VEOLIA

MPPE Systems

WATER TECHNOLOGIES

MPPE Systems

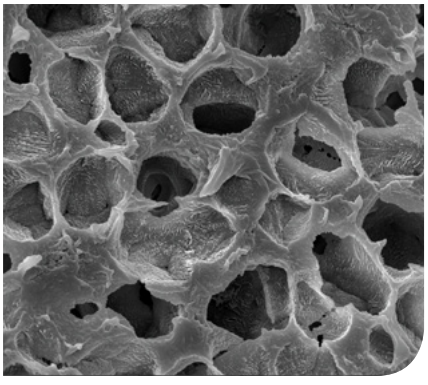
The Macro Porous Polymer Extraction (MPPE) system is a highly-effective, fully-automated, remote-controlled and guaranteed Veolia technology for removing hydrocarbons from water by means of extraction in a Macro Porous Polymer (MPP) bed.

MPPE systems are used for:

- Process water
- Offshore produced water
- Groundwater remediation
- Wastewater

MPPE systems removes dissolved and dispersed hydrocarbons with efficiencies 99.9999%, down to below ppb level, or as specified. This applies to different types of hydrocarbons, including:

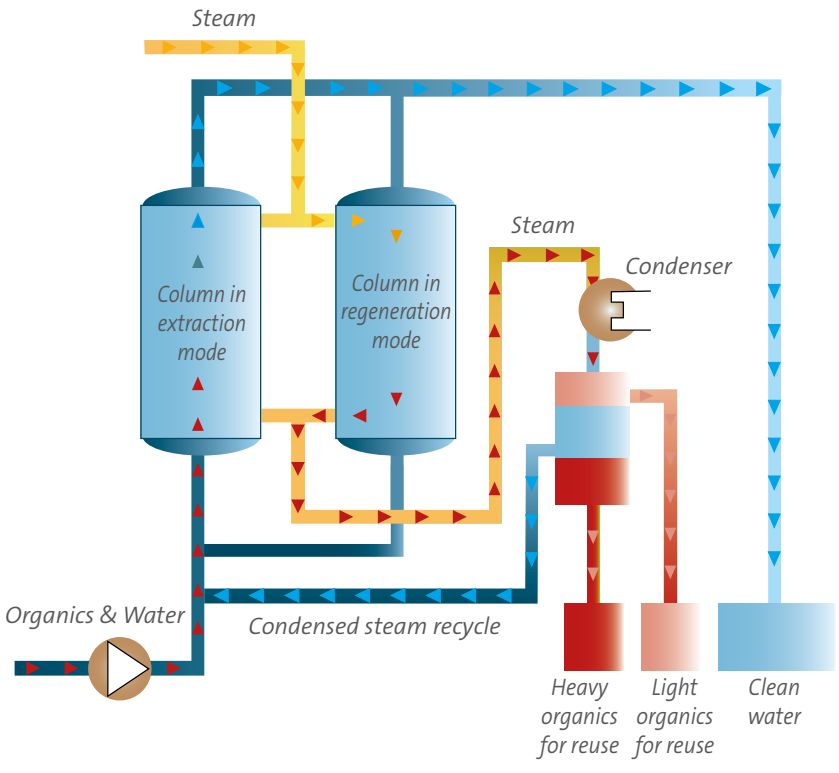
- Aliphatic
- Aromatic
- Polyaromatic
- Halogenated, such as chlorinated, bromated



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 immobilized in the pores of the MPPE particle. The immobilized extraction liquid removes the hydrocarbons from the water. Only Hydrocarbons that have affinity for the extraction liquid are removed. The purified water can 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 allows continuous operation with simultaneous extraction and regeneration. A typical cycle is one hour of extraction and one hour of regeneration.

The MPPE Process



Columns alternate in fixed timing from Extraction mode to Regeneration mode

MPPE Benefits

1 Very High Separation Performance

Reduction factor 1,000,000 times = 99.9999% removal if required

2 Cost Competitive

Cost competitiveness proven compared with air stripping and activated carbon, steam stripping and biotreatment systems

3 Low Energy Consumption

- Low energy input to release hydrocarbons from MPPE particles (in situ regeneration)
- Energy consumption up to 50 times lower than steam stripping

4 Robust, No Fouling

- Anaerobic operation at ambient temperature. No interference from dissolved iron, heavy metals, surfactants, salt and polar compounds, and no scaling
- No biological fouling because of periodic in situ regeneration by steam

5 Reliable and Easy Operation

- Fully automated
- Remote control using laptop and mobile device

6 Flexible Operation

Once installed, the unit can treat higher and lower flows and concentrations. For example, if the concentration is 50% higher, effluent requirements can still be maintained with only a 10% lower flow. At lower feed concentrations, higher flows can be treated while still meeting the effluent demand.

7 Compact Equipment

Compared to existing technologies, the unit is compact with a small footprint.

8 Ideal for Upstream Process Integration

Because it is compact, robust, reliable, fully automated, remote controlled, easy-to-operate and flexible, it is ideal for process integrated applications.

9 Performance Guarantee during Operational Life

The MPPE media performance is guaranteed through the Performance Guarantee Service Contract.

10 Environmental Benefits

- Practically pure, separated hydrocarbons for use/reuse
- Low waste of polymer
  - Long lifetime
  - Reuse of spent material
- Low energy consumption
- Low noise
- No addition of chemicals
- No emission to air
- No sludge generation
- No chemical used, no chemical sludge wasted

MPPE Statoil Kolsnes, Norway

Industrial Process & Wastewater

Process water streams are treated upstream or end of pipe for reuse in the production process, discharge to surface water, or further treatment in site/community biological wastewater systems.

MPPE LBC Rotterdam, The Netherlands

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.

Additional benefits

- Small footprint
- Upstream integrated operation with remote control
- Scope for adding other process and groundwater streams, for treatment in one unit
- Reduced sludge formation in biotreatment
- Modular setup for large flows (thousands of m³/hr)
- Over 40 years accumulated experience

Flexible Operation

- Fully automated
- Remote control using laptop and mobile device

Flexible Operation

- Non-polar toxic non-biodegradable compounds and polar biodegradable compounds are removed by MPPE in series with biotreatment.
- Full turnkey contracting is possible, as is partnering with local biotreatment suppliers.

Industries

- Natural gas production/treatment
  - Aromatics, polyaromatics, aliphatics (3,000 ppm and above)
- LNG terminals/gas to liquid plants
  - Aromatics, polyaromatics, aliphatics
- Underground gas storage
  - THT (tetrahydrothiophene), aromatics
- Water, oil, gas/condensate produced 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 process water
  - Aromatics, aliphatics and halogenated hydrocarbon
- Resin production
  - Solvents/aromatics removal from process streams containing monomer residues
- Electronics Industry
  - Solvents removal (toluene) e.g. television screen factories
- Rayon/viscose industry
  - Carbon disulphide (CS2), aromatics, aliphatics

MPPE Statoil/Shell Ormen Lange, Norway

Groundwater

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 for meeting challenges in groundwater applications are

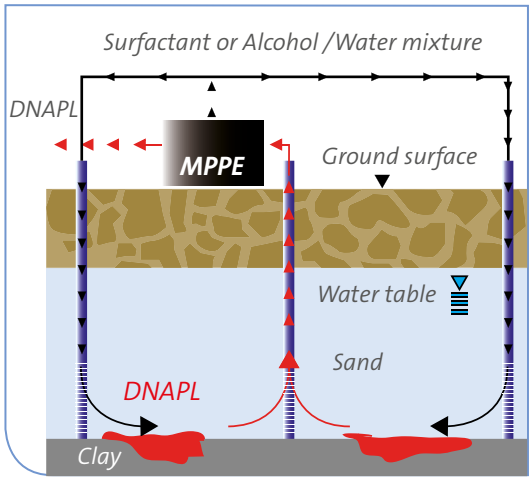
- Ideal for handling a broad range of compositions
- Able to cope with unexpected higher influent compositions at no additional costs
- No iron removal necessary (anaerobic process)
- Robust, can withstand salts, humic acids, surfactants, heavy metals, dissolved/suspended solids, high/low pH, etc.
- No sludge formation (as with iron removal and biotreatment)
- Scope for combination with other ground and process water streams in one unit

MPPE is successfully applied in the following soil remediation processes

- DNAPL and LNAPL Surfactant Enhanced Acquifer Remediation (SEAR)
- Pump & Treat
  - With reinjection or
  - Final discharge in sewer
- In-Pile Therma/Desorption (IPTD)

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
- MPPE proven as the ideal separation technology for these extremely high concentrations in surfactant/alcohol water mixtures
- Surfactant/solvent consumption savings as MPPE enables recirculation and recovery



MPPE LMBV Schwarze Pumpe, Germany

MPPE groundwater applications			
Jacksonville, Florida	US	Alcohol injection	Chlorinated hydrocarbons
Skopau	DE	Surfactant injection	Chlorinated hydrocarbons
Schwarze Pumpe	DE	Pump & Treat	PAHs/BTEX
Oss	NL	Pump & Treat	Chlorinated hydrocarbons/BTEX
Danang	VN	IPtd	Dioxines
Livorno	IT	Pump & Treat	MTBE/ Aliphatics

Offshore & Onshore Produced Water

Regulations for offshore produced water are becoming more and more stringent. New technologies are required for this challenging segment in order to meet future emission standards that are being set by international organizations, for example OSPAR* for the Northeast Atlantic.

MMPPE systems proven in removal of dissolved and dispersed:

- Aromatic hydrocarbons (BTEX)
- Polyaromatic hydrocarbons (PAHs)
- NPD (naphthalenes, phenanthrenes, dibenzothiophenes)
- Aliphatics
- Hydrophobic components in oil field chemicals (e.g. inhibitors)

Significant Mercury removal has been observed in various benchmark studies with clients.

Robust and can withstand:

- Salt, methanol, glycols
- Corrosion inhibitors
- Scale inhibitors
- H2S scavengers
- Demulsifiers
- Defoamers
- Dissolved (heavy) metals

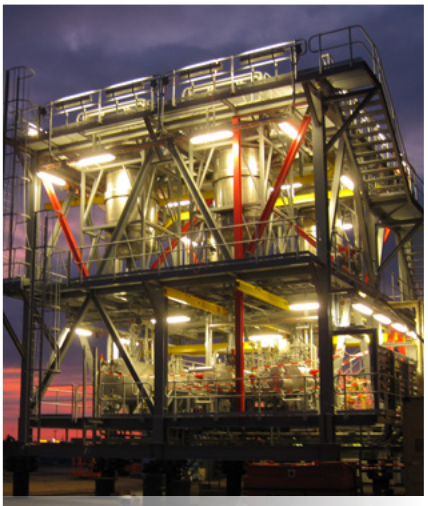
Environmental aspects:

- Separated hydrocarbons are recovered in practically pure form for use as a product
- No emissions to air and water, and no sludge formation
- Small footprint

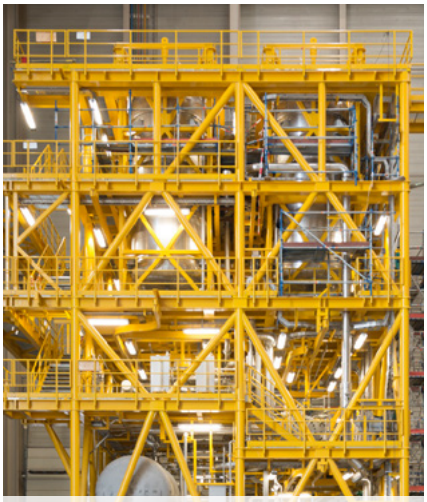
Evidence of success:

- Verified by Orkney Water Technology Center on water produced with oil and gas
- MPPE selected as best option from among 55 technologies (Government and Oil & Gas Industry Study)
- MPPE listed by OSPAR* as Best Available Technology (BAT)
- Experiences published in SPE Conference (TOTAL) and Offshore Technology Conference (Shell/ Exxon)
- First commercial unit in operation since 1994. Total of installed MPPE units treating Produced Water 9

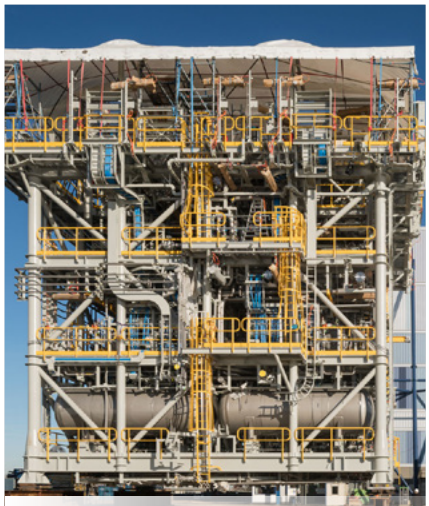
**OSPAR: Oslo Paris Convention for the Protection of the Marine Environment of the Northeast Atlantic*



MPPE Woodside Pluto Unit (Onshore), Australia



MPPE Shell Prelude FLNG Module, Australia



MPPE Inpex Ichthys, Australia

Route to your solution

In practice, local situations, water compositions and effluent requirements are always specific, as is the technology to be chosen. A typical project would be conducted as follows:

MPPE demo unit

Preliminary cost estimate within one week

A preliminary cost estimate can be made based on:

- Influent specification
- Effluent requirements
- Flow rate
- Availability of utilities like cooling water, pneumatic air and Low Pressure Steam (0.5 barg)

Laboratory test

If economically attractive, the usefulness of the various types of laboratory tests compared with an immediate field test can be jointly evaluated.

Onsite field demonstration

An onsite field demonstration on customer premises can be arranged upon request for either offshore or onshore.

Lease/rent or buy

Options for lease or buy can be evaluated. Various mobile units are available for immediate leasing for periods ranging from weeks to years.

Turnkey delivery of proposed solution

The investment cost is based on turnkey delivery including startup and, if applicable, including other Veolia technologies to be combined with the unit.

Ongoing Performance Guarantee and Service

A clear annual operating expenditure overview will be given for the MPPE technology, including an ongoing performance guarantee and service.
This is valid for the total operational life of the unit and independent of the frequency of MPPE material exchange.

Mobile unit/operating characteristics:

- Self-contained, including a steam generator
- Can be installed and started up in one day
- Designed for onshore and offshore with all necessary HSE provisions
- Remote control by means of a mobile telephone connection or direct line
- Built in a container for operations in remote areas
- Turndown ratio to <10% of design capacity
- Operational support by remote control or onsite service
- Onsite training and education of local personnel
- Operation by Veolia is possible

Resourcing the world

Veolia Water Technologies

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