively by incumbent technologies





# Pharma Applications

## Eliminate Off-site Trucking/Disposal

Treat problem streams on-site to eliminate off-site trucking & incineration



## Eliminate API's in Effluent

Treat APIs in wastewater to eliminate discharging APIs to the environment



## Protect/Expand Biological Systems

Pre-treat high COD streams to reduce toxicity & aeration load pre-bio



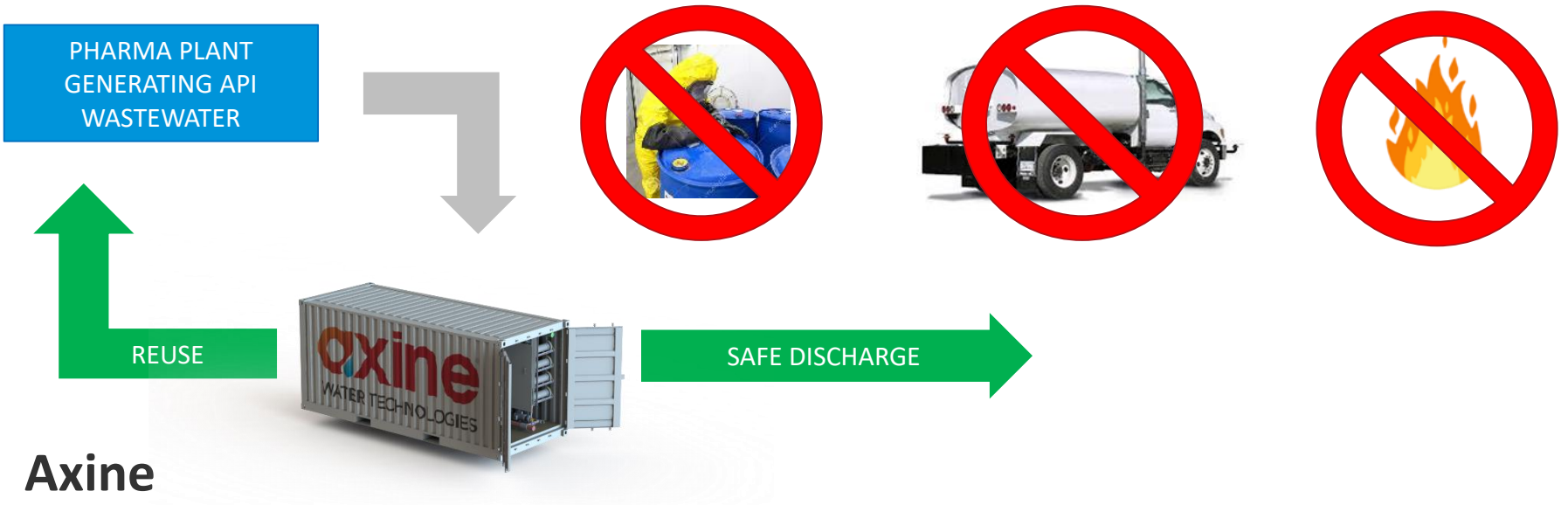
## Ensure Regulatory Compliance

Treat wastewater to ensure permit levels are safely achieved





# Automate Rinse Water Treatment On-Site





# Eliminate APIs in Plant Effluent

PHARMA PLANT  
GENERATING API  
EFFLUENT

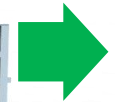


**Current**

API DISCHARGE TO  
SEWAGE TREATMENT

API DISCHARGE TO  
SURFACE WATER

PHARMA PLANT  
GENERATING API  
EFFLUENT



**Axine**

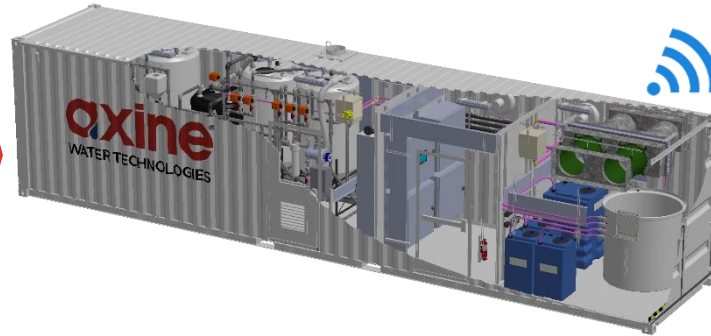




# Axine Solution

## Customer

- Delivers wastewater at specification
- Provides site & energy to operate the Axine system



## Axine

- Treats wastewater-as-a-service under multi-year contract
- Guarantees specified treatment performance

## Axine Wastewater-as-a-Service

- Axine designs, builds, owns, operates, maintains, services turnkey system at customer's site
- Systems based on Axine's proprietary electrochemical oxidation technology; fully automated & remotely operated



# Pharma Streams & Pollutants We Treat

## Problem Stream Sources

- CIP rinse water
- Line and tank rinses
- Fermentation waste
- Biologics manufacturing waste
- Off-spec disposal operations
- Scrubber blowdown
- Solvent extraction
- Cleaning processes
- Formulation operations

## Problem Organic Pollutants

- APIs – e.g. antibiotics, antidepressants, antimicrobials, opioids, oncology, hormones, cardiovascular drugs, etc.
- Solvents – e.g. toluene, methylene chloride, ethanol, methanol, IPA, acetone, acetonitrile, etc.
- Other Organics – e.g. chloroform, detergents (Triton X-100), surfactants, biocides, etc.
- Ammonia and other nitrogen species

- Axine solutions are highly versatile and capable of treating a wide range of contaminants including APIs down to levels well below 1 ppb.
- Complete mineralization of APIs in highly contaminated wastewater provides pharma manufacturers a robust tool to achieve risk quotients less than 1 for their most ecotoxic APIs with very low PNEC values.



# Example 1 – Electronics Manufacturer

Eliminates off-site trucking; enables reuse

- ✓ Treats IPA solvent  
COD >70,000 mg/L
- ✓ Treated water  
reused on-site in  
cooling towers
- ✓ Automates and  
streamlines rinse  
water system
- ✓ Reduces opex, site  
labor and EHS time
- ✓ Eliminates off-site  
trucking and  
incineration
- ✓ Aligns site ESG  
performance





# Example 2 – Pharma Plant

Automated treatment to meet regulatory compliance

- Axine system at a pharma site in the US north east
- Enables site to meet local and EPA limits
- Treats solvents and organics at COD >1000 mg/L
- Treated water discharged to sewer
- Streamlines and simplifies wastewater system





# Example 3 – Pharma Plant

Eliminates off-site trucking & incineration

- ✓ Treats organics and API at COD >4,000 mg/L
- ✓ Treated water discharged to sewer
- ✓ Automates and streamlines waste
- ✓ Reduces opex, site labor & EHS time
- ✓ Eliminates off-site trucking and incineration
- ✓ Avoids business interruption risk





# Axine Benefits to Pharma Sites

1. Automate, streamline and simplify wastewater treatment
2. Reduce opex vs. off-site trucking
3. Reduce labor cost, free-up EHS personnel, improve employee safety
4. Eliminate operational risks due to disruptions to trucking services
5. Guarantee the highest degree of treatment performance
6. Provide price certainty and transparency
7. Enable water reuse and improve ESG performance
8. Minimize capex investment and impact to operations



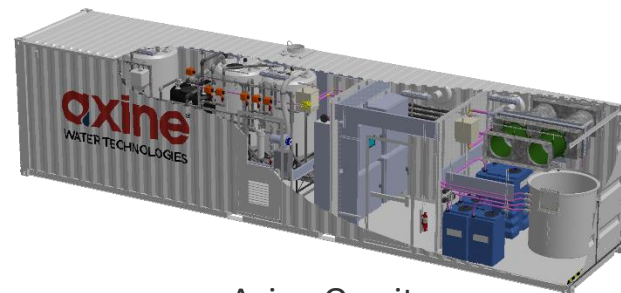


# Axine vs Trucking (over 5 year service term)



Off-site trucking and incineration

VS



Axine On-site

<b>No</b>	<b>Guaranteed treatment</b>	<b>Yes</b>
<b>\$1 – 5M</b>	<b>Cost (\$)</b>	<b>up to 50% savings</b>
<b>up to 10 million</b>	<b>Waste incinerated (lbs)</b>	<b>zero</b>
<b>up to 500,000</b>	<b>Trucking (miles)</b>	<b>zero</b>
<b>up to 1,000</b>	<b>GHG (tons)</b>	<b>up to 90% less</b>
<b>No</b>	<b>Water reuse</b>	<b>Yes</b>
<b>Yes</b>	<b>Production Bottlenecks</b>	<b>No</b>
<b>No</b>	<b>Sustainability compliant</b>	<b>Yes</b>

# Technology and Systems

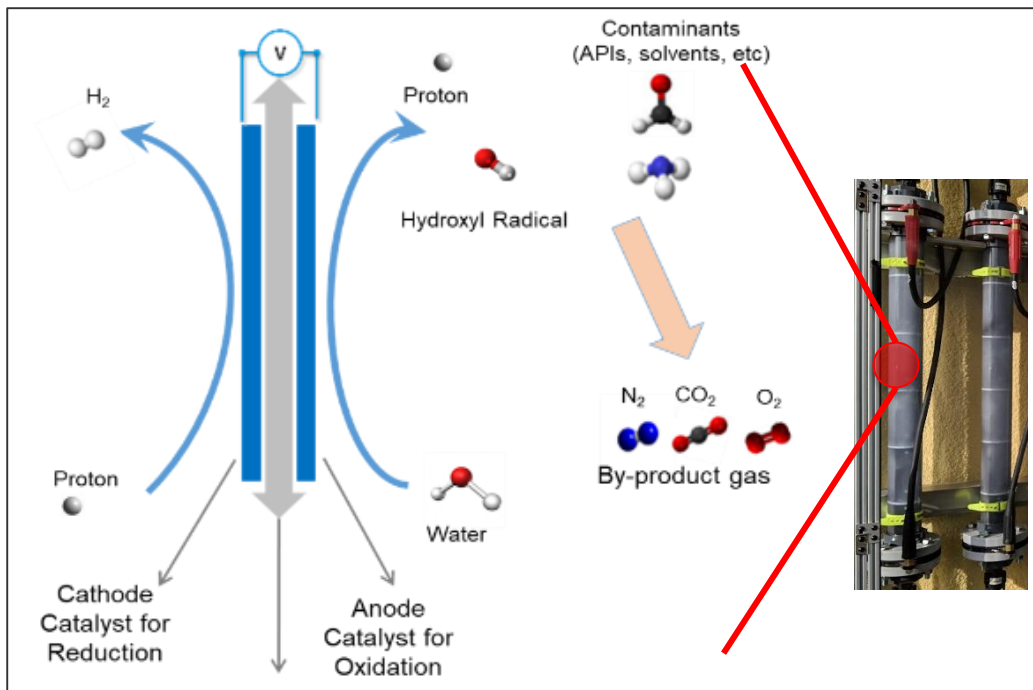
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# Breakthrough EOx Technology

## A New Standard for Treating Toxic Organics Pollutants



### Unmatched Performance

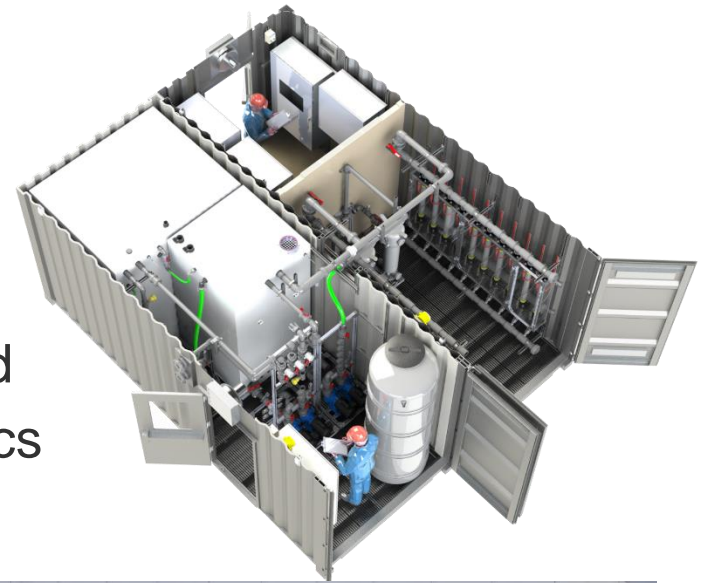
- Destroys virtually any organic pollutant or API to meet the most stringent treatment requirements down to ppb or non-detection levels
- Operates in wide range of wastewater quality and pollutant concentrations

- Axine's systems are based on its proprietary **electrochemical oxidation** technology (EOx)
- Electricity is applied to **catalysts that generate hydroxyl** (OH\*) and other mixed oxidants
- Direct and indirect oxidation breaks down pollutants to **trace by-product gases** N<sub>2</sub>, H<sub>2</sub>, O<sub>2</sub> & CO<sub>2</sub>
- Organic pollutants **completely mineralized and destroyed** unlike other AOP technologies
- No hazardous chemicals required; **no liquid or solid waste generated**
- Axine owns its technology, which is protected by an extensive IP portfolio



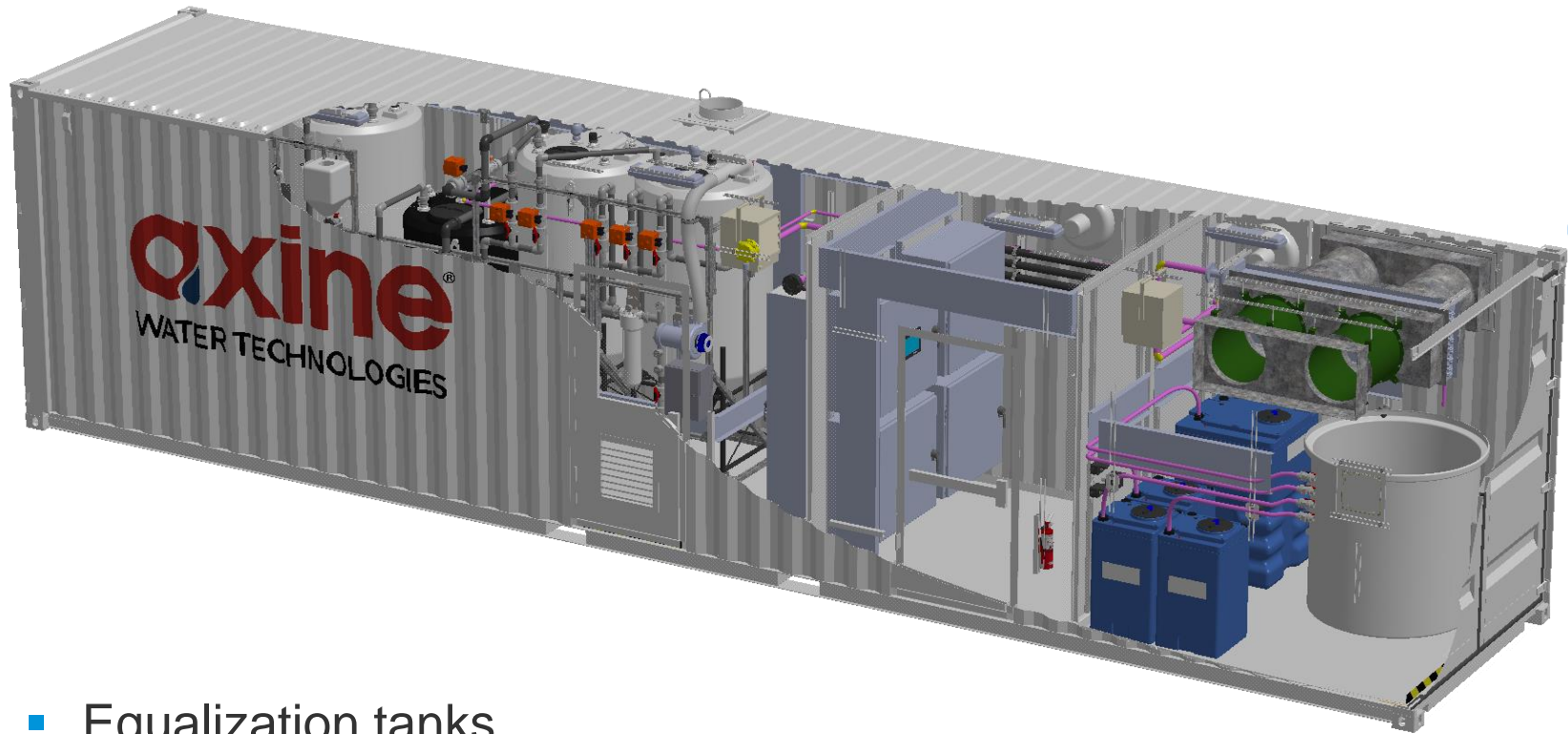
# Axine Modular Treatment Systems

- EOX technology is integrated into modular, turnkey treatment systems
- Systems are assembled off-site for “plug-and-play” installation at customer sites and designed to be scaled as needed
- They are fully-automated with data analytics for remote operation and monitoring





# Axine Turnkey Treatment Systems



- Equalization tanks
- Pre-treatment and post-treatment (e.g. membranes, filters, etc.)
- Electrochemical reactors, power supply, control system, control system interface, instrumentation
- Electrolyte, electrolyte dosing, pumping & exhaust systems



# Axine Testing/Product Development

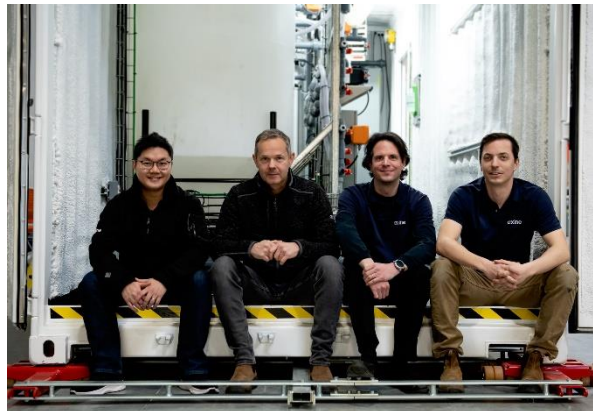
- Extensive in-house testing capabilities including full-scale commercial skids (left), full-scale pilots (right) & mini E-box pilots (not shown)
- Dedicated technical services team including test engineers, technicians & full service analytical capabilities





# Axine Manufacturing Facility

- Dedicated 10,000 square foot facility located in Metro Vancouver for manufacturing, assembly and testing of turn-key wastewater systems



# Treatability Results



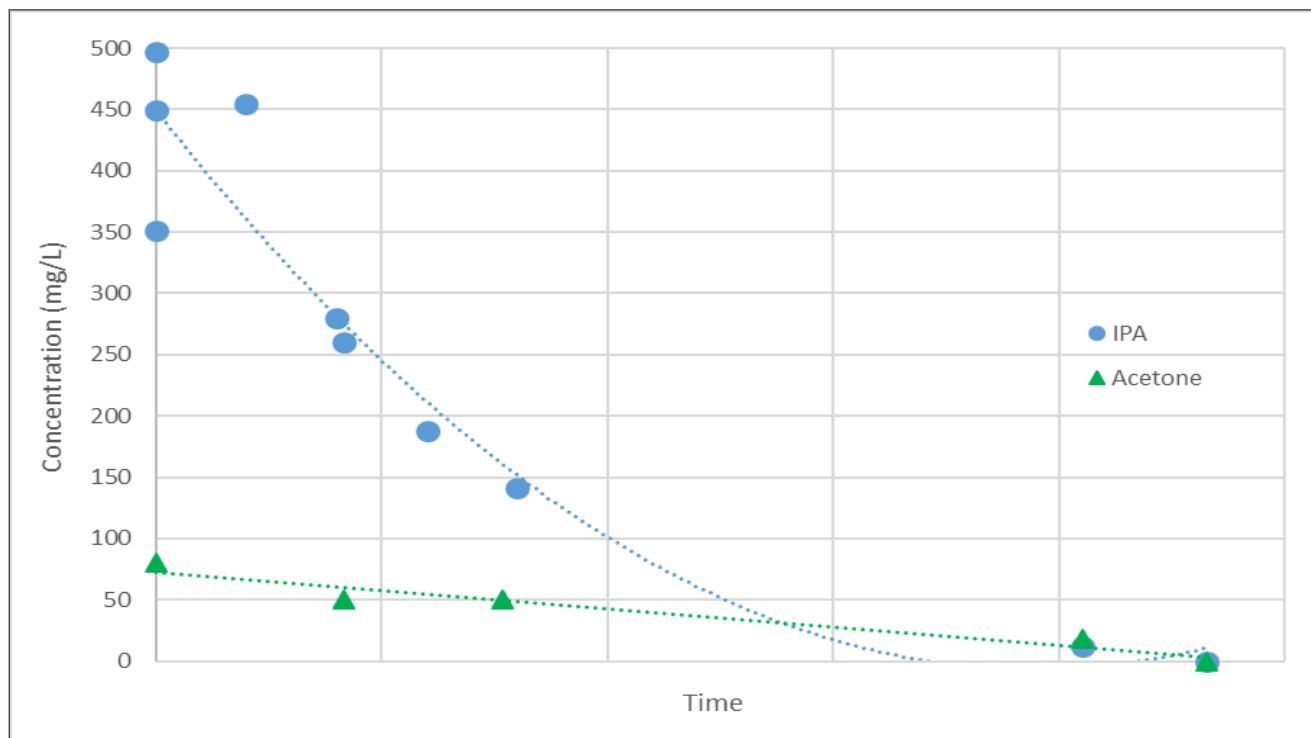


# Treatment Performance Example #1

## Reducing IPA & Acetone by >99% for a Pharma plant

- COD reduction by >99%
- IPA destruction by >99%
- Acetone destruction by >99%

Parameter	Units	Treatment Requirement	Influent	Effluent
COD	mg/L	N/A	1,300	<10
IPA	mg/L	<5	500	<1
Acetone	mg/L	<2	75	<1





# Treatment Performance Example #2

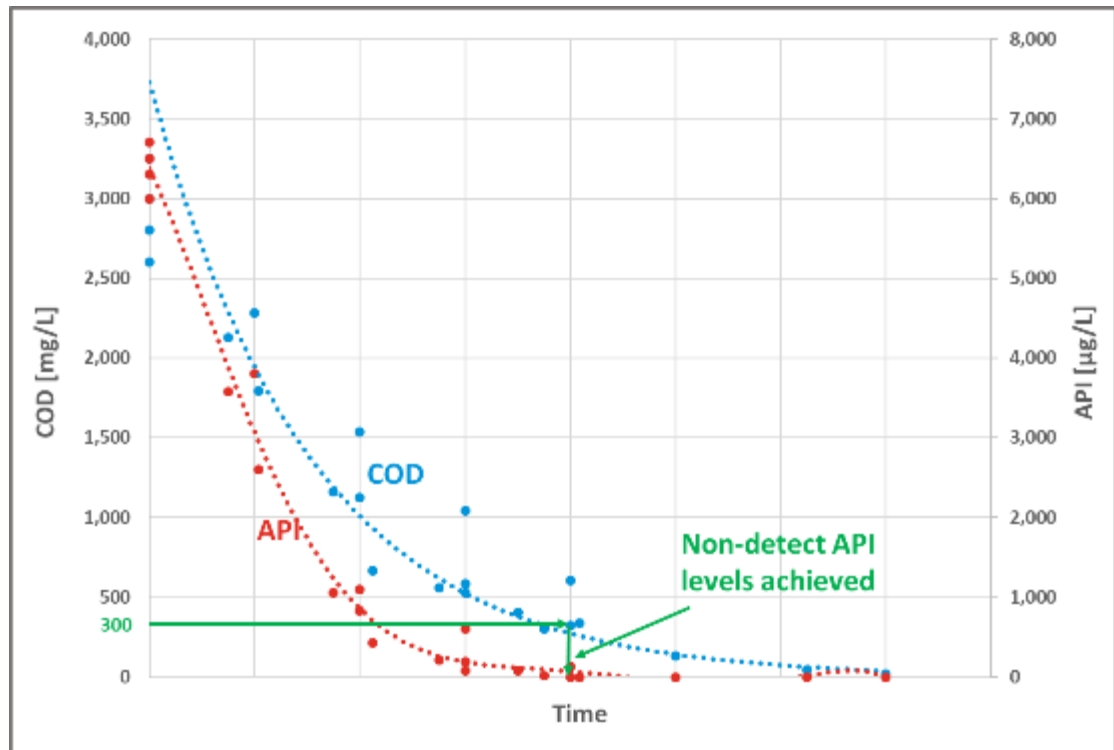
## Eliminating Antimicrobial API for a Pharma plant

- API molecular weight is > 500 g/mol
- API destruction by > 99.2%
  - 7,000 to < 50 µg/L
  - Below 70 µg/L site permit requirement

- Technical Bulletin

Parameter	Before Treatment	Treatment Required	Axine Treated	% Reduction
API µg/L	7,000	70	< 50*	> 99.2%
COD mg/L	3,250	N/A	< 50*	> 98.4%

\* Values indicate the analytical detection limit of these compounds







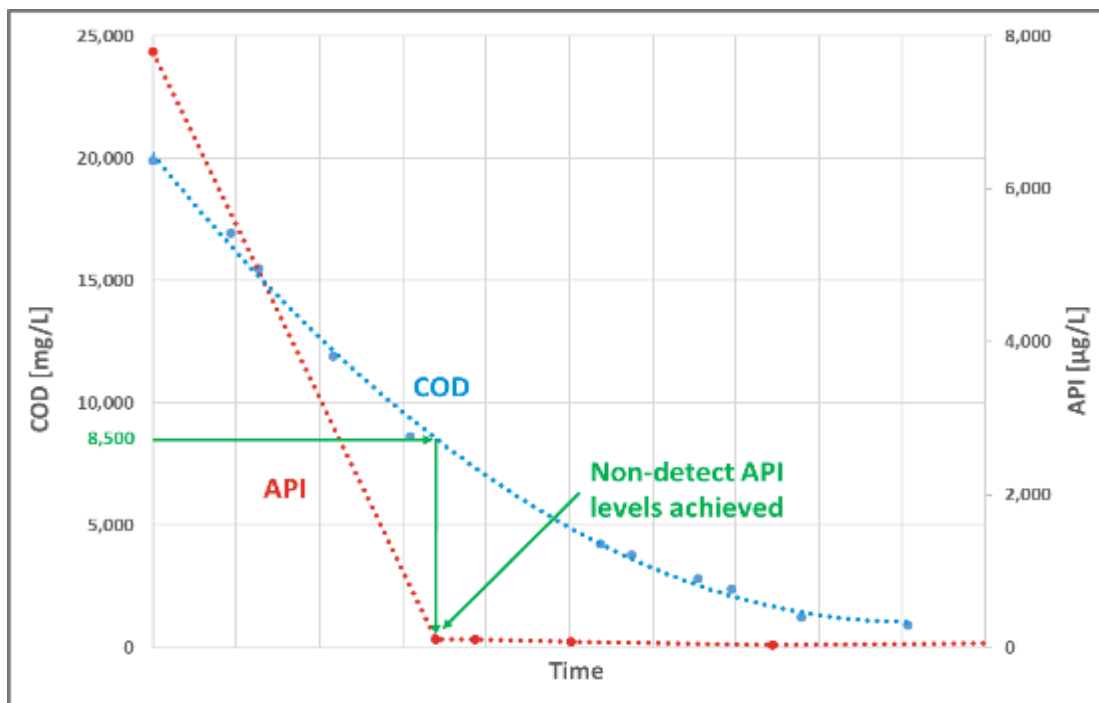
# Treatment Performance Example #3

## Eliminating Oncology API for a Pharma plant

- API molecular weight is > 800 g/mol
- API destruction by >99.3%
  - 7,800 to < 50 µg/L
  - Below 200 µg/L site target
- Chloroform destruction by > 99.999%
- [Technical Bulletin](#)

Parameter	Before Treatment	Treatment Required	Axine Treated	% Reduction
API µg/L	7,800	200	< 50*	> 99.3%
Chloroform mg/L	500	2	< 0.001*	> 99.9%
COD mg/L	19,920	N/A	920	> 95.3%

\* Values indicate the analytical detection limit of these compounds

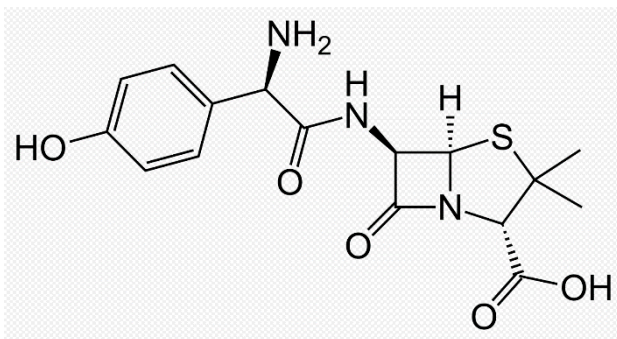




# Treatment Performance Example #4

## Amoxicillin Treatability Testing on Model Wastewater

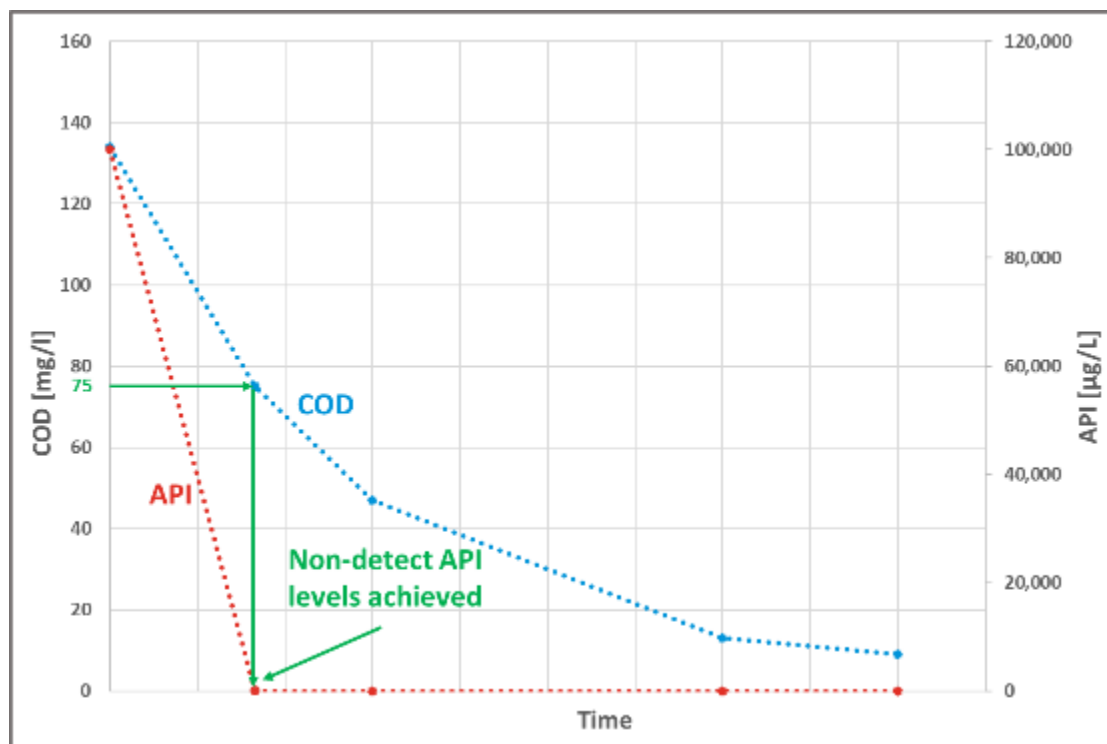
- API molecular weight is 365.4 g/mol
- API destruction by > 99.9999%
  - 100,000 to < 0.1 µg/L
  - Below 0.25 µg/L PNEC level
- Molecular structure:



Parameter	Before Treatment	PNEC	Axine Treated	% Reduction
API µg/L	100,000	0.25 <sup>A</sup>	< 0.1 <sup>*</sup>	> 99.9%
COD mg/L	134	N/A	< 10 <sup>*</sup>	> 92.5%

<sup>A</sup> Values per Temple University's Water and Environmental Technology (WET) Center PNEC List, 2019

<sup>\*</sup> Values indicate the analytical detection limit of these compounds





# Treatment Performance Example #5

## API Blend Treatability Testing

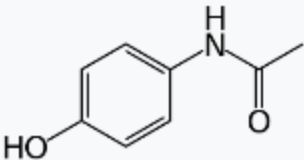
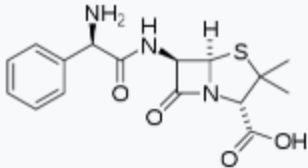
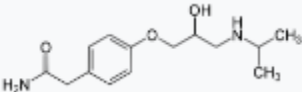
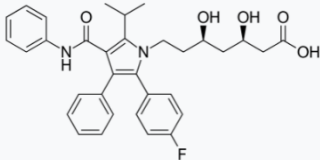
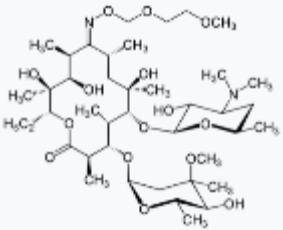
Parameter	Before Treatment	PNEC	Axine Treated	% Reduction
Acetaminophen $\mu\text{g/L}$	102,000	95 <sup>A</sup>	< 0.2*	> 99.9998%
Ampicillin $\mu\text{g/L}$	1,320,000	0.25 <sup>B</sup>	< 0.2*	> 99.9999%
Atenolol $\mu\text{g/L}$	94,000	148 <sup>A</sup>	< 0.05*	> 99.9999%
Atorvastatin $\mu\text{g/L}$	71,000	14 <sup>A</sup>	< 0.005*	> 99.9999%
Roxithromycin $\mu\text{g/L}$	75,000	1 <sup>B</sup>	< 0.005*	> 99.9999%

<sup>A</sup> Values per Temple University's Water and Environmental Technology (WET) Center PNEC List, 2019

<sup>B</sup> Values per AMR Industry Alliance's recommendation, 2019


\* Values indicate the analytical detection limit of these compounds

■ [Technical Bulletin](#)

Acetaminophen	Ampicillin	Atenolol	Atorvastatin	Roxithromycin
MW: 151.16 g/mol	MW: 349.41 g/mol	MW: 266.34 g/mol	MW: 558.64 g/mol	MW: 837.05 g/mol
				



# Axine vs. Competitors

		Trucking & Incineration	Chemical AOP
Capex (customer)	Minimal	Low/Moderate	High
Opex (customer)	Low	High	Moderate/High
Versatility/Efficacy	High	High	Low/Moderate
Trucking miles/risk	Zero	High	Moderate
Safety risk	Low	High	Moderate
Waste disposal	None	Yes	Variable
Hazardous chemicals	None	None	Yes
Water reuse	Yes Possible	No	Yes Possible
GHG emissions	Low	High	Low/Moderate
Performance guarantee	Yes	Variable	No

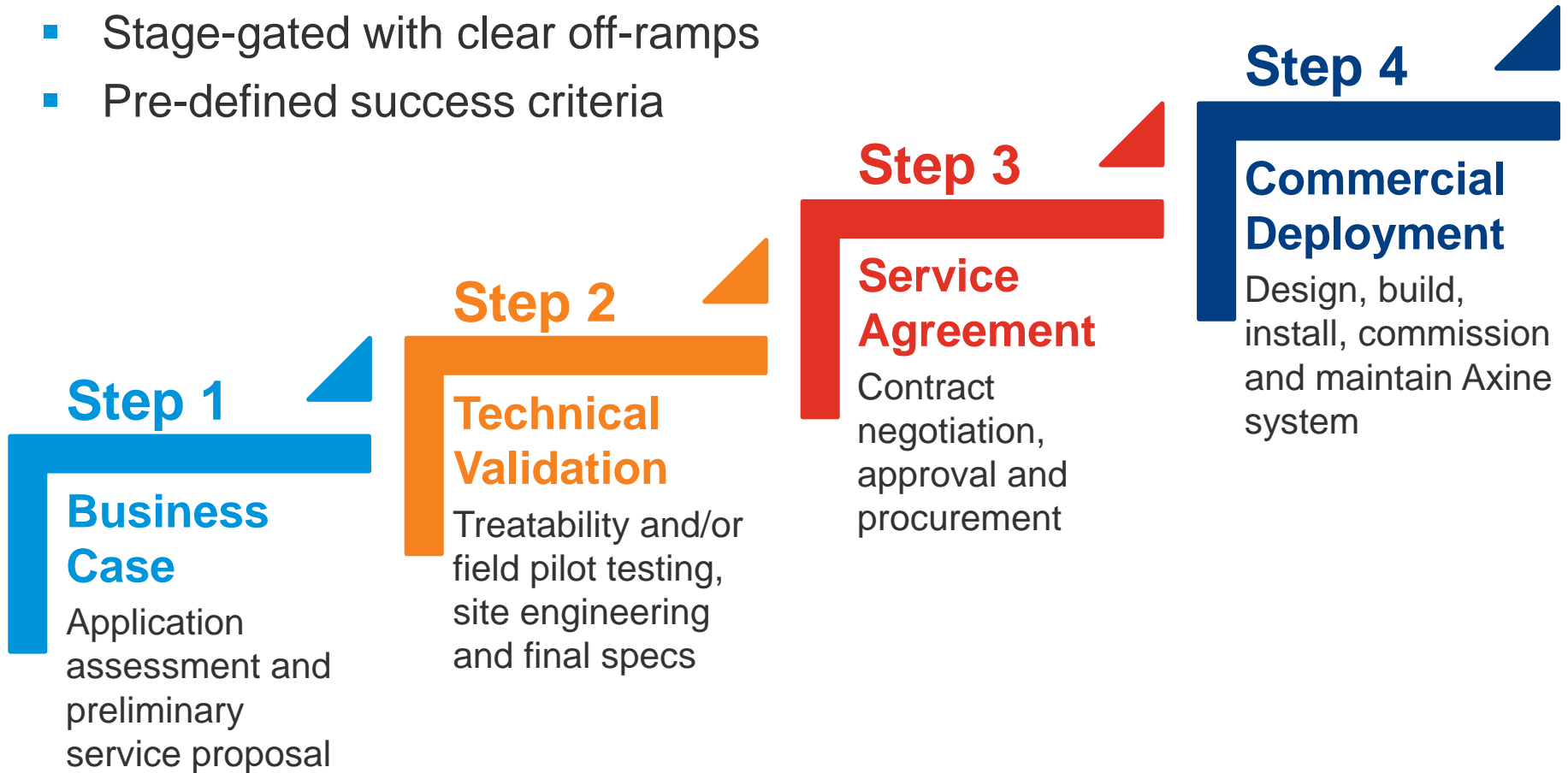
# Project Development Steps





# Project Development Steps

- Progression from initial assessment to deployment
- Stage-gated with clear off-ramps
- Pre-defined success criteria





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