New Trends for Purification of Industrial Contaminated Water

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Industrial Water Use

Water withdrawals for industry

- Domestic use: 8%
- Industrial use: 22%
- Agricultural use: 70%

World: 22%
High-income countries: 59%
Low-income countries: 8%

The annual water volume used by industry

1995: 752 km³/year
2025: 1,170 km³/year (estimated)

In 2025, the industrial component is expected to represent about 24% of total freshwater withdrawal.
Summary of EU Directive 96/61/EC concerning Integrated Pollution Prevention and Control

The "Integrated Pollution Prevention and Control" (IPPC) Directive is based on several principles, namely

(1) an integrated approach,
(2) best available techniques,
(3) flexibility and
(4) public participation

Water is of vital importance to many industrial sectors and is the most frequently used medium in industries.

The major EU water using and or polluting industries are:

- Paper & Pulp
- Textile
- Leather (tanning)
- Oil/Gas
- Chemical/- Pharmaceutical
- Food
- Energy
- Metal
- Mining

They are of great economic importance looking at:

- annual turnover > 1,500,000 M€,
- annual investments > 15,000 M€
- EU employment
- number of companies: > 200,000
- employees: > 7.5 million
Water Using and/or Polluting Industrial Sectors

The major functions of water in industry are:

- raw material (incorporating water into a product)
- transport medium
- washing/rinsing/cleaning
- heat transfer
- reaction medium/solvent

⇒ 300-500 million of wastes accumulate each year from industry.

- Heavy metals
- Solvents
- Toxic sludge
- Organic pollutant

⇒ More than 80% of the world's hazardous waste is produced in the United States and other industrial countries

⇒ In developing countries, 70% of industrial wastes are dumped untreated into waters where they pollute the usable water supply
Industry is the second largest water user
Industry is for a big part responsible for polluting surface and groundwater

The water related costs are significantly for industry covering in general:

- **Water intake and pre-treatment:** - tap water, groundwater, surface water
  - pre-treatment to required process water quality
- **In-process treatment:** - treatment to re-use (closed loop)
- **Effluent treatment:** - treatment to meet discharge standards
- **Energy** - heating and cooling
- **Content of materials** - raw material
  - product

The water related costs will increase in the forthcoming decades by:
- water scarcity
- secure and increase of the required process water quality
- more stringent discharge standards
Water Quality and **Quantity issues**

**INTAKE:** Securing availability of sufficient water of the quality demanded
- Sources, storage, treatment

**IN-PROCESS:** Water and energy saving by re-use and closing the water cycle
- Treatment of water streams for re-use;
- Separation of critical substances
- Determination of water quality demands related to the product quality, “fit-for-use”
- Increased process stability and product quality
- Recovery of raw materials
- Cost-effective treatment technologies

**DISCHARGE:** Less hazardous process chemicals
- Less polluting processes
- **Advanced waste water treatment**
- Less discharge Fees
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<th>Industrial Sector</th>
<th>Water used as</th>
<th>Critical Compounds</th>
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<tr>
<td>Chemical Pharmaceutical</td>
<td>Reaction medium/Solvent</td>
<td>Inorganic, Polymers, Non-biodegradable Organics, Nutrients, Microorganisms, Bio-accumulative &amp; Bio-toxic</td>
</tr>
<tr>
<td></td>
<td>Washing, Cleaning, Cooling, Heating</td>
<td></td>
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<tr>
<td>Paper &amp; Pulp</td>
<td>Bleaching and Forming</td>
<td>Salts, Stickier, Additives &amp; Extractives Organic Chlorine Compounds</td>
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<tr>
<td></td>
<td>Washing, Screening</td>
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<tr>
<td>Textile</td>
<td>Dyeing, Finishing, Washing/Rinsing</td>
<td>Dyestuff, Surfactants, Hardness and Salts</td>
</tr>
<tr>
<td>Food</td>
<td>Part of the product, Washing/Rinsing Cleaning</td>
<td>Micro-biological Products, Cleaning agents, Pesticides, Colouring and Smelling Compounds</td>
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<tr>
<td>Leather (tanning)</td>
<td>Soaking Washing/Rinsing and Dyeing</td>
<td>Hide/skin materials, Grease, Salt, Sulphides, Cr (III), Biocides</td>
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<tr>
<td>Metal</td>
<td>Electroplating/Anodising Coatings, Degreasing, Passivating, Pickling</td>
<td>Metals. Oil, fats, Dyes, Pigments, Cyanides Corrosion Inhibitors</td>
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<tr>
<td>Oil/Gas</td>
<td>Drilling activities</td>
<td>Salts, Heavy metals, Biologically degradable organics</td>
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<td>Mining industry</td>
<td>Working pit Drainage</td>
<td>Chloride &amp; sulphate, Heavy metals Natural Radioactive Elements</td>
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<td>Cooling water</td>
<td>Cooling</td>
<td>Cooling water additives and their reactants Corrosion products, Leaked process</td>
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Industrial Wastewater Treatment

The different types of contamination of wastewater require a variety of strategies to remove the contamination.

**Standard Treatment Process**

Primary treatment
Solids are Separated from Liquids.

Secondary (biological) treatment.
is used to Lower the Organic Load

Oxygen is added to activate the living microorganisms that eat the dissolved organic material still in the wastewater.

An 'activated sludge' treatment process where the organisms are maintained at a very high level to accelerate the consumption process.

**Advanced Treatment Process**

This advanced treatment involves an additional filtration step to remove any remaining solids and an extended disinfection process.
Types of Advanced Wastewater Treatment

Advanced Wastewater Treatment may be broken into three major categories by the type of process flow scheme utilized:

- Tertiary Treatment
- Physical-Chemical Treatment
- Combined Biological-Physical Treatment

Advanced Wastewater Treatment is used for:

- Additional organic and suspended solids removal
- Removal of nitrogenous oxygen demand (NOD)
- Nutrient removal
- Removal of toxic materials

Another way to classify Advanced Wastewater Treatment is to differentiate on basis of desired treatment goals.
Advanced Wastewater Treatment

- **Tertiary Treatment**

**Reverse Osmosis** is a high-pressure membrane process capable of removing bacteria, viruses, dissolved organic matter and salts from liquids.

The process is called “Reverse” Osmosis since it requires pressure to force pure water across a membrane, leaving the impurities behind.

Particles that cannot pass through the reverse osmosis membrane are concentrated in a side-stream that must be treated or disposed.

**Reverse Osmosis is capable of removing 95%-99% of the total dissolved solids (TDS) and 99% of all bacteria, thus providing safe, pure water**
Ion-exchange is a process used to remove dissolved solids from aqueous solution by electrostatic adsorption into ion resins.

It is mainly used for purification purposes, but can also be implemented as a technique for valuable metals recovery from wastes and hydrometallurgical processes.

The ion exchange operation is divided into the following subprocesses of sorption, elution eventually followed by regeneration.
**Advanced Wastewater Treatment**

- **Tertiary Treatment**

  **Activated Carbon**
  
  Adsorption: the most well-known mechanism, through physical adsorption or chemisorption

Reduction: e.g. removal of chlorine from water is based on chemical reduction reactions

Carrier of biomass: support material in biological filters

Apart from the activated carbon product to be selected, a key issue to address is the type of technology to apply.

*Powdered activated carbon is dosed into the process stream (gas or liquid) and, after a certain contact time, separated by filtration or settling.*

*Granular activated carbon is mostly used in fixed filter beds, or alternatively in (pseudo-) moving filter beds*

AC filtration does not remove microbes, sodium, nitrates, fluoride, and hardness.
To make water re-use possible and to reduce the emissions to surface water new treatment techniques and concept have to be developed.

Important research issues within this framework are:

- development of integrated water treatment advanced systems
- development of cost-effective desalination technique
- development of the techniques for selective removal of critical components
- development of small scale techniques
- treatment techniques for wet residues
The PACT (powdered activated carbon treatment) System combines biological treatment and carbon adsorption into a single, synergistic treatment step, resulting in significant cost savings and performance advantages over other systems.

The PACT system can be used to treat industrial wastewater, landfill leachate and highly contaminated surface water or groundwater.

No problems with prefiltration or column plugging
Advanced Membrane Technologies

- IMS (Integrated Membrane Systems):
  Continuous Microfiltration (CMF) or UF (Ultrafiltration) in combination with Reverse Osmosis (RO) and Nanofilter (NF) systems

- Electrodialysis
  Electric current moves salts selectively through a membrane, leaving fresh water behind.

Membrane-based processes and electrodialysis, are an energy intensive technology, due to fouling of membrane surfaces which reduces the flow of water.

- New Generation of the Membranes
  developed using nanotechnology which may lead to breakthrough technologies in cost-effective and high efficient water recovery systems.
Electromagnetic Water Treatment

Non-chemical water treatment has been around for many years, generally in the form of "permanent magnets".

AQA-total, a German company, offers a device that uses a special electrode assembly that works directly on the carbonic acid balance of the water

1) water "clusters" can be broken up by a magnetic field, and
2) doing so can have any effect its ability to dissolve solids.
   (99% calcium-magnesium removal)
ESIL Water Technology has the potential to make drinkable water from contaminated sources around the world.

The bacterial, parasitic and viral organisms are killed within the ESIL cell. The electrical current forces all possible reactions in the water to take place.

Heavy metals are rendered inert and neutral.

Synthetic organic compounds (dioxins and PCB’s) are effectively shattered and broken down.

The inert particulates formed after the process are easily removed by standard filtration.

Water technology consists of multiple series of electrolytic cells containing anodes and cathodes.

Low-voltage direct current (DC) is applied as water continuously flows through a labyrinth of holes in the cathodes.
The Spectra Solar Cube can purify and desalinate water from almost any source.

Powered from the integrated photovoltaic solar panels and wind powered generator

Solar Cube solutions can provide both pure drinking water and electricity for small villages, resorts, or disaster relief
The different types of contamination of wastewater require a variety of strategies to remove the contamination.

To make water re-use possible and to reduce the emissions to surface water new treatment techniques and concept have to be developed. They are:

- **Development of integrated water treatment advanced systems**
  New hybrid technologies which combine the advantages of different technologies

- **Development of cost-effective technique**
  New techniques has to be developed, possibly in combination with the application of sustainable energy sources

- **Development of the techniques for selective removal of critical components**
  The development of new adsorbents with a high selectivity

- **Development of small scale techniques**
  Small modular techniques for SMEs

Development and implementation of new, reliable, cost-effective water technologies ensuring the availability of sufficient water quantities of the right quality at the right time.

Minimization of water consumption based on tailor-made water management and treatment concepts.
Thank you for your attention

C3P AND NASA TECHNICAL WORKSHOP

"PARTNERING FOR ENERGY AND ENVIRONMENTAL STEWARDSHIP"