MPP SYSTEMS

Macro Porous Polymer Extraction

Water treatment

99.9999% removal of hydrocarbons

VEOLIA WATER
Solutions & Technologies
VWS MPP Systems
The hydrocarbon removal watertreatment specialist

MPP Systems is specialized in developing, marketing, manufacturing and servicing water purification systems based on Macro Porous Polymers (MPP). The Macro Porous Polymer Extraction (MPPE) system is a highly effective, fully automated, remote controlled and guaranteed technology for removing hydrocarbons from water by means of extraction in a MPP bed.

**MPPE systems are used for:**
- Offshore and onshore produced water
- Industrial waste water
- Industrial process water
- Groundwater

**The MPPE Process Description**

In the MPPE process, hydrocarbon-contaminated water is passed through a column packed with MPPE particles. The particles are porous polymer beads, which contain a specific extraction liquid. The immobilized extraction liquid removes the hydrocarbons from the water. Only the hydrocarbons, which have a high affinity for the extraction liquid, are removed. The purified water can then either be reused or discharged.

Periodical in situ regeneration of the extraction liquid is accomplished by stripping the hydrocarbons with low-pressure steam. The stripped hydrocarbons are condensed and then separated from the water phase by gravity. The almost 100% pure hydrocarbon phase is recovered, removed from the system and ready for use/reuse or disposal. The condensed aqueous phase is recycled within the system. The application of two columns allow continuous operation with simultaneous extraction and regeneration. A typical cycle is one hour of extraction and one hour of regeneration.

MPPE removes dissolved and dispersed hydrocarbons with removal rates of 99.9999%, down to below ppb level or any desired level.

Removable hydrocarbons, e.g.:
- Aliphatic
- Aromatic
- Polyaromatic
- Halogenated, e.g. chlorinated, bromated
Industrial Process & Waste Water

The MPPE technology can be applied anywhere in the water line upstream or end of pipe. The treated water may be recycled to process, discharged to surface water or to site/municipal biotreatment.

Typical challenges MPPE can meet:
• High influent concentrations
• High reduction factors
• Varying concentrations and compositions
• Varying flows
• Varying/wide pH range
• Presence of salts, surfactants, heavy metals, alcohols, monomer residues, pre-polymers, etc.

MPPE benefits:
• Small footprint
• Upstream integrated operation with remote control
• Scope for adding other waste- and groundwater streams, for treatment in one unit
• Reduced sludge formation in biotreatment
• Modular set up for large flows (thousands of m³/hr)

Industries
• Natural gas production/treatment
  - Aromatics, polyaromatics, aliphatics (3,000 ppm and above)
• LNG terminals/gas to liquid plants
  - Aromatics, polyaromatics, aliphatics
• Refineries
  - Aromatics, aliphatics
• Underground gas storage
  - THT (tetrahydrothiophene), aromatics
• Water, oil, gas/condensate produced water onshore
  - Aromatics, polyaromatics, aliphatics
• Chemical, specialty chemical and pharmaceutical raw material producers
  - Broad range of aromatics, aliphatics and halogenated (chlorinated/bromated) hydrocarbons
• Chemicals/oil storage distribution industry
  - Tank cleaning waste water and groundwater
  - Aromatic, aliphatic and halogenated hydrocarbons
• Resin production
  - Solvents/aromatics removal from waste streams containing monomer residues
• Electronics Industry
  - Solvents removal (toluene) e.g. flat screen factories
• Rayon/viscose industry
  - Carbon disulphide (CS₂), aromatics, aliphatics
• More than 15 years of operational experience (Philips, Gaz de France, TOTAL, Synthexim, AkzoNobel, Albemarle, Dow Chemical, LBC, Woodside, Western Refining)

Removal of total spectrum of non-polar and polar organics proven in practice:
• MPPE removes toxic non-polar, non-biodegradable compounds
• Followed by biotreatment removing polar biodegradable compounds
• Optional: UF and/or activated carbon filtration and RO for reuse as process or boiler feed water
Offshore and LNG produced water

MPPE for Zero Harmful Discharge

Risk based management of offshore produced water is gaining worldwide interest of Oil & Gas companies and governments. Specific water treatment focused on removing toxic hydrocarbons leads to Zero Harmfull Discharge (ZHD).

Environmental Impact Factor (EIF)

- Management tool Norwegian Industry
- To minimize Harmful Discharge of produced water

MPPE reduces EIF 95-99%

Reduction effect of MPPE™ vs. Flotation

<table>
<thead>
<tr>
<th>Compounds</th>
<th>ppm</th>
<th>Composition</th>
<th>EIF Flotation</th>
<th>EIF MPPE™</th>
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</thead>
<tbody>
<tr>
<td>Dispersed oil +</td>
<td>40-100</td>
<td>DA</td>
<td>DA</td>
<td>DA</td>
</tr>
<tr>
<td>Dispersed hydrocarbons +</td>
<td></td>
<td>BTEX</td>
<td>BTEX</td>
<td>BTEX</td>
</tr>
<tr>
<td>Dissolved hydrocarbons</td>
<td>200-800</td>
<td>BTEX</td>
<td>BTEX</td>
<td>BTEX</td>
</tr>
<tr>
<td>Toxic</td>
<td></td>
<td>Aromatic</td>
<td>Aromatic</td>
<td>Aromatic</td>
</tr>
<tr>
<td>BTEX</td>
<td></td>
<td>Aromatic</td>
<td>Aromatic</td>
<td>Aromatic</td>
</tr>
<tr>
<td>PAHs</td>
<td>0.2-6</td>
<td>PAHs</td>
<td>PAHs</td>
<td>PAHs</td>
</tr>
<tr>
<td>NPD</td>
<td>0.1-0.2</td>
<td>NPD</td>
<td>NPD</td>
<td>NPD</td>
</tr>
<tr>
<td>Dissolved hydrocarbons</td>
<td>100-200</td>
<td>Dissolved</td>
<td>Dissolved</td>
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</tr>
<tr>
<td>PAHs</td>
<td>0.1-0.2</td>
<td>PAHs</td>
<td>PAHs</td>
<td>PAHs</td>
</tr>
<tr>
<td>Aromatic</td>
<td></td>
<td>Aromatic</td>
<td>Aromatic</td>
<td>Aromatic</td>
</tr>
<tr>
<td>Acids</td>
<td></td>
<td>Fibrous</td>
<td>Fibrous</td>
<td>Fibrous</td>
</tr>
<tr>
<td>Alcohols (Methanol)</td>
<td></td>
<td>Aromatic</td>
<td>Aromatic</td>
<td>Aromatic</td>
</tr>
<tr>
<td>Polar</td>
<td></td>
<td>Aromatic</td>
<td>Aromatic</td>
<td>Aromatic</td>
</tr>
</tbody>
</table>

Evidence of success:

- MPPE selected as best option among 55 technologies (Government and Oil & Gas Industry Study)
- MPPE listed by OSPAR® as Best Available Technology (BAT)
- Experiences published with customers at conferences - TOTAL; SPE
  - Shell/Exxon L2 offshore; OTC
  - Statoil Kollsnes; TÜV/NEL, SPE
  - Statoil/Shell Ormen Lange; TÜV/NEL, TEKNA
  - Woodside Pluto; APPEA
- More than 15 years of operational experience
  TOTAL, NAM (Shell/Exxon), StatoilHydro/Shell Ormen Lange, Woodside Pluto, Statoil Kollsness, Shell Prelude, Inpex Ichthys, BP West Nile

*OSPAR: Oslo Paris Convention for the Protection of the Marine Environment of the Northeast Atlantic

MPPE removes dissolved and dispersed toxic hydrocarbons:
- Aliphatic (dispersed oil)
- Aromatic (BTEX)
- Polyaromatic (PAHs)
- NPD (Naphthalenes, Phenanthrenes, Dibenzothiophenes)
- Hydrophobic parts of field chemicals (e.g. inhibitors)

100% water and hydrocarbon recovery
- Separated hydrocarbons practically pure for (re)use
- No waste stream/sludge formation

Robust and can withstand:
- Salt, methanol, glycols
- Corrosion inhibitors
- Scale inhibitors
- H,S scavengers
- Demulsifiers
- Defoamers etc.
- Dissolved (heavy) metals
**Groundwater Remediation**

Aromatic, polyaromatic and halogenated hydrocarbons in groundwater can be found in lower concentrations dissolved in water diffused over the area or concentrated as DNAPLs (dense non-aqueous-phase liquids) or LNAPLs (light non-aqueous-phase liquids) creating an enduring source of contaminant supply to the water phase.

**MPPE benefits:**
- Ideal for handling a broad range of compositions
- Able to cope with unexpected higher inlet compositions at no additional costs
- No iron removal necessary (anaerobic process)
- Robust, can withstand e.g. salts, humic acids, surfactants, heavy metals, dissolved/suspended solids, high/low pH, etc.
- No sludge formation (as with iron removal and biotreatment)
- Scope for combination with other ground- and also waste water streams in one unit
- More than 15 years operational experience with Organon/Scherling Plough/Merck Sharp & Dome, AkzoNobel, Stadtwerke Flensburg, Solvay, LMBV Schwarze Pumpe and LMBV Lauchhammer

**Proven removal rates**

<table>
<thead>
<tr>
<th>Chemical/Pharmaceutical Industry</th>
<th>IN (ppb)</th>
<th>OUT (ppb)</th>
<th>% REMOVAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHC</td>
<td>100,000</td>
<td>&lt; 10 (dl)*</td>
<td>&gt; 99.99</td>
</tr>
<tr>
<td>DCPE</td>
<td>550</td>
<td>&lt; 2 (dl)*</td>
<td>&gt; 99.2</td>
</tr>
<tr>
<td>TCE</td>
<td>1,693</td>
<td>&lt; 1 (dl)*</td>
<td>&gt; 99.9</td>
</tr>
<tr>
<td>TCA</td>
<td>49.7</td>
<td>&lt; 1 (dl)*</td>
<td>&gt; 98</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oil &amp; Gas Industry</th>
<th>IN (ppb)</th>
<th>OUT (ppb)</th>
<th>% REMOVAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTBE</td>
<td>4,860</td>
<td>&lt; 0.1 (dl)*</td>
<td>&gt; 99.9</td>
</tr>
<tr>
<td>BTEX</td>
<td>50,000</td>
<td>&lt; 0.1 (dl)*</td>
<td>&gt; 99.9</td>
</tr>
<tr>
<td>GROs**</td>
<td>2,315</td>
<td>&lt; 5 (dl)*</td>
<td>&gt; 99.8</td>
</tr>
<tr>
<td>DROs***</td>
<td>280</td>
<td>&lt; 5 (dl)*</td>
<td>&gt; 99</td>
</tr>
</tbody>
</table>

* (dl = detection limit)  
** GROs = Gasoline Range Organics (C7-C10)  
*** DROs = Diesel Range Organics (C11-C27)

**DNAPL and LNAPL removal by solvent or Surfactant Enhanced Aquifer Remediation (SEAR)**
- Surfactant or alcohol injection enhances the dissolution of chlorinated hydrocarbons, PAHs, DNAPLs and LNAPLs in water from a few ppm to 10,000 – 50,000 ppm
- Organics recovered in two weeks equaled eight years of normal pump and treat
- The highly concentrated organics/surfactant/alcohol water mixtures are pumped to the surface
- MPPE is ideal to separate these extremely high concentrated hydrocarbons from the surfactant/alcohol water mixtures
- Surfactant/solvent consumption savings as MPPE enables recirculation and recovery
- MPPE applied in the USA Jacksonville (FL), Tampa (FL) (both alcohol injection), Alameda (CA) and in Germany Schkopau, Leipzig, Castrop Rauxel (all surfactant injection)
The majority of toxic hydrocarbons have non-polar and extractable properties. This is why MPPE - being an extraction based technology - is capable of removing just these specific compounds.

Gas/Oil Produced Water Treatment
- Produced water and especially Gas and LNG Produced Water contains high concentrations of toxic compounds like:
  - BTEX (Benzene, Toluene, Ethyl Benzene and Xylene)
  - PAH (Poly Aromatic Hydrocarbons)
  - Dispersed & dissolved Aliphatic compounds
All these compounds can be removed to below ppb level
- An increasing number of Authorities are incorporating the Zero Harmful Discharge Principle into their Discharge Regulations
- The Risk Based Approach and the Norwegian E1F are well known examples of models for legislation
- MPPE is able to remove the harmful content
- Even removal of Mercury being a highly toxic compound has been observed
- Offshore legislation allows discharge of non-harmful biodegradable compounds (alcohols, organic acids etc. expressed as TOC or COD) making direct discharge after MPPE treatment possible
- Onshore legislation for discharge into rivers, estuaries or nearshore locations often includes TOC or COD limits that require additional biological treatment. The Upstream MPPE ensures removal of non-biodegradable compounds and protects the biotreater from toxic compounds

Industrial Waste Water
- MPPE removes extractable and reusable compounds leaving treated non toxic water for biotreatment or direct discharge
- Compounds that are harmful for the biotreater are removed by MPPE and recovered as practically pure organics in the smallest volume possible, readily available for reuse or destruction

Groundwater Remediation
- Groundwater remediation often requires reinjection of the treated groundwater
- Preferably the natural background composition of the groundwater should be conserved to improve the natural attenuation
- MPPE removes the toxic organic compounds leaving all other non harmful compounds untouched
- MPPE ensures a non-toxic discharge to the sewer system or surface waters
**MPPE benefits**

1. High and guaranteed separation performance
2. Separation performance is independent of inlet concentration
3. Robust against:
   - Corrosion and scale inhibitors, H₂S scavengers, biocides, surfactants etc.
   - Peak loads
4. Flow/inlet concentration flexibility while maintaining outlet demand:
   - 10% lower flow rate allows 50% higher inlet concentration
   - Lower inlet concentration allows higher flow
5. Operational flexibility:
   - Capacity turn down/up ratio: 0 to 100%
   - Batch wise operation
   - Immediate performance at startup
6. 100% water and hydrocarbon recovery:
   - Separated hydrocarbons practically 100% pure for (re)use
7. No chemicals used
   - No waste stream
   - No air emission

**Route to your solution**

1. **Budget price within one week**
   - Inlet specification
   - Inlet requirements
   - Flow rate
   - Non/available of steam
2. **Laboratory test**
   - Various types of laboratory tests for joint evaluation
3. **Field test on site onshore and offshore**
   - Plug and play fully contained mobile MPPE units
   - One week and longer
4. **Turnkey delivery of integrated units: lease/rent or buy**
5. **Ongoing Performance Guarantee and related Services**
   - A clear annual operating expenditure overview will be given for the MPPE technology, including an ongoing performance guarantee and related services. This is valid for the total operational life of the unit and independent of the frequency of MPPE material exchange
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VWS MPP Systems is a hydrocarbon removal water treatment specialist and a member of the VWS Oil & Gas division of Veolia Water Solutions & Technologies

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www.vwsoilandgas.com

For other water treatment technologies please visit:

www.veoliawaterst.com

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