Advanced Wastewater Treatment

For Challenging Environmental Compliance

May 23, 2019 | Maheswaran Nair

Our Safety Commitment 安全承诺

Incident Free Workplace

We are committed to an **incident free workplace** where everybody goes home safe.提供一个**无事故工作环境**，使所有项目参与人员都可以平安回家。

Respect for people means to care for them and to **protect the environment** in which we live and work.
尊重人类意味着关爱和**保护我们工作和生活环境**。

Prevent 预防
harm to people & the environment

Control 控制
workplace conditions

Influence 影响
employees' behaviour

The History of Exyte

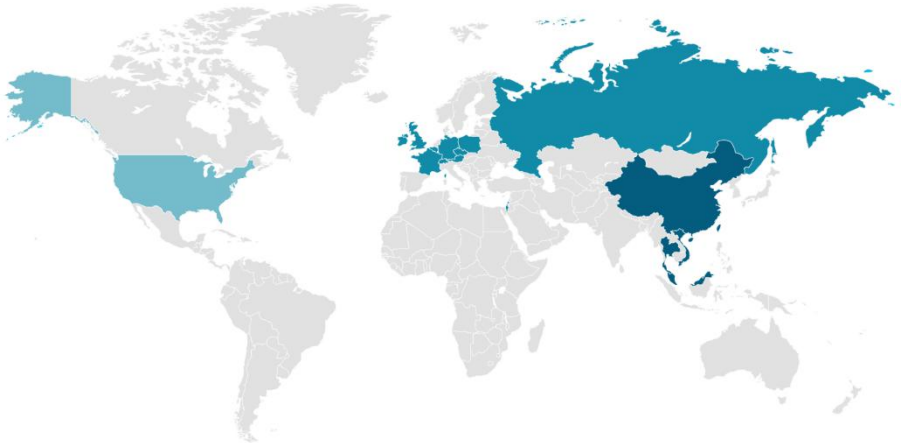
German Engineering Heritage Exceeding 100+ Years of History

1912	**Karl Meissner and Paul Wurst** (“M+W”) **founded the Company** in Stuttgart, Germany, **filing their first patent for a wood chip extractor**		
1960s	M+W Group is a **leading supplier of heating, ventilation and air conditioning systems**, **a pioneer in cleanroom technology and equipment supplier** for semiconductor, pharma, R&D and energy		MEISSNER & WURST
1970s	Supplier of all **airflow equipment for largest nuclear power station** of its time in Germany		MEISSNER & WURST GmbH & Co Lufttechnische Anlagen
1980s	**Semiconductor facility in Taiwan** as the **first large project in Asia** marks a milestone in Advanced Technology Facilities		MEISSNER+WURST
1990s	**Lead contractor for various semiconductor projects** in “Silicon Saxony” in Germany. First **major contract for large scale flat panel display production facility** in Taiwan. Establishing a **strong presence in the United States and China**		m+w zander total facility solutions
2000s	Set up of **new segments** such as Pharmaceuticals & Biotechnology and Science & Research; **Acquisition of M+W Group by Stumpf Group in 2008**		M+W GROUP
2010s	**Global expansion** and **major EPC contracts worldwide**, such as biotechnology and pharmaceutical projects in Europe as well as large semiconductor and flat panel projects in Asia and the United States		M+W GROUP
2018	The **M+W Group which has reorganised** its activities in 2018, thereby creating two, distinct groups of companies ‘**Exyte**’ and ‘M+W’. Effective August 1st, the **core business activities**, namely Advanced Technology Facilities (ATF), Life Sciences and Chemicals (LSC), Data Centers (DTC) and Regional Specific Businesses (RSB) in the **defined target countries** are known as **Exyte.**		

At a Glance

Global leader in the design, engineering and construction of high-tech facilities, plants and factories

- **5600** employees (2018) - highly experienced and motivated
- History of **100+ years**
- Sales of approximately **€3.5bn** (2018)
- **Full spectrum of services** from consulting and design to managing turnkey solutions
- Special expertise in **controlled and regulated environments**
- Serving the most **technically demanding clients**



- Uniquely positioned to support locally and globally
- Client-centric operation in **20+ countries**

30 YEARS OF EXCELLENCE IN APAC

exyte

1989
First large project in Asia

2010
Delivered key EPC projects in Asia

2016
Secured major contract for global client in Dalian, China

2017
Obtained Grade A General Contractors License in China

2019
Exyte celebrates 30 years in APAC

1912
"M+W" founded in Stuttgart, Germany

1991, 1994 and 2007
Established offices in Singapore, Mainland China and Vietnam

2011
Completed project with major medical device client in Hanoi, Vietnam

2017
Awarded Project of The Year 2nd Runner Up in Singapore

2018
Secured major contract for global client in Singapore

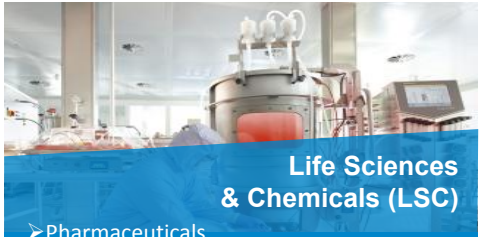
Rebranded to Exyte

exyte

Areas of Technical Expertise

Advanced Technology Facilities (ATF)

- Semiconductor
- Flat Panel Display
- Photovoltaics



Life Sciences & Chemicals (LSC)

- Pharmaceuticals & Biotechnology
- Food & Nutrition
- Consumer Care

Data Center (DTC)

- Cloud Computing
- Enterprise
- Co-Location
- High Performance Computing

Life Sciences: Areas of Technical Expertise

Biopharmaceuticals | **Pharmaceuticals** | **Vaccines** | **Aseptic Fill/Finish**

Plasma Fractionation | **Animal Health** | **Medical Devices**

Exyte Life Sciences Group

Highly recognized in the industry

ISPE Facility of the Year Awards (FOYA)

FOYA	Category	Company	Project	Class	Country
2019	Operational Excellence	Kantonsapotheke Zürich	New Compounding Pharmacy for Canton Zürich Hospitals	Pharmaceutical	Switzerland
2018	Honorable Mention	Government Pharmaceutical Organization (GPO)	Rangsit Pharmaceutical Production Plant 1	Pharmaceutical	Thailand
2014	Process Innovation	Patheon Pharma Services (fka DSM Biologics)	Facility of the Future	Biotechnology	Australia
2013	Project Execution	F. Hoffman–La Roche Ltd.	TR&D – Building 97	Pharmaceutical	Switzerland
2012	Operational Excellence	Roche Diagnostics GmbH	TP Expand	Biotechnology	Germany
2011	Process Innovation	F. Hoffman–La Roche Ltd.	MyDose	Pharmaceutical	Switzerland
2011	Equipment Innovation	Novartis Vaccines and Diagnostics GmbH	MARS	Biotechnology	Germany
2008	Project Execution	F. Hoffman–La Roche Ltd.	Biologics IV	Biotechnology	Germany
2007	Project Execution Regional Excellence	Shanghai Roche Pharmaceuticals Ltd.	SHiP	Pharmaceutical	China

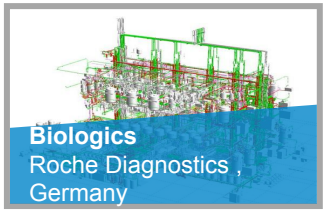
Global Footprint

Ability to Follow Our Clients Just About Anywhere

Biologics
Ireland, Abbvie

Flexi Lab –
Location/Client TBD

Vaccine Facility
Hungary, GSK



Biologics
Roche Diagnostics ,
Germany

Sterile Fill/Finish
USA, Fresenius Kabi

Biologics
Fuji Film, UK

Biologics Laboratory
USA , Amgen

Modular Biologics
Pfizer, USA

GMP Pilot Plant
Vertex, USA

MultiPurpose Pharma
Athenex, USA

Biologics
USA, Sanofi

Sterile Fill/Finish
Roche, Switzerland

Life Science Projects in China

- F&B
- Biopharma
- Pharma
- Nutritional
- Consumer Care
- Medical Devices
- Labs / Bio Safety Labs 3

Advanced Wastewater Treatment

For Pharmaceutical Industry

May 23, 2019

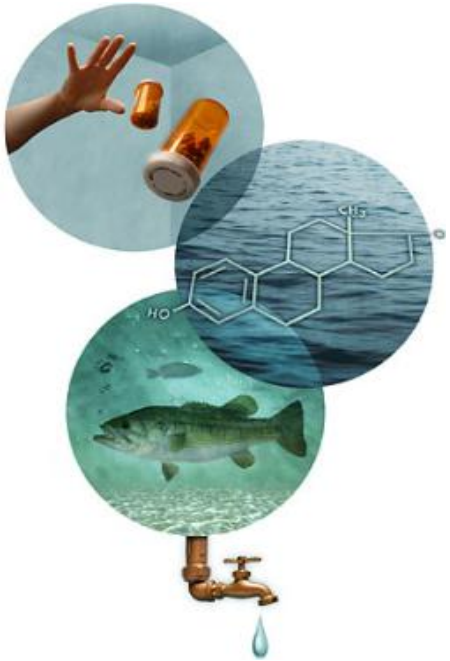
Advanced Wastewater Treatment

Impact of pharmaceuticals in water bodies

- Increasing amount of pharmaceuticals are released from manufacturing facilities and end up in the effluent water of wastewater treatment plants
- Generic WWTs are not specifically designed for pharmaceutical removal.
- The presence of pharmaceuticals were identified in surface and wastewaters in the United States and Europe in 1960s
- Several studies suggest diverse negative effects on aquatic life that are exposed to these trace amounts of pharmaceuticals in their habitats.
- Concerns about their potential risk was raised much later in 1999

Advanced Wastewater Treatment

Impact of pharmaceuticals in water bodies



- Aquatic life is at higher risk than humans due to direct and constant exposure to pharmaceuticals.
- Hormones or compound mimic the properties of hormones, which are capable of feminizing or masculinizing fish.
- Anti-inflammatory drug, diclofenac, has shown to have damaged the gills and lungs of fish.
- In some areas, water scarcity has resulted in the practice of wastewater reuse, and the drinking water has been detected to have trace levels of pharmaceuticals (ppb)
- The contaminants include antibiotics, anti-depressants, anti-inflammatory, anti-epileptic, as well as various hormones etc.

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Impact of pharmaceuticals in water bodies

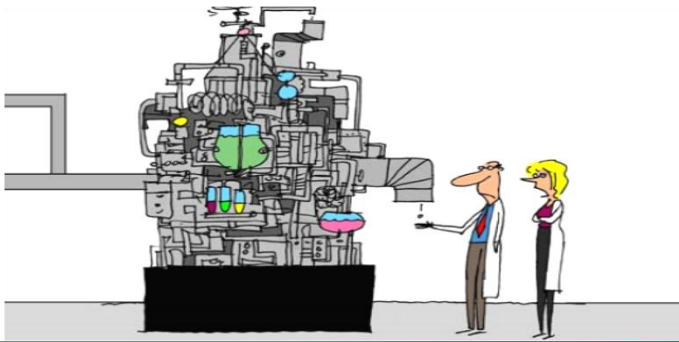
- Presence of trace amount of pharmaceutical is proved to be harmful to both aquatic life as well as humans.
- Authorities are continually updating policies that address the issue of pharmaceutical pollution.
- Current wastewater treatment has been researched to determine how well these treatment plants can address the issue.
- Utilize / remodel the current wastewater treatment plants or find new solutions depends on the residual level of pharmaceuticals.

Advanced Wastewater Treatment

Challenges in Pharmaceutical Waste Treatment

	Waste from production of			
Characteristic	**Penicilin**	**Terramycin**	**General antibiotic**	**Fermentation products**
BOD,ppm	8,000-13,000	20,000	1500-1900	4,500
S.S		10	500-1000	10,000
pH	2-4	9.3	1-11	6-7

- Diverse characteristics of PWW.
- Different drugs produce different type of waste
- Variable amount of waste products
- Mixing of pharmaceutical waste with other type of waste
- High BOD and highly variable pH
- Inherent behavior for pharmaceutical to resist biological activity
- Lack of in-line monitoring of critical trace pollutants



Advanced Wastewater Treatment

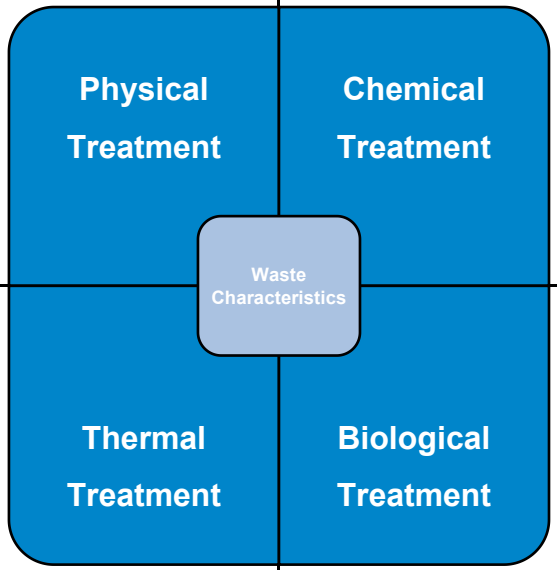
Overview of Wastewater Treatment Methods

Filtration, Membrane Process

- Particulate Removal

GAC, Pre-Coat filters

- Oxidant, Organic Removal



Ion Exchange

- Ionic pollutant removal

Chemical dosing, Precipitation, AOP

- Neutralization and removal of pollutant that are precipitative, non-biodegradable organics, Metal, PO4, etc.

Incineration, Pyrolysis

- Burning combustible waste or high temperature decomposition without oxygen

Thermal Catalytic Oxidation

- Ammonia removal etc.

Aerobic Process

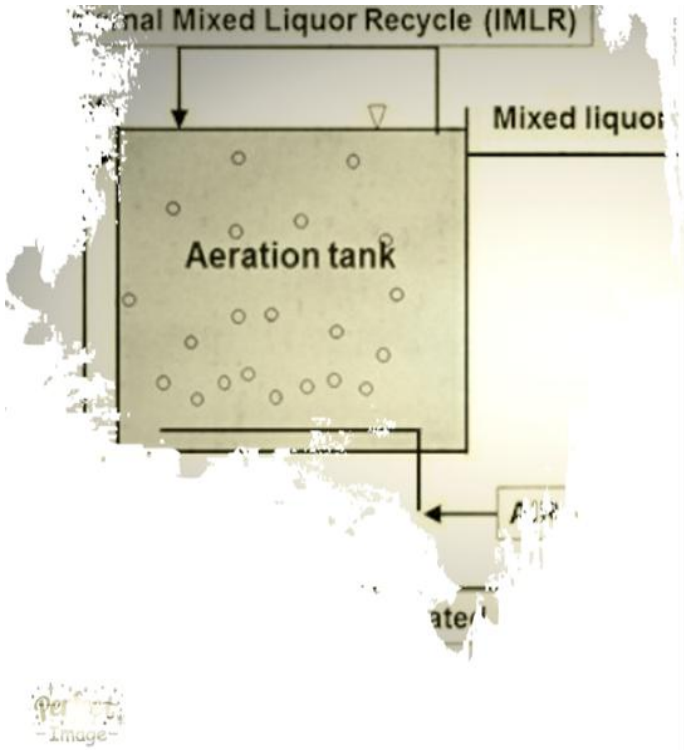
- Activated sludge process, Trickling Filters, Membrane Bio Reactors for biodegradable organics removal

Anaerobic Process

- High concentration organics treated without Oxygen

Advanced Wastewater Treatment

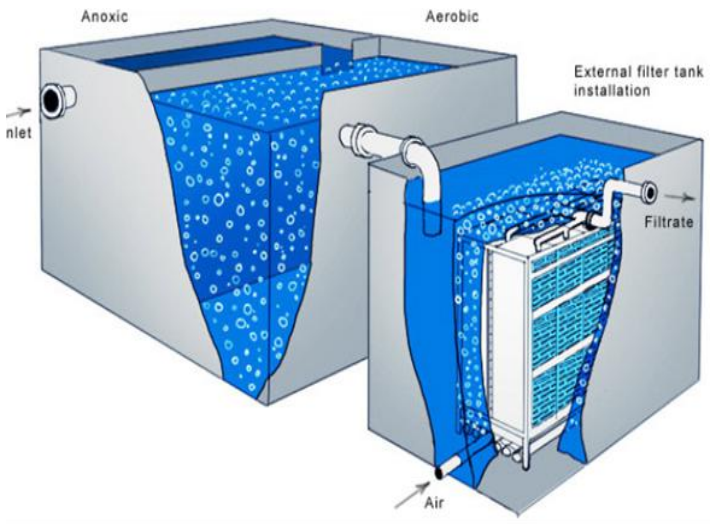
Workaround with existing system



- In general, conventional water wastewater treatment processes are often not designed to remove trace levels of pharmaceuticals
- One strategy for finding a solution to pharmaceuticals in effluent waters of wastewater treatment plants is through exploration of already-operating wastewater treatment plants.
- By evaluating how well certain wastewater treatment plants already remove pharmaceuticals, solutions for their improvement
- This could potentially save time and money by considering the wastewater treatment options which are already in operation instead of trying to think of completely new solutions.
- These diverse wastewater treatment methods could use advanced technologies.

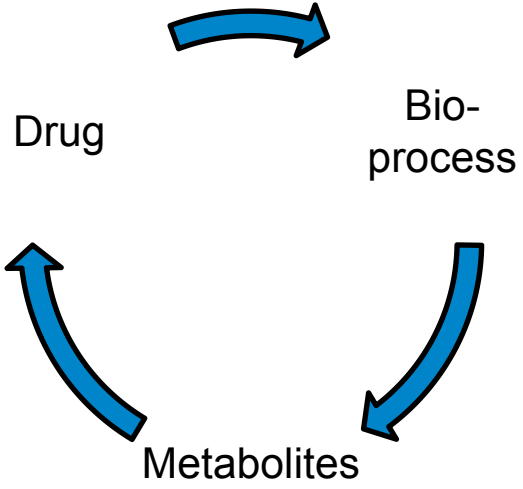
Advanced Wastewater Treatment

Activated Sludge Process



- Activated sludge is a common method for wastewater treatment; microorganisms help degrade the organic compounds in the wastewater
- Fairly cheap, but generates contaminated sludge and challenges in disposing it
- Landfill, fertilizer, incineration (potential issues with contamination)
- Activated sludge treatment has the ability to break down certain pharmaceuticals to some degree.
- sulfamethoxazole (antibiotic), ibuprofen and acetylsalicylic acid degrades to some degree in 2 -5 days up to 98%
- Anti-epileptic gabapentin, up to 84%
- Diclofenac (anti-inflammatory), Roxithromycin (antibiotic) need 5- 15 days
- Carbamazepine, (anti-epileptic drug) and diazepam (psychoactive drug) no significant degradation even in 20 days.

Advanced Wastewater Treatment
Activated Sludge Process

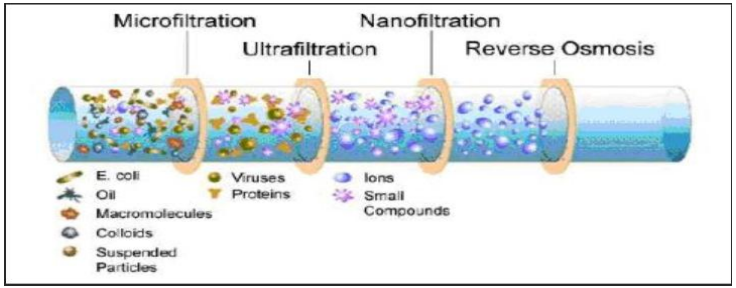


- Use of pre-acclimated bacteria culture could improve biodegradability to some extend.
- In some case the concentration increases after some time for some drugs like Diclofenac (anti-inflammatory)
- After biological activity the metabolites remains in the water and has ability to get converted into the parent product.

Advanced Wastewater Treatment

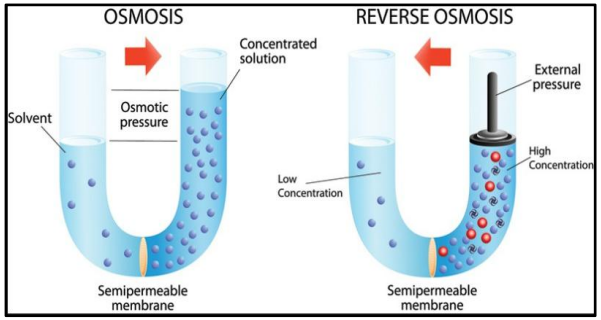
Membrane Process

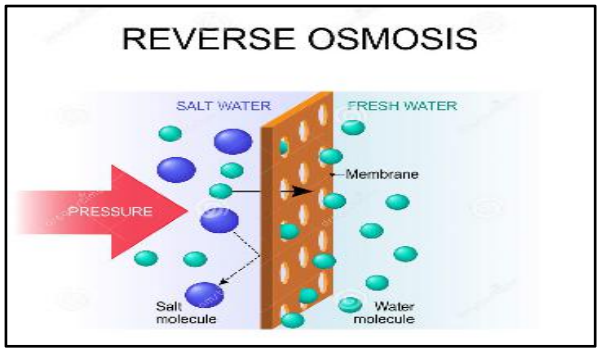
- Advanced membrane process is another viable solution for pharmaceutical wastewater treatment
- It's not a destruction process.
- It separates the pollutant and concentrates it.
- Some kind of destruction process required to remove the pollutants (thermal / chemical / aerobic oxidation)
- Or the concentrate needs to be evaporated for a zero liquid discharge or hauled out



Advanced Wastewater Treatment

Membrane Process

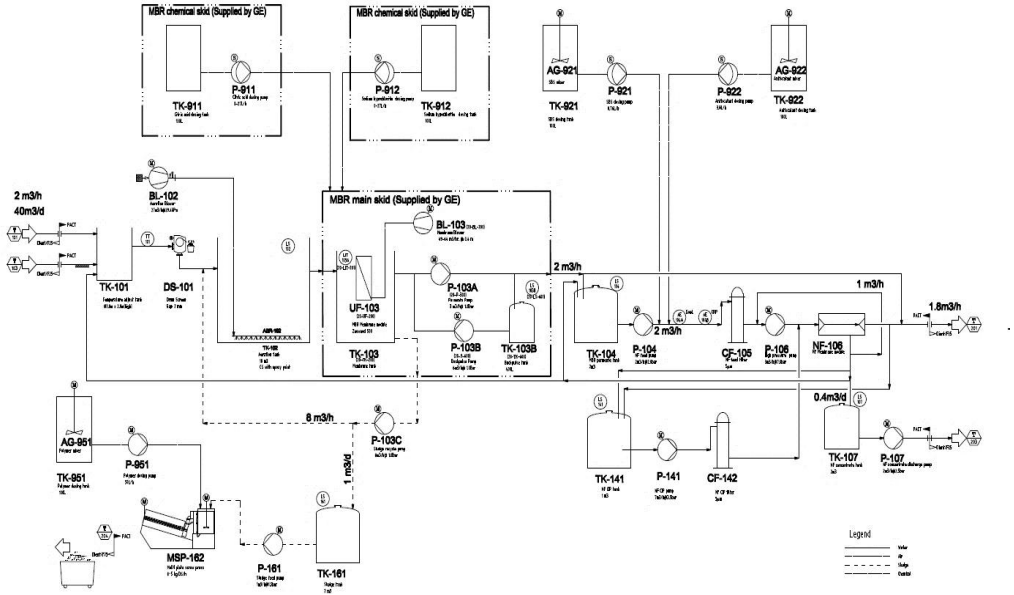




- Mainly two types of membrane treatment - Nano filtration and reverse osmosis.
- Nano Filtration: . Nano Filtration is pressure driven membrane filtration
- Operates in cross flow mode
- Nano filtration membranes have pore sizes from 1-10 nanometers
- A Typical Nano filtration filter has a pore size of 2 nanometer and is therefore able to remove most organic substances, almost all viruses and other organic molecules and a range of salts
- Generally good rejection for higher molecular weight pollutants.
- Poor rejection for lower molecular weight pollutants
- Membrane construction allow vide verity of cleaning agent for membrane cleaning

Advanced Wastewater Treatment
Membrane Process

Example of Membrane System coupled with bio-reactor



- Reverse Osmosis: Reverse Osmosis is a pressure driven membrane filtration
- Operates in cross flow mode
- Typical RO module has a pore size of 0.1nanometer and can reject even low molecular weight substances
- Member is prone to biological, particulate and hydrophobic substances
- Good pre-treatment is essential for membrane performance and life

Advanced Wastewater Treatment
Membrane Process

Merits

- Membrane process is lower foot print and easily accommodate in an existing plant
- Quick to build or even standard ready to use systems available
- Water Recycling : Permeate water is good for non-process applications like, cooling tower, irrigation etc.

Demerits

- High cost of equipment
- High operation cost due to high energy consumption.
- Feed water shall be treated / conditioned to make sure that the water is not biologically active.
- This is only a separation process and reject from the membrane systems shall be reprocessed
- If the pharmaceuticals are refractory to biological process another destruction process together with it (AOP)
- Alternatively haul off the waste for off site disposal.

Advanced Wastewater Treatment

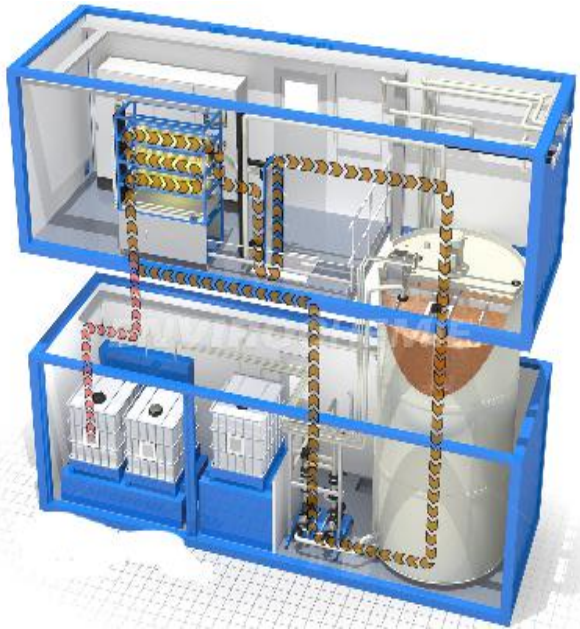
Advanced Oxidation Process

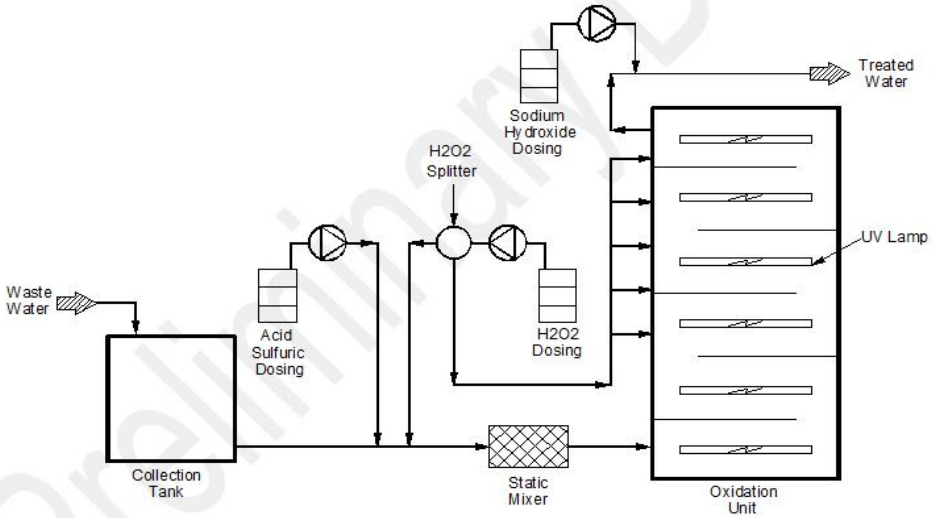
Oxidation potential (eV)	
Oxidant	Oxidation potential (eV)
Hydroxyl radical(OH•)	2.80
Singlet Oxygen O(1D)a	2.42
Ozone (O3)	2.07
Hydrogen peroxide (H2O2)	1.77
Perhydroxy radical	1.70
Permanganate Ion (MnO4-)	1.67
Chlorine Dioxide (ClO2)	1.50
Chlorine (Cl2)	1.36
Oxygen (O2)	1.23

- Advanced oxidation Technology generally involve generation and use of powerful oxidizing species, primarily hydroxyl radicals (OH•).
- Hydroxyl radicals can be generated by both photochemical process and non-photochemical process.
- Ultraviolet (UV) with a combination of H2O2, O3 or Fenton reagent is photochemical process.
- Non-photochemical process includes, Combination of H2O2 and O3, Dark Fenton process
- Hydroxyl free radicals having high oxidation potential,
- Decomposes most of the organic species including non-biodegradable
- AOP destruct the pollutant completely or convert non-biodegradable into biodegradable

Advanced Wastewater Treatment

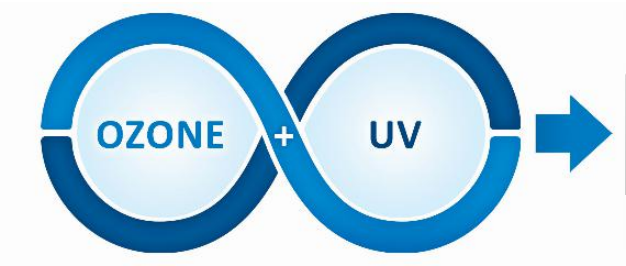
Advanced Oxidation Process (UV + Peroxide)



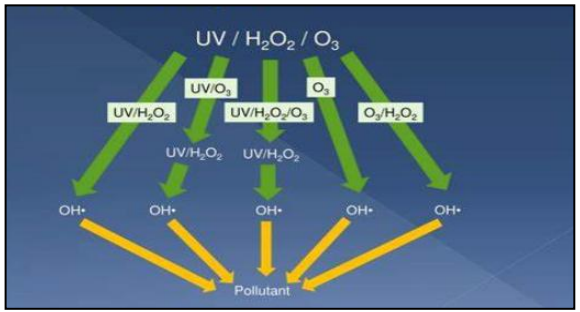


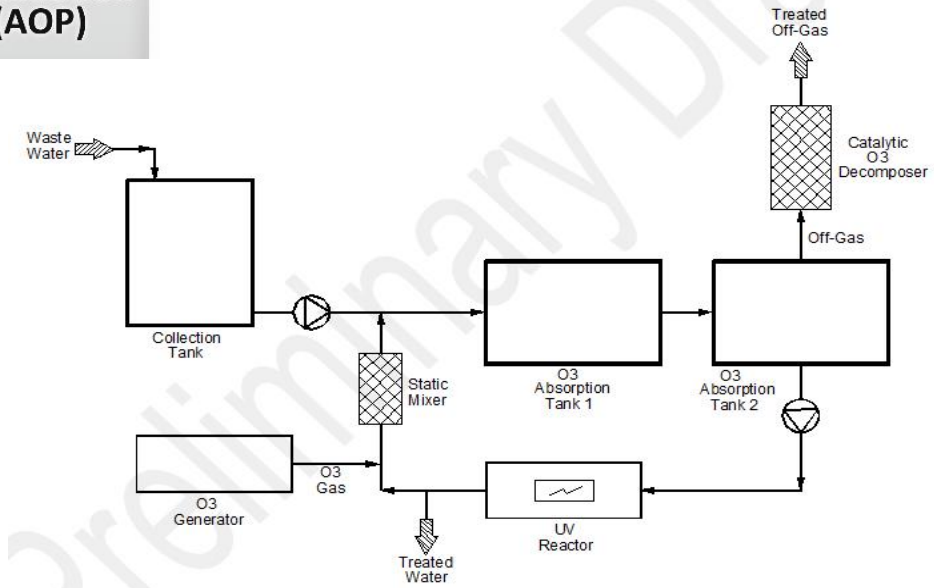
Advanced Wastewater Treatment

Advanced Oxidation Process (UV+ Ozone)



Advanced Oxidation Process (AOP)



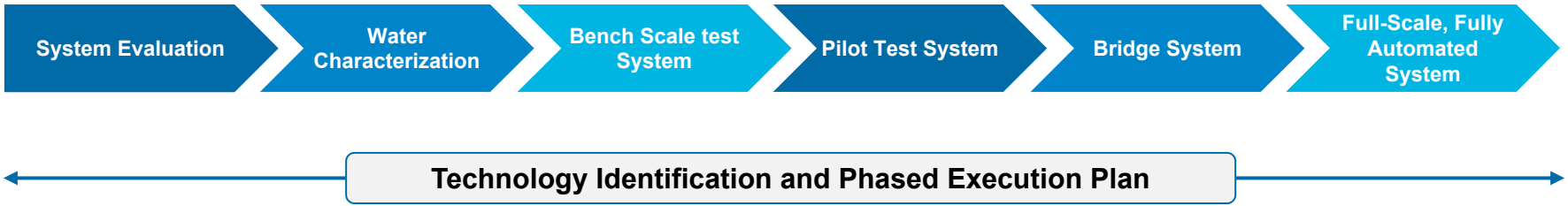


Advanced Wastewater Treatment
Development Path

- Waste stream characteristics are complex
- It may not be practical to arrive on a conclusion of a treatment scheme, without a pilot / bench scale study.
- It may also necessary to employ more than one technology to achieve the desired result.
- A pilot-scale system shall be engineered to estimate the performance and cost of a particular treatment scheme
- Helps to Identify the field operational problems, and to evaluate the scale-up requirement for implementing a technology.
- A commercial system shall be selected only after pilot-scale system proves successful

Advanced Wastewater Treatment
Development Path

Provides a safe, robust and sustainable treatment method (Best Available Technology)



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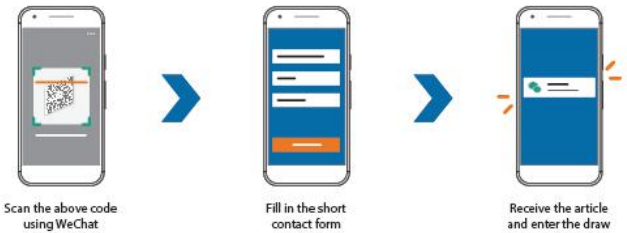

Thank You.

Maheswaran Nair
Exyte China
maheswaran.nair@exyte.net