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**Collaborative Project– GA No. 211534**



**Sustainable water use in chemical, paper, textile and food  
industries**

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	Deliverable No. Deliverable Title Issue date Page	D 6.1.1 Technological Portfolio 09-02-2010 2/100
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## Executive Summary

This report, is one of the results of the activities concerned with the integration and horizontal knowledge transfer within the AquaFit4Use Project, Water in Industry, Fit-for-Use, Sustainable Water Use in Chemical, Paper, Textile and Food Industry, initiative funded through the Seventh Framework Programme of the European Commission.


The technology offers included in the Technological Portfolio, 53 in total, are a description of innovative technologies belonging to various technology families, from anaerobic treatments to filtration processes that deal with different types of pollutants in water.

The Technological Portfolio aims at establishing a contact between the industrial partners and those technology providers offering the latest developments with regards to water treatment with the final aim of promoting the adoption of innovative technologies with potential to contribute to a sustainable water use in the industry.



## Contents

<b>1</b>	<b>INTRODUCTION .....</b>	<b>4</b>
<b>2</b>	<b>TECHNOLOGICAL PORTFOLIO.....</b>	<b>5</b>
2.1	METHODS .....	5
2.2	TECHNOLOGIES.....	5
2.3	EXPLOITATION AND DISSEMINATION .....	9
2.4	CONCLUSIONS .....	9
2.5	SUMMARY TABLE OF TECHNOLOGIES .....	10
2.6	DESCRIPTION OF TECHNOLOGIES .....	13

	Deliverable No. Deliverable Title Issue date Page	D 6.1.1 Technological Portfolio 09-02-2010 4/100
--	--	---

## 1 Introduction

The information compiled in the Technological Portfolio is coming from technology providers from whole over Europe, mainly from outside the consortium. This Portfolio aims at establishing a contact between the industrial partners and those technology providers offering the latest developments with regards to water treatment with the final aim of promoting the adoption of innovative technologies with potential to contribute to a sustainable water use in the industry. This document can be used by the industrial partners to gain an overview of the latest commercial developments with regards to industrial water treatment. The information of the portfolio will be used in the project AquaFit4Use on internal and external seminars. Some technologies can also be demonstrated.



Deliverable No.	D 6.1.1
Deliverable Title	Technological Portfolio
Issue date	09-02-2010
Page	5/100

## 2 Technological Portfolio

The Technological Portfolio aims to foster the contact between the industrial partners participating in the project and those technology providers offering innovative water treatment technologies having a high efficiency and/or low environmental impact with the final objective of promoting the implementation of sustainable water systems in the industry. The Technological Portfolio is a compilation of innovative technologies, most of them already in the market, coming from technology developers from outside the consortium and from some consortium partners. From the questionnaires used to elaborate the Knowledge Portfolio and after a survey the consortium will identify those technology offers from the Technological Portfolio that can be of interest for the corresponding industrial partners. With this information, the SP6 leader will organize technical visits of providers to the facilities of the industrial partners addressed.

Summarising, the objectives of the portfolio are:

- knowledge to the public of innovative technologies by publishing a report and putting the report on the AquaFit4Use website
- giving alternative and innovative solutions to the problems encountered in the pilot cases in the four target industries of the project AquaFit4Use
- learning from each other by giving the involved companies the change to give a poster or a presentation on internal and external seminars
- giving some companies the possibility to demonstrate their product or technology on the site of an industrial end user involved in AquaFit4Use.

### 2.1 Methods

An inquiry was performed within the technology suppliers whole over Europe. By reaching thousands of companies much publicity was done for the AquaFit4Use project. The inquiry was mainly performed by mail but also a lot of companies were directly contacted in meetings or on trade fairs.

We selected information of 53 products or technologies fitting in the scope of water in the industry. A further selection lead to 36 promising technologies. They are innovative and entered recently the market or are in the stage of a pilot plant or tests. Finally we proposed some technologies fitting directly with the products or technologies in the frame of the AquaFit4Use project.

### 2.2 Technologies

#### 1.2.1 AquaFit4Use background and selected technologies

In AquaFit4Use technologies are developed in the sub-projects 2 “Modelling, Monitoring and Automation in Industrial Water Systems” and Sub-project 3 “Treatment technologies”. The sub-projects are further divided in work packages.



We divide the collected technologies of the technological portfolio in subjects similar to the work packages of AquaFit4Use:

Work package in AquaFit4Use	Subject of technological portfolio
WP2.1: Monitoring and automation	Monitoring and automation
WP2.2: Unit process modelling	Modelling
WP2.3: Integrated modelling and control strategy	
WP2.4: Uncertainty propagation and risk analysis	
WP3.1: Tailor made combined systems	
WP3.2: Biofouling and scaling	Biofouling and scaling
WP3.3: Selective removal of substances	Micropollutants
WP3.4: Disinfection	Disinfection
WP3.5: Saline streams	Concentrates/saline streams

### Monitoring and automation

#### *AquaFit4Use background*

Selection and evaluation of sensors, sampling tools to analyse biofilm and corrosion, in situ analysis of relevant micro-organisms, data processing for modeling (WP 2.1)

#### *Collected technologies*

- Online biosensor for anaerobic digester
- AquaScope FISH biomonitor
- Chemometric methods for characterisation of textile wastewater
- SystemCheck Water®
- Control systems for activated sludge processes
- Optisense, optical biosensor technology for real time monitoring
- Methodology for flocculation control
- AqquaScan®, SCADA application for wastewater treatment plant
- Deposit monitor for fouling
- 3D Trasar® for boiler scale control

### Modelling

#### *AquaFit4Use background*

Unit process modelling, integrated modelling and control strategies

#### *Collected technologies*

- Optimization tools for the treatment of colored waste water by UV/H<sub>2</sub>O<sub>2</sub>
- WEST-applications for wastewater treatment plants: WESTfor DESIGN, WESTfor OPERATORS, WESTfor AUTOMATION, WESTfor IUWS (Integrated Urban Water Systems)

### Tailor made combined systems

#### *AquaFit4Use background*


New technologies are compared to existing technologies with the main objective to reuse water. Technologies are combined in a global treatment train.

Considered technologies are: anaerobic treatment, membrane bioreactor, filtration processes, nanofiltration, AOP's, coagulation/flocculation, crystallization, evapoconcentration and electro dialysis

#### *Collected technologies*

##### Anaerobic treatment

- A low cost anaerobic treatment in a covered lagoon system
- Biomar® AHP, high-rate anaerobic reactor with gas recirculation

	Deliverable No. Deliverable Title Issue date Page	D 6.1.1 Technological Portfolio 09-02-2010 7/100
--	--	---

- Biopaq Anaerobic Flotation Reactor (AFR®)
- BIODIGAT-SB, anaerobic treatment

#### Filtration processes

- Active Filter Media (AFM) based on glass
- Spruce Multi Media Filtration
- Filter media Aqualite™
- Fuzzy filter for removing suspended solids
- MT-IBA microfilter technology
- 3FM™ Filtration System, Flexible Fibre Filter Module

#### Membrane processes

- Back flushable filter cassette Flow-Cel® for biotech applications
- BioBooster Pressurised Biofilm Reactor and Membrane Bioreactor
- Envopur® spiral-wound membrane modules with new type of spacer (tubular spacer)
- Multibore® membranes for water treatment with ultrafiltration
- Cross-flow ceramic membranes with permeate conduits
- Dead-end SiC ceramic membranes
- MEDOX®, membrane bioreactor with pure oxygen

#### AOP's

- Enviolet®, UV oxidation process
- Ozone process

#### Other

- Spiral plate technology separator
- AguaCure electro-coagulation
- Biofilm bioreactor using naturally immobilized tailor-made microorganisms
- One step ANNAMOX®
- Jet Zone Reactor (JZR), high performance aerobic biological treatment

### Biofouling and scaling

#### *AquaFit4Use background*

Selected technologies under AquaFit4Use are:

- Denutritor®, biofiltration technology preventing biofouling
- Filtration Assisted Crystallization Technology (FACT) for scaling prevention
- Impact of nano-scaled silver

#### *Collected technologies*

- AiRO, air/water cleaning to control membrane fouling
- Novopure, biodegradable and sustainable water treatment chemicals as antiscalants
- BIO-CEL®-MCP, chemical free mechanical cleaning of submerged membranes in a MBR
- Filtration Assisted Crystallization Technology
- Enzyme based membrane cleaning and biofilm removal

### Micropollutants

#### *AquaFit4Use background*

Selected technologies under AquaFit4Use are:

- wastewater treatment with zerovalent iron
- destabilization of recalcitrant organic colloids with advanced coagulation/flocculation

#### *Collected technologies*

- Oxycon®, aerated activated carbon filtration for wastewater applications
- Moving Bed Adsorption
- Membrane contactor, removal of dissolved contaminants by using a suitable extracting solvent

### Disinfection

### AquaFit4Use background

- Ultrasound treatment

### Collected technologies

- Innovative UV systems
- Atlantium, hydro-optic UV technology
- EcoClearProx® innovative H<sub>2</sub>O<sub>2</sub> solution
- USO<sub>3</sub> ultrasound based technology
- TA-Aqua+ UV system in combination with photo-catalyst

### Concentrates/saline streams

#### AquaFit4Use background

- Flow Through Capacitor
- Membrane Distillation Crystallization
- Small scale evaporation system

#### Collected technologies

- Dynamic Vacuum Recompression
- Memstill, membrane distillation
- Small units for desalination of seawater by electro dialysis
- Fully coupled heat integrated distillation column

### 1.2.2 Promising technologies

We selected 37 promising technologies. They are innovative and entered recently the market or are in the stage of a pilot plant or tests. Finally we proposed 19 technologies fitting directly with the products or technologies in the frame of the AquaFit4Use project.

Collected technologies	Promising	Selected
Online biosensor for anaerobic digester	X	
AquaScope FISH biomonitor	X	X
Chemometric methods for characterisation of textile wastewater	X	
SystemCheck Water®	X	
Control systems for activated sludge processes	X	
Optisense, optical biosensor technology for real-time monitoring	X	X
Methodology for flocculation control	X	
AquaScan®, SCADA application for WWTP	X	
Deposit monitor for fouling	X	X
3D Trasar® for boiler scale control	X	X
Optimization tools for the treatment of colored waste water by UV/H <sub>2</sub> O <sub>2</sub>	X	X
WEST-applications	X	X
A low cost anaerobic treatment in a covered lagoon system		
Biomar® AHP: high rate anaerobic reactor with gas recirculation		
Biopaq AFR® Anaerobic Flotation Reactor	X	X
Biodigat-SB anaerobic waste water treatment		
AFM, Active Filter Media based on glass		
Spruce Multimedia Filtration		
Filter media Aqualite™		
Fuzzy filter for removing suspended solids		
MT-IBA microfilter technology	X	X
3FM™ filtration system	X	X

New back flushable filter cassette Flow-cel® for biotech applications	X	
Biobooster PBR and MBR		
Envopur® spiral-wound membrane modules with new type of spacer	X	
Multibore® membrane		
CoMeTas CoMex - Cross flow SiC ceramic membranes with permeate conduits	X	
CoMeTas Aqua Solution - Dead end SiC ceramic membranes	X	
MEDOX® MBR with pure oxygen		
Enviolet®, UV oxidation process	X	
Ozone process		
Evodos spiral plate technology separator	X	X
AguaCure Electro-coagulation		
Biofilm bioreactor using naturally immobilised tailor-made microorganisms	X	
One-Step ANAMMOX®	X	
Jet Zone Reactor, aerobic waste water treatment		
AiRO, air/water cleaning to control membrane fouling	X	X
Novopure, biodegradable water treatment chemicals	X	X
Bio-cel®-MCP, chemical free cleaning of MBR wastewater treatment plants	X	X
FACT, Filtration Assisted Crystallization Technology	X	X
Enzyme based membrane cleaning and biofilm removal	X	X
Oxycon, aerated activated carbon filtration for waste water applications	X	
Moving Bed Adsorption	X	
Membrane contactor	X	
Innovative UV systems for disinfection		
Atlantium - Hydro-optic disinfection technology		
EcoClearProx®, innovative stabilised H <sub>2</sub> O <sub>2</sub> solution	X	
USO <sub>3</sub> , ultrasound based disinfection technology	X	X
TA-Aqua+, oxidation process with UV in combination with photo-catalyst		
Dynamic Vacuum Recompression	X	X
Memstill, membrane distillation	X	X
Small units for desalination of seawater by electrodialysis		
Fully coupled heat integrated distillation column	X	X

## 2.3 Exploitation and dissemination

The report will be published and be put on the AquaFit4Use website.

The information of the portfolio can be used in the project AquaFit4Use, in the Sub Project 2 “Modelling, Monitoring and Automation in Industrial Water Systems” and the Sub Project 3 “Treatment Technologies”. Some technologies can be demonstrated in Sub Project 5 “Pilot case in the four target industries”. The information will also be used on internal and external seminars of Sub Project 6 “Knowledge transfer and dissemination”.

## 2.4 Conclusions

53 innovative products or technologies are identified for water in the industry. They can be used in the frame of the project AquaFit4Use or externally for dissemination activities.



## 2.5 Summary table of technologies

Nr	Technology	Company	Country	State of development
1	Online biosensor for anaerobic digester	Econcern/Ecofys	The Netherlands	Tests
2	AquaScope FISH biomonitor	Aqua Explorer	The Netherlands	On the market
3	Chemometric methods for characterisation of textile wastewater	UMB	Slovenia	Tests
4	SystemCheck Water®	PTS	Germany	On the market
5	Control systems for activated sludge processes	CEIT	Spain	Demonstration
6	Optisense, optical biosensor technology for real-time monitoring	Optisense	The Netherlands	Prototype
7	Methodology for flocculation control	CUM	Spain	Demonstration
8	AquaScan®, SCADA application for WWTP	ATM	Spain	On the market
9	Deposit monitor for fouling	Nalco	The Netherlands	Prototype
10	3D Trasar® for boiler scale control	Nalco	The Netherlands	Demonstration
11	Optimization tools for the treatment of colored waste water by UV/H <sub>2</sub> O <sub>2</sub>	UMB	Slovenia	Tests
12	WEST-applications	MOSTforWATER	Belgium	On the market
13	A low cost anaerobic treatment in a covered lagoon system	Econcern/Ecofys	The Netherlands	On the market
14	Biomar ® AHP: high rate anaerobic reactor with gas recirculation	Envirochemie	Germany	On the market
15	Biopaq AFR® Anaerobic Flotation Reactor	Paques	The Netherlands	Prototype
16	Biodigat-SB anaerobic waste water treatment	Wehrle	Spain	On the market
17	AFM, Active Filter Media based on glass	Caldic/Dryden Aqua	Belgium	On the market
18	Spruce Multimedia Filtration	AWWS	The Netherlands	Pilot plant



Deliverable No.  
Deliverable Title  
Issue date  
Page

D 6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
11/100

<b>Nr</b>	<b>Technology</b>	<b>Company</b>	<b>Country</b>	<b>State of development</b>
19	Filter media Aqualite™	Josab International	Sweden	On the market
20	Fuzzy filter for removing suspended solids	Bosman	The Netherlands	On the market
21	MT-IBA microfilter technology	V&T Group	The Netherlands	On the market
22	3FM™ filtration system	Veolia	France	On the market
23	New back flushable filter cassette Flow-cel® for biotech applications	DVD/Microdyn Nadir	Belgium	Tests
24	Biobooster PBR and MBR	Grundfos	Denmark	On the market
25	Envopur® spiral-wound membrane modules with new type of spacer	Envirochemie	Germany	Pilot plant
26	Multibore® membrane	Inge	Germany	On the market
27	CoMeTas CoMex - Cross flow SiC ceramic membranes with permeate conduits	CoMeTas	Denmark	On the market
28	CoMeTas Aqua Solution - Dead end SiC ceramic membranes	CoMeTas	Denmark	On the market
29	MEDOX® MBR with pure oxygen	ATM	Spain	On the market
30	Enviolet®, UV oxidation process	DVD/ack Aqua concept	Belgium	On the market
31	Ozone process	ITT	Germany	On the market
32	Evodos spiral plate technology separator	Evodos	The Netherlands	On the market
33	AguaCure Electro-coagulation	AguaCure	United Kingdom	Pilot plant
34	Biofilm bioreactor using naturally immobilised tailor-made microorganisms	Aquatest	Czech Republic	On the market
35	One-Step ANAMMOX®	Paques	The Netherlands	On the market
36	Jet Zone Reactor, aerobic waste water treatment	Wehrle	Spain	On the market



Deliverable No.  
Deliverable Title  
Issue date  
Page

D 6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
12/100

<b>Nr</b>	<b>Technology</b>	<b>Company</b>	<b>Country</b>	<b>State of development</b>
37	AiRO, air/water cleaning to control membrane fouling	Logisticon/KWR	The Netherlands	Pilot plant
38	Novopure, biodegradable water treatment chemicals	Holland Novochem	The Netherlands	On the market
39	Bio-cel@-MCP, chemical free cleaning of MBR wastewater treatment plants	DVD/Microdyn Nadir	Belgium	Tests
40	FACT, Filtration Assisted Crystallization Technology	TNO	The Netherlands	On the market
41	Enzyme based membrane cleaning and biofilm removal	Realco	Belgium	On the market
42	Oxycon, aerated activated carbon filtration for waste water applications	Desotec	Belgium	On the market
43	Moving Bed Adsorption	TNO	The Netherlands	Pilot plant
44	Membrane contactor	TNO	The Netherlands	On the market
45	Innovative UV systems for disinfection	DVD/ack Aqua concept	Belgium	On the market
46	Atlantium - Hydro-optic disinfection technology	Inrada	Belgium	On the market
47	EcoClearProx®, innovative stabilised H <sub>2</sub> O <sub>2</sub> solution	ABT Belgium	Belgium	On the market
48	USO <sub>3</sub> , ultrasound based disinfection technology	Ultrasonic Systems	Germany	On the market
49	TA-Aqua+, oxidation process with UV in combination with photo-catalyst	Blygold	The Netherlands	On the market
50	Dynamic Vacuum Recompression	Aqua Explorer	The Netherlands	On the market
51	Memstill, membrane distillation	TNO	The Netherlands	Demonstration plants
52	Small units for desalination of seawater by electrodialysis	PCCell	Germany	Pilot plant
53	Fully coupled heat integrated distillation column	Lowendis	Germany	Tests



## 2.6 Description of technologies

### 1. Online biosensor for anaerobic digester

<b>Title and name of product or technology</b>
Ecofys Digester Monitoring System
<b>Abstract</b>
<p>The EDMS targets the commercial development of a new process sensor for anaerobic digesters. The sensor is an advanced process monitor consisting of an electronic sensor device connected to a digital processing unit. The EDMS translates a biochemical process parameter (derived from the bacterial/biochemical processes which take place in a digester) into an electronic signal that can be processed, transmitted and integrated into an operator supervisory monitoring system.</p> <p>The sensor can predict the failure of an anaerobic digester and can also be used for daily operational management. No such devices are available on the market as yet. The current accepted practice for digester monitoring is by sampling, followed by laboratory analysis (e.g. of Volatile Fatty Acids and Total Alkalinity) in conjunction with pH, temperature, gas production and composition. Not only is the current practice intensive in operating cost, it is also slow as there is a delay of at least several hours between the moment of sampling and the process information becoming available for making a control decision. For high-rate processes such as UASB and EGSB applications this could be a critical time.</p> <p>An on-line process monitor provides real-time information and also reduces the operating cost through the availability of real-time process information. Many attempts to develop an on-line process monitor have been confined to university research. Most attempts to predict digester failure have been restricted to measurement of parameters (such as hydrogen, carbon monoxide and F420 cofactors etc) that issue a warning at the moment that it is 'already too late', so this type of sensors do not have any predictive value.</p> <p>The EDMS Digester Monitoring System is intending to change this.</p>
<b>Description including main features/advantages</b>
<p>The main benefits of the EDMS are in the better utilization of installed capacity (improved return on investment) and reduced operating costs</p> <p><i>Better utilization of installed digester capacity</i> Getting more out of an existing digester. Because of the difficulties often experienced in monitoring of digesters many systems are over-designed so that they operate at sub-optimal loading rates. The EDMS will allow for higher loading rates (near optimal) and thus signifying a better utilization of installed plant capacity.</p> <p><i>Lower operating cost</i> Many digestion plants (e.g. co-digesters) are not large enough in capacity to justify the appointment of qualified personnel for routine monitoring. As a result digesters are operated by technicians or farmers with very limited knowledge of digester operation management. This could lead to undesirable situations and digester instability as a result of inadequate monitoring.</p> <p><i>Remote monitoring of un-manned installations: co-digesters, sewage sludge digesters and anaerobic wastewater treatment plants</i> The EDMS allows the connection of remote digesters to existing Supervisory Control and</p>



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
14/100

Data Acquisition systems and Man Machine Interfaces (MMI) (Beeldscherm Besturingssystemen in Dutch). This would be very beneficial for power generating organizations with ownership of multiple digesters located at distributed locations.

#### **Innovative aspects**

The sensor measures the transfer of biochemical compounds which takes place between different groups of bacteria that are active in the anaerobic digestion process. When a digester becomes overloaded, the transfer rate of such biochemical components becomes saturated leading to accumulation intermediates.

The sensor determines the current rate of transfer of intermediates as well as the saturation point. The operation of the sensor system can be compared with a speedometer in an unknown car. The driver sits in the car but doesn't know either the current speed nor the maximum speed of the car. The sensor determines the maximum speed of the car as well as the relative scale position of the current speed in comparison with the maximum speed of the car.

For digesters this translates into the current loading rate to the digester relative to the maximum attainable organic loading rate. Is the ratio low, then it means that the digester operation is very stable and that there is capacity to increase the organic loading rate. Is the ratio high then the (near) maximum loading rate of the digester has been reached and the digester runs the risk of becoming unstable or overloaded.

#### **Current and potential industrial users/domains of application**

The EDMS can be applied to both low-rate as well as high rate processes:

- Completely Stirred Tank Reactor (e.g. co-digestion and sewage sludge digestion)
- Anaerobic Lagoon Systems (e.g. industrial wastewater treatment)
- UASB (Upflow Anaerobic Sludge Blanket)
- EGSB (Expanded Granular Sludge Blanket)

#### **Current state of development**

A proof of Principle is build and a patent application is filled. Prototypes, testing and final design of the sensor still needs to be done.

#### **Contact details**

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## 2. AquaScope FISH biomonitor

<b>Title and name of product or technology</b>
AquaScope
<b>Abstract</b>
The Aquascope is a biomonitor to continuously monitor the microbiological composition of a fluid on line.
<b>Description including main features/advantages</b>
For the on line monitoring of bacteria with the Aquascope, a combination of existing and innovative techniques is used, based on Fluorescent In Situ Hybridisation (FISH), using bacteria-specific DNA-probes. When the probes are labelled on the r-RNA of bacteria they are visualized with an optical instrument. The images are automatically analysed by means of high tech software.
<b>Innovative aspects</b>
The Aquascope is the 1st autonomous in-line biosensor for both quantitative and qualitative bacterial detection in liquids.
<b>Current and potential industrial users/domains of application</b>
The Aquascope can be applied anywhere where bacteria need to be detected in fluids, with the following practical examples: <ul style="list-style-type: none"> <li>• Detection of Legionella in cooling water systems</li> <li>• Detection of Bacillus Cereus in potato processing industry</li> <li>• Detection of E. Coli in drinking water</li> <li>• Detection of viruses in feed water in greenhouses</li> <li>• Detection of beer spoilers in the brewing industry</li> <li>• Detection Colony forming Units (CFU)</li> <li>• Live and dead detection</li> <li>• Etc.</li> </ul>

<b>Current state of development</b>	
The Aquascope is being demonstrated and successful tested at various (industrial) locations. The first sales is realised. Several applications are in development for sales.	
<b>Contact details</b>	
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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
16/100

### 3. Chemometric methods for characterisation of textile wastewater

<b>Title and name of product or technology</b>
Chemometric methods as useful tool for characterization of textile wastewater streams ( Cross Correlation Table, Cluster analysis, Principal Component Analysis, Linear Discriminant Analysis)
<b>Abstract</b>
<p>Characteristics of textile waste waters are influenced by industrial processes such as sizing and desizing, weaving, scouring, bleaching, mercerizing, carbonizing, filling, dyeing and finishing. Chemical pollutants arise from the raw material itself and composition of the finishing recipe. Pollutants are non biodegradable highly coloured organic dyes, pesticides, metals, softeners, acids, bases, salts etc. It is evident that the textile waste water chemical composition is subject to considerable change due to the diversity of the textile processes and chemicals used. The aim of this work is focused on water quality classification of the textile waste water streams and evaluation of pollution. Data from the chemical characterization of the effluents were elaborated to identify a useful separation in potentially treatment for reuse. This was done with the aim of realizing a full scale characterization of effluents. In the two textile companies analyzed, machineries are used to carry out different production processes. Different process effluents from the same machinery were found to be very diverse in pollution level. 25 and 49 samples of textile waste waters from two different textile companies were analyzed and physical chemical measurements were performed. The following physicochemical and chemical water quality parameters were controlled: absorbance measured at three different wavelengths, pH, conductivity, turbidity, total suspended solids, volatile suspended solids, chemical oxygen demand, metals content (Ba, Ca, Cu, Mn, K, Sr, Fe, Al, Na) and total nitrogen content.</p> <p>For handling the results, basic statistical methods for the determination of mean and median values, standard deviations, minimal and maximal values of measured parameters and their mutual correlation coefficients, were performed. Different chemometric methods, namely, principal component analysis (PCA), cluster analysis (CA), and linear discriminant analysis (LDA) were used to find hidden information about textile waste water quality.</p>
<b>Description including main features/advantages</b>
<p>The proposed chemometric methods can be used for classification and characterization of textile wastewater streams. After basic statistic methods for the determination of mean and median values, standard deviations, minimal and maximal values of measured parameters and their mutual correlation coefficients, different chemometric methods were used to characterize water streams.</p> <p>The aim of the work is to find the best solution for both textile companies for reuse of waste waters. For water recycling it is necessary to find correlation between different textile waste water streams. Chemometric methods can help in characterization of textile waste water effluents and thus can be used for separation of concentrated textile waste waters from non concentrated streams. After collecting concentrated textile waste waters, evapoconcentration treatment process will be used before additional cleaning at waste water treatment plant. For treatment of non concentrated textile waste water streams AOP processes, like H<sub>2</sub>O<sub>2</sub>/UV process, and membrane filtration processes will be used. The cleaned waste water with the best quality can then be reused in different textile production processes.</p>
<b>Innovative aspects</b>
Chemometric methods for classification of different textile wastewater streams
<b>Current and potential industrial users/domains of application</b>
Wastewater treatment – separation of non concentrated and concentrated textile waste



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
17/100

waters streams.

**Current state of development**

Tested on textile waste waters from Textina and Svilanit.

**Contact details**

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#### 4. SystemCheck Water®

<b>Title and name of product or technology</b>
PTS SystemCheck Water®
<b>Abstract</b>
Water circuits are an important key to enhanced efficiency in papermaking. Water is involved in all important production steps. Its quality and availability are crucial to process productivity and product quality. Suitable circuitry can greatly improve water quality.
<b>Description including main features/advantages</b>
PTS SystemCheck Water® is used to analyse and optimise existing plants. The optimisation of water circuits requires interdisciplinary know-how. PTS has developed specific evaluation tools that ensure complete detection and collection of all potentials. The PTS SystemCheck Water® has a modular architecture. The basic module includes system stocktaking and evaluation of the circuitry, water use, loading parameters as well as the save-all's that are used. Additional tools may be used from case to case including the following: odour and volume analysis (elimination of anaerobic reactions), scaling evaluation, heat balance optimisation and tools for integrating new treatment methods. Simulation technology using the software IDEAS™, of course, is an integral part of this process. Only with simulation technology is it possible to selectively determine solutions that achieve both the technical and economical optimum. The PTS service comprises analytical data acquisition in the water circuit, evaluation, drawing up an operating concept with a set of measures, documentation and presentation. If desired, PTS consultants can take over project management entirely, carrying out the agreed concepts from basic engineering right through to project implementation.
<b>Innovative aspects</b>
The unique synthesis of technological consultancy services and ongoing research and development work provides PTS customers with a long-term competitive edge.
<b>Current and potential industrial users/domains of application</b>
Pulp and paper industry PTS offers you many years of experience gained from a good deal more than 100 system analyses in all product groups in the European pulp and paper industry.
<b>Current state of development</b>
Commercial product – continuous further development based on ongoing research and development work.

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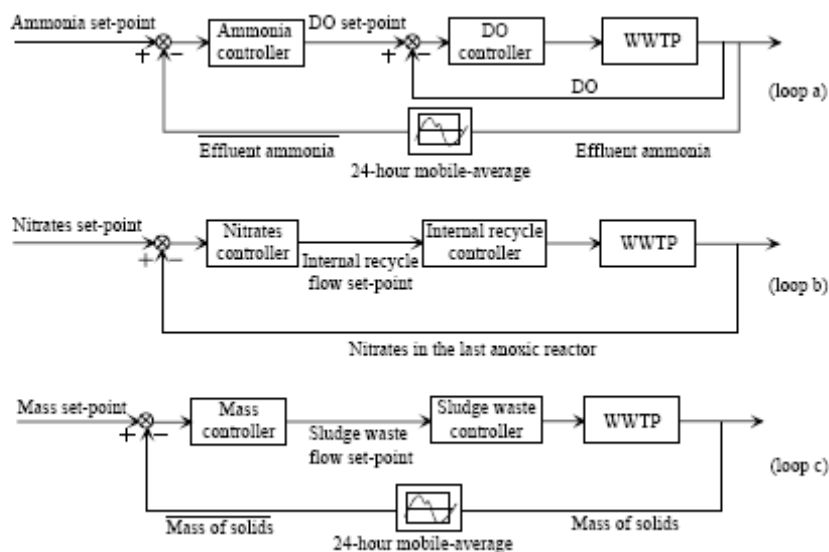


## 5. Control systems for activated sludge processes

<b>Title and name of product or technology</b>
Control Systems for Activated Sludge Processes
<b>Abstract</b>
New supervisory control strategy designed for wastewater treatment plant (WWTP) with nitrogen removal. The control strategy combines three complementary control loops to optimise the nitrogen removal in pre-denitrifying activated sludge plants. The first controller is designed to maintain the average concentration of the ammonia in the effluent via the automatic selection of the most appropriate DO set point in the aerobic reactors. The second control loop optimises the use of the denitrification potential and finally, the third control loop maintains the selected amount of biomass in the biological reactors by automatic manipulation of the wastage rate. Mobile-averaged windows have been implemented to incorporate commonly used averaged values in the control objectives.
<b>Description including main features/advantages</b>
<p>The main objective of the supervisory control strategy designed for Activated Sludge treatment plants with nutrient removal is the optimisation of the existing plant capacity, improving process stability and effluent quality with minimum cost. Therefore, the automatic supervision was conceived as a way to select, at any moment, the most appropriate set-point for the lower-level controllers, leaving the human decision for the top of the hierarchical plant control structure. It is well known that in a conventional or 'rigid' operational strategy of a predenitrification activated sludge plant, the process operator has to select (based on their knowledge and experience) several parameters such as the DO concentration in the aerated volumes, the recirculation flow of nitrates to the anoxic zone and the wasting of the excess of sludge. The concentration of DO in the aerated zones should be maintained at a sufficiently high level to support the growth of the adequate organisms, to guarantee the required nitrification rate and to maintain the required level of mixing, but sufficiently low to save energy, avoid the excess mixing and to reduce, as much as possible, the oxygenation in the anoxic volumes induced by the nitrate recirculation. Nitrification is improved by high DO values; however, lowering the DO set-point not only favours the denitrification in the anoxic zone but also some simultaneous nitrification–denitrification in the aerated zone. It is important to point out that for a conventional WWTP, this DO set-point is not able to eliminate completely the fluctuations in the effluent ammonia. Therefore, it is suggested that a variable DO set-point should be selected to only reach the required (not the minimum) averaged value of the ammonia concentration at the end of the aerated volume.</p> <p>The first controller designed for the AS plants (Figure 1 loop a) has the aim of maintaining the selected 24 h-averaged concentration of the ammonia in the effluent by automatically selecting the most appropriate DO set point in the aerobic reactors. Logically, the measurement of effluent ammonia concentration should be made at the outflow of the biological reactors, in order to eliminate the delay and the equalisation effects produced by the volume of the clarifiers. The 24 h mobile averaged window is a simple mathematical concept that filters the typical variation in the effluent concentration generated by the daily load profile. The width of the mobile average window can also be used to 'distribute' these cyclical perturbations between the effluent ammonia and the DO set-point. Therefore, the plant operator can select the most appropriate size of the mobile average window for each particular plant.</p> <p>The second control strategy aims at the optimum use of the denitrification potential of the plant, selecting the most appropriate recycle flow of nitrates from the exit of the aerated volume to the anoxic zone. This means that there is maximum nitrates removal, maximum carbon consumption without oxygen and maximum recovery of the water alkalinity. For this</p>

purpose, the second control loop (loop b) designed is continuously selecting the required recycle flow to maintain a low and stable concentration of nitrates at the end of the anoxic zone. A low nitrates set-point ensures the complete denitrification using the minimum recycle flow, with a minimum amount of recirculated oxygen and a maximum hydraulic retention time in the anoxic volume.

the third control loop (loop c) has the aim of maintaining a selected averaged value of the total mass of suspended solids in the biological reactors via the automatic manipulation of the wastage rate. The use of the total mass of solids (instead of the direct MLSS measurement), makes the generalisation of this strategy to step-feed or contact-stabilisation plants possible. However, for selecting an appropriate value for the mass set-point, the operator should take into account the maximum solid flux that can be accepted by the settler (associated with the MLSS in the final reactor). A 24-h mobile average filter has been also introduced to reduce the disturbances produced by the daily influent load profile.



The application of supervisory control strategies for the automatic selection of the main operational parameters in WWTPs can be a very useful tool for optimising the exploitation of the process. The synergetic combination of three supervisory control loops facilitates a stable operation of the biological process, improves the effluent quality and lowers simultaneously the air flow needed.

### Innovative aspects

The control system here presented is based on measurements of real sensors and the full-scale implementation of the control algorithms is based on experimental data combined with simulation programs and requires many additional improvement to the computing code so as to guarantee a safe operation of the process (upper and lower limits for all the manipulated variables, digital filtering and sampling of the signals, detection and elimination of outliers, automatic procedures for the initialisation and commutation of the control loops, etc.).

### Current and potential industrial users/domains of application

WWTP operators and technology suppliers.

### Current state of development

Tested at lab, pilot and full scale urban WWTP (Galindo, Bilbao, Spain)



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
21/100

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## 6. Control systems for activated sludge processes

<b>Title and name of product or technology</b>
Optisense, optical biosensor technology for real time monitoring
<b>Abstract</b>
Patented biosensor platform technology for instant and ultra-sensitive detection of (bio-)chemical substances. Technology based on unique combination of integrated optical chip technology, bio-chemistry and micro fluidics. Measurement of refractive index changes of agent specific absorbents.
<b>Description including main features/advantages</b>
The Optisense optical biosensor technology is based on integrated Mach-Zehnder interferometry and SiON-technology. Principally, the sensors consist of a chemo-optical transduction layer (the refractive index of which is sensitive to the chemical concentration of a specific analyte), an integrated optical system (which converts the change of refractive index into an electrical signal) and processing and control electronics. The generic part of the sensor (integrated electronics, software and sensor chip) can be customized for specific use by applying application-specific, selective bio-chemical layers. The bio-chemical layers can be regenerated (on site) and reused (up to 500-1000x).
<b>Innovative aspects</b>
<ul style="list-style-type: none"> <li>• On-site detection of contaminants (portable options)</li> <li>• Instant on line read-out of measuring results</li> <li>• Platform technology</li> <li>• High sensitivity (laboratory quality, ppb)</li> <li>• Flexibility (choice of bio-chemical layers)</li> <li>• Reliability</li> <li>• Cost efficiency (on-site applications, no highly skilled staff required)</li> </ul>
<b>Current and potential industrial users/domains of application</b>
<p><i>Current domain of application</i></p> <ul style="list-style-type: none"> <li>• On line monitoring of drinking water quality Example: The SafeWat-project (Σ! 3181) This project encompasses: (1) the development of an integrated monitoring system for drinking water supplies which enables immediate response to water quality changes and (2) the construction of a sensing system integrated in the drinking water supply infrastructure for the 'source to tap' monitoring of drinking water quality. The SafeWat-project is a cross-border cooperation representing all links of the drinking water chain: <ul style="list-style-type: none"> <li>- Vitens</li> <li>- Kiwa Water Research</li> <li>- Mekorot National Water Co</li> <li>- OptiSense</li> <li>- Sandia National Laboratories</li> </ul> </li> <li>• On site detection of specific contaminants Example: Mobile detection of pesticides in drinking water Optisense develops, in close collaboration with Dutch drinking water company Vitens, a highly sensitive (0,1µg/L), portable, field-use measuring system for the concentration of pesticides in water-collection areas.</li> </ul> <p><i>Potential domain of application</i></p>



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
23/100

Food industry, health care, security

The Optisense sensor technology is available to a wide range of markets that require accurate, quick and sensitive testing methods at low cost per test. Thanks to the platform-based core technology, the Optisense sensors have an almost infinite range of application possibilities.

Currently, Optisense is finalizing a sensor for the detection of mycotoxins.

#### **Current state of development**

Fine tuning of prototype

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
24/100

## 7. Methodology for flocculation control

<b>Title and name of product or technology</b>
Methodology for flocculation control
<b>Abstract</b>
<p>The Complutense University of Madrid has developed a new methodology for studying, controlling and optimising the flocculation process. Due to its considerable advantages, this department offers it as a technical cooperation. This methodology is useful to study about any flocculation or coagulation process involved in industries as the papermaking, the wastewaters, the metals recovering, the sludge thickening, etc. It will allow you to monitor the flocculation process and to control it on line.</p>
<b>Description including main features/advantages</b>
<p>The study or control of the flocculation or coagulation process is carried out by monitoring the evolution of the particles chord size distribution in real time. This distribution is obtained by a focused beam reflectance measurement technique (FBRM). This distribution contains information about the size and concentration of particles, the variation of which, is inherent to the flocculation process with independence to the mechanism through which the process takes place.</p> <p>This methodology allows to determine optimal dosage of flocculant, to study the kinetics of the flocculation process, as well as those of the flock breakage (deflocculation) and reflocculation processes. From these studies, it is possible to determine flock properties and to propose the flocculation mechanisms model that explains the flocculant behaviour.</p> <p>The measurement technique used by the developed methodology consists of a commercial Mettler Toledo equipment with a probe, which is introduced in the suspension or in the pipe, and an electronic box with a detector. A computer system controls the equipment and receives the data. This equipment is provided with a laser diode that generates a laser beam which is split in different parallel beams. These beams are focused in a point (focal point) on the external sapphire probe window (sited in the extreme of the probe that is introduced on the suspension) through a rotating lens. The focal point describes a circular path at high speed as a result of the rotation of the lens.</p> <p>When a particle traverses the focal point path, light reflected is conducted to the detector, which receives light pulses, whose duration is proportional to the particle chord.</p> <p>The equipment can measure thousands of particles per second and obtain a chord length distribution, representative of the particle population. The evolution of this distribution characterised to the flocculation process.</p>
<b>Innovative aspects</b>
<p>The traditional methodologies, based on the measurement of the surface charge of the particle are only appropriate to study the aggregation process when it implies the modification of these properties, but not when the flocculation is carried out by other mechanisms, as bridging with neutral polymers, for example. However, the developed methodology is appropriate to study every flocculation process, independently of the aggregation mechanism or the suspension nature.</p> <p>Most of the optical techniques used to studying the flocculation process requires the previous manipulation of the suspension, to dilute or to adjust pH or ionic strength, this can affect to the flocculation process. However, it is not necessary to manipulate the suspension</p>



before using of this methodology.

The study of the flocculation kinetics requires a technique able to measure on real time. Many of this kind of techniques are based on measuring turbidity or on the image analysis. These techniques detect or measure the intensity of the light that passes through the suspension or that is slightly deviated by the particles, because the intensity of the reflected light would be too low. However, these techniques are useful only if the suspension is diluted enough to allow the pass of the light through it, an example of these techniques is the dispersion photometric analyser. Furthermore, the use of these techniques implies to assume that the turbidity or the colour of the suspension does not change or to assume that the particles are spheres. This introduces an error; because the turbidity often decreases during the flocculation process, the colour can change and the particles are not always spheres.

Using this methodology does not require diluting the sample neither assuming any particle shape. It is not necessary to assume that the turbidity and the colour of the suspension are constant during the flocculation process. Therefore, it eliminates these error sources.

The technique used by the developed methodology focuses a beam at a focal point whose size is much lower than the size of the particles to measure, this increments the intensity of the backscattered light and makes it independent from the size or the shape of the particles. Furthermore, the focal point is on the window surface, therefore, the distance between the particle surface, which reflects the light, and the window, which receives the light, is almost null. Because of that, the reflected light intensity, that the detector receives, is not affected by the turbidity or the colour of the suspension. This fact reduces the measurement error and allows us to apply the developed methodology for studying the flocculation process of opaque suspensions, that the techniques based on the light transmission cannot study on line.

Finally, the measurement interval of this technique is quite wide: from 0,5  $\mu\text{m}$  to 2000  $\mu\text{m}$ . This allows studying the behaviour of a huge variety of suspensions.

#### **Current and potential industrial users/domains of application**

Paper Industry  
Fibre cement fabrication  
Wastewater treatment and sludge thickening  
Research and development of new retention or flocculation additives  
Food industries  
Recovery of metallic fractions

#### **Current state of development**

Developed, available for demonstration

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
26/100

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## 8. AqquaScan®, SCADA application for WWTP

<b>Title and name of product or technology</b>
AqquaScan®
<b>Abstract</b>
AqquaScan® is an S.C.A.D.A. application oriented to the exploitation of Waste Water Treatment Plants (WWTP). It is a newly way of controlling and monitoring the WWTP via internet. The main distinctive characteristics from any other monitoring system is its capacity of estimation relevant operational indicators of the WWTP online, as they are the Oxygen Uptake Rate, the oxygen transfer coefficient and the efficiency of the oxygenation system.
<b>Description including main features/advantages</b>
AqquaScan® is a web based application with the following main purposes: <ul style="list-style-type: none"> <li>▪ Supervision: the general state of the WWTP can be checked whenever, both the historical data and the current data of the plant.</li> <li>▪ Control: the WWTP operational conditions can be modified changing the set point values.</li> <li>▪ Analytical data: the system is ready for the insertion and consulting of the laboratory measured data</li> <li>▪ Notification: the system alerts of the WWTP events, either via internet, by e-mail or by sms in a mobile.</li> <li>▪ Online estimation of relevant information of the WWTP state, as the OUR, oxygen transfer rate and oxygen transfer efficiency.</li> </ul>
<b>Innovative aspects</b>
Many features of AqquaScan® are innovative, but two can be highlighted: <ul style="list-style-type: none"> <li>▪ The estimation of the WWTP indicators, OUR, K<sub>la</sub> and OTE</li> <li>▪ The flexibility of this monitoring system to be adapted to the plant configuration and the client needs. Estimation and monitoring of other required plant variables.</li> </ul>
<b>Current and potential industrial users/domains of application</b>
Currently, AqquaScan® can be applied to any WWTP, although the estimation of the parameters can be applied to WWTP with pure oxygen. In the near future, this OUR estimation will be available also for aerated WWTP.
<b>Current state of development</b>
AqquaScan® is currently working as described above, but it is in continuous development including new features required by the clients.

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
28/100

## 9. Deposit monitor for fouling

<b>Title and name of product or technology</b>
Nalco Deposit Monitor
<b>Abstract</b>
<p>The Nalco Deposit Monitor (NDM) is a sensor designed to monitor fouling formation in cooling water, process related, or other water applications where fouling is of concern. The device incorporates a sensitive measurement of mass buildup on a heated surface with self-cleaning and pressure compensation capabilities.</p> <p>The NDM is based on quartz crystal microbalance technology and patented by Nalco. Oversimplified the technology consists of a vibrating crystal; as mass builds up on the surface of the crystal the frequency of the vibration decreases, which provides a very sensitive way of measuring fouling build up on the surface. The possibility of heating the surface allows mimicking a heated surface (such as of a heat exchanger) and monitoring specifically these areas sensitive to scale formation.</p>
<b>Description including main features/advantages</b>
<p>Novel online monitoring of fouling in cooling systems (and other) and capability to especially monitor fouling in critical heat exchangers</p> <p>The monitoring capability and on-line data collection helps to obtain:</p> <ul style="list-style-type: none"> <li>- Highlighting scale formation or system upsets (e.g. pH, conductivity, etc)</li> <li>- Diagnose and solve fouling problems, saving cost in downtime and energy and water usage</li> <li>- Tied to the Nalco 3D Trasar platform have data available real-time</li> <li>- Run at "more-ragged" edge</li> </ul>
<b>Innovative aspects</b>
<p>Online fouling monitor that can also mimic heat exchange surfaces and can accurately follow mass build up on surfaces. The monitor has capability for self cleaning to "reset" the measurement.</p>
<b>Current and potential industrial users/domains of application</b>
<p>Fouling monitoring in cooling water systems as well as process water systems.</p>
<b>Current state of development</b>
<p>The concept has been technically proven in several technical trials and currently the field validation of the commercial prototype is being carrying out. Demonstration sites are welcome.</p>

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## 10. 3D Trasar® for boiler scale control

<b>Title and name of product or technology</b>
3D Trasar® Boiler Technology
<b>Abstract</b>
3D Trasar Boiler automations builds on Nalco's 3D Trasar platform, advancing the premier technology in control capability. The 3D Trasar boiler system uses the Nalco patented fluorescence technology platform for Boiler scale control, and introduces a unique, patented Nalco Corrosion Stress Monitor™ for preboiler corrosion control. The 3D Trasar detects systems variations, then determines and adjust the correct program adjustments (Program dosage, operation parameters, alarm enablement etc.).
<b>Description including main features/advantages</b>
3D TRASAR® Boiler Technology is the innovative and unique boiler treatment package designed to deliver superior sustainability performance, operational efficiency, and asset protection. This Modular technology continuously responds to changes in boiler operation and feedwater quality, reducing system corrosion, ensuring clean waterside surfaces, and minimizing water and energy resource use. The result is continuity of production, conservation of resources, minimization of emissions including GHG, and improved cost management.
<b>Innovative aspects</b>
<ul style="list-style-type: none"> <li>- The 3D Trasar controller is now enabled to monitor and control boiler scale prevention programs.</li> <li>- The Nalco Corrosion Stress Monitor™ is a novel way of monitoring and minimizing corrosion in the preboiler. It functions by measuring and reacting to the net oxidation/reduction potential of the bulk feedwater measured at the actual boiler operating temperatures and pressures. It detects changes in this measurement and responds by changing the oxygen scavenger or metal passivator feed.</li> </ul>
<b>Current and potential industrial users/domains of application</b>
Any boiler or steam generating system ranging from small low pressure boilers to large higher pressure systems.
<b>Current state of development</b>
The technology development is completed and is currently going through filed implementation phase. Demonstration projects are welcome.

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## 11. Optimization tools for the treatment of colored wastewater by UV/H<sub>2</sub>O<sub>2</sub>

### Title and name of product or technology

Optimization methods as useful tool for wastewater treatment management (Artificial NN, Response Surface Methodology, mathematical programming)

### Abstract

The UV/H<sub>2</sub>O<sub>2</sub> process has often been proposed as an effective treatment technology for remediation of colored wastewaters. However, it has frequently been noted that it is not as economically efficient as other treatment technologies. To limit this drawback as much as possible, an effort to optimize the treatment technology from both the economical and operating points of view is needed.

For this reason we developed an optimization procedure through which the treatment technology was simultaneously optimized from the perspective of operating and economic efficiency. The presented approach is based on a response surface methodology in conjunction with mathematical programming.

### Description including main features/advantages

The proposed optimization approach combines the response surface methodology and mathematical programming. Flowchart in Fig. 1 represents the activities within the framework of the proposed approach. After the pre-screening (preliminary experimentation), an appropriate experimental design is selected, the experiments are performed, and the results are analyzed (modelling of responses, statistical analyses). If statistical tests regarding the obtained response models (polynomial approximations) produce unsatisfactory results, modifications in response surface modelling and/or experimental design are required. If the statistics is satisfactory, the obtained response models are used to formulate an appropriate optimization problem, which is solved using a software for constrained optimization.

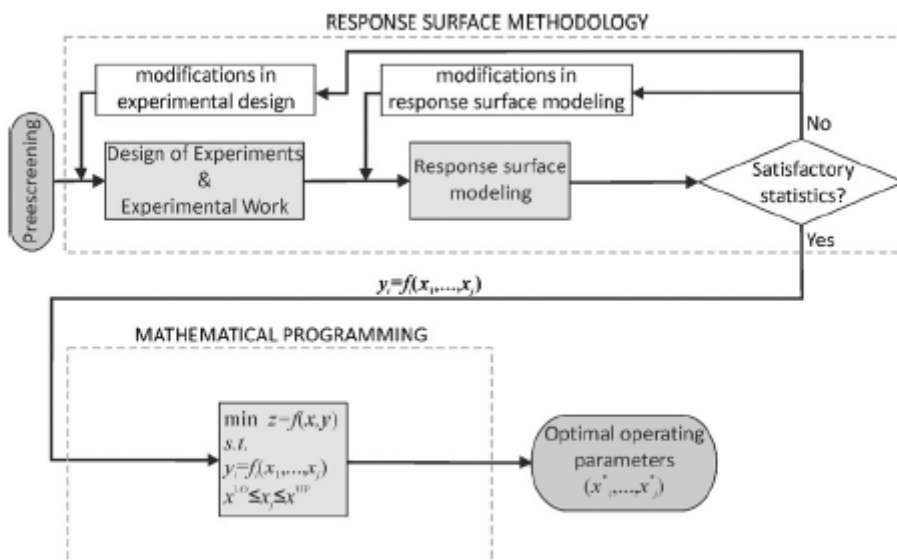


Fig. 1. Process optimization strategy combining response surface methodology and mathematical programming.

The results indicate that if the simultaneous optimization of operating parameters and costs is used, a significant improvement in economic efficiency of the treatment technology can be achieved. For the case studied, the operating cost of the treatment process optimized solely with respect to the maximization of operating efficiency could be up to 5.5 times higher than



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
31/100

those obtained using the proposed approach.



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
32/100

<b>Innovative aspects</b>
An optimization procedure through which the treatment technology was simultaneously optimized from the perspective of operating and economic efficiency.
<b>Current and potential industrial users/domains of application</b>
Wastewater treatment – cost reduction.
<b>Current state of development</b>
Tested on laboratory scale (model wastewater).

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12. WEST-applications for wastewater treatment plants: WESTfor DESIGN, WESTfor OPERATORS, WESTfor AUTOMATION, WESTfor IUWS (Integrated Urban Water Systems)

<b>Title and name of product or technology</b>
WESTforDESIGN
<b>Abstract</b>
Based on state-of-the-art software technology, WESTforDESIGN allows for validation of design options and evaluation of different plant layouts in dynamic conditions. This is done by running scenarios, e.g. for high load and low load conditions, and by evaluating the effect of complex control strategies.
<b>Description including main features/advantages</b>
<ul style="list-style-type: none"> <li>• Quick and fast set-up</li> <li>• Plant layout set-up (unlimited size and complexity, including multiple controllers) using the extended model and components library, including controllers (for the list of models, see Annex)</li> <li>• Automatic generation of optimized models code, resulting in unparalleled simulation speed</li> <li>• Influent fractionation and data evaluation</li> <li>• Dynamic and interactive simulation runs</li> <li>• Graphic display of data results during simulation runs</li> </ul>
<b>Innovative aspects</b>
Integration of dynamic simulation into design leads to better designs.
<b>Current and potential industrial users/domains of application</b>
Design engineers, Plant managers, research institutes
<b>Current state of development</b>
New Product line

<b>Title and name of product or technology</b>
WESTforOPTIMIZATION
<b>Abstract</b>
Based on state-of-the-art software technology, WESTforOPTIMIZATION allows consultants and engineers to optimize the wastewater treatment processes. The flexibility and the truly open model structure (one can change any model in the model library without limitations) in combination with add-on modules for easier calibration (sensitivity analysis, automatic parameter estimation, scenario analysis and uncertainty analysis) makes WESTforOPTIMIZATION the most powerful tool available.
<b>Description including main features/advantages</b>
<ul style="list-style-type: none"> <li>• Quick and easy set-up.</li> <li>• Plant layout set-up (unlimited size and complexity) using the extended model and components library, including controllers (for the list of models, see Annex).</li> <li>• Automatic generation of optimized models resulting in unparalleled simulation speed.</li> <li>• Influent fractionation and data evaluation.</li> <li>• Dynamic and interactive simulation runs.</li> <li>• Graphic display of data during simulation runs.</li> <li>• Model Editor</li> <li>• Parameter estimation</li> <li>• Scenario analysis</li> <li>• Sensitivity analysis</li> </ul>



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
34/100

<ul style="list-style-type: none"> <li>Uncertainty analysis</li> </ul>
<b>Innovative aspects</b>
Integration of dynamic simulation into process optimization leads to better designs.
<b>Current and potential industrial users/domains of application</b>
Consultants, design engineers, plant managers, research institutes
<b>Current state of development</b>
More than 1000 users worldwide

<b>Title and name of product or technology</b>
WESTforOPERATORS
<b>Abstract</b>
Based on state-of-the-art software technology, WESTforOPERATORS allows for operators to perform short-term (e.g. storm events) and long-term (e.g. consistent nutrient removal) evaluations of WWTPs their plant. This approach makes it possible, for operators, to re-use the modeling efforts of their consultants in a flexible and customizable tool. The evaluations are done for bottleneck identification, running scenarios for specific influent and operational conditions, and for evaluation of costs. The tool is most useful to improve understanding of the WWTP and hence for operator training.
<b>Description including main features/advantages</b>
<ul style="list-style-type: none"> <li>Dynamic and interactive simulation runs.</li> <li>Graphic display of results during simulation runs</li> </ul>
<b>Innovative aspects</b>
Integration of dynamic simulation as decision support tool for operators leads to better and more cost efficient operation of WWTPs.
<b>Current and potential industrial users/domains of application</b>
Plant managers, operators
<b>Current state of development</b>
New product line

<b>Title and name of product or technology</b>
WESTforAUTOMATION
<b>Abstract</b>
Based on state-of-the-art software technology, WESTforAUTOMATION, an extended toolkit that allows for fast integration of modeling and simulation in custom applications by automation or software engineers. Different SDKs containing comprehensive and extensive documentation and sample sets, allow for linking WEST with SCADA systems or other modeling software (Matlab, CFD, Mike Urban, ...)
<b>Description including main features/advantages</b>
<ul style="list-style-type: none"> <li>.NET API (standard)</li> <li>C API (on project basis only)</li> <li>C++ API (on project basis only)</li> <li>OpenMI API (on project basis only)</li> </ul>
<b>Innovative aspects</b>
Integration of dynamic simulation into automation projects leads to better results.
<b>Current and potential industrial users/domains of application</b>
Control engineers, BOOT companies, research institutes
<b>Current state of development</b>
More than 50 users



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
35/100

<b>Title and name of product or technology</b>	
WESTforIUWS	
<b>Abstract</b>	
<p>Based on state-of-the-art software technology, WESTforIUWS allows for:</p> <ul style="list-style-type: none"> <li>• Exploration of specific water quality scenarios developed by the system manager (e.g. flow diversions, introduction of tanks, changes in operation, etc.)</li> <li>• Automatic optimization of the operating parameters.</li> <li>• Performing short-term and long-term evaluations.</li> <li>• Uncertainty and sensitivity analysis of the model to spot the most influential operating parameters and to assess the risk of non-compliance with regulations.</li> </ul>	
<b>Description including main features/advantages</b>	
<ul style="list-style-type: none"> <li>• Plant layout set-up (unlimited size and complexity) using the extended model and components library (including components for sewer, WWTP and surface water).</li> <li>• Dynamic and interactive simulation runs</li> <li>• Graphic display of data during simulation runs.</li> <li>• Linking with GIS systems.</li> <li>• Model Editor</li> <li>• Parameter estimation</li> <li>• Scenario analysis</li> <li>• Sensitivity analysis</li> <li>• Uncertainty analysis</li> </ul>	
<b>Innovative aspects</b>	
Integration of dynamic simulation into the management of IUWS leads to better performance.	
<b>Current and potential industrial users/domains of application</b>	
Consultants, design engineers, plant managers, research institutes	
<b>Current state of development</b>	
New product line	

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### 13. A low cost anaerobic treatment in a covered lagoon system

<b>Title and name of product or technology</b>										
Low-cost anaerobic wastewater treatment with energy recovery and emission reduction										
<b>Abstract</b>										
<p>Technology represented by a range of innovative products consisting of know-how, detailed designs and constructions for anaerobic treatment of organic waste streams (wastewater or slurries such as manure) in an engineered covered lagoon system. The advantages of anaerobic digestion are production of energy rich biogas, emission reductions, environmental pollution control, production of valuable byproducts and sanitation.</p> <p>The Ecofys Anaerobic Lagoon technology has similar or better performance in comparison with commonly used technology, which is tank-based. However the main advantage of the lagoon-based technology is a dramatic reduction of capital investment, in some cases savings of up to 80% in comparison with conventional technology can be achieved. For some of the innovative products patent applications have been filed.</p>										
<b>Description including main features/advantages</b>										
<p>The technology is represented by a range of products which consist of innovative technology products for lagoon-based anaerobic treatment of wastewater and slurries. The innovative aspects are represented as know-how and detailed engineering designs. For part of these products patent applications have been filed.</p> <p>Anaerobic treatment is a biological process during which organic matter is converted into energy-rich biogas. The commonly accepted practice by the use of tanks in which anaerobic bacteria are mixed with wastewater or slurries such as for instance manure. Tanks, being constructed of steel or concrete are expensive and especially for very large biogas plants treating large waste streams such as palm oil mill effluent, tapioca starch processing waste, ethanol vinasse or sewage (to name a few) the cost of tank construction may become prohibitive for the investment to go ahead.</p>										
<b>Innovative aspects</b>										
<p>This technology is based on the use of low-cost plastic films to engineer lagoon digesters. The plastic is used to:</p> <ul style="list-style-type: none"> <li>• Collect biogas</li> <li>• Retain the bacteria in the lagoon</li> <li>• Prevent leakages to ground water</li> <li>• Many other innovative functions</li> </ul> <p>For instance the innovative PCL-UASB technology replaces concrete and load-bearing heavy steel constructions in conventional technology by plastic membrane sheets suspended by floats, weights and low-cost cables inside lagoon systems.</p>										
<b>Current and potential industrial users/domains of application</b>										
<p>This has led to the development of the following products which are near market ready:</p> <table border="0"> <tr> <td>CHEAP™</td> <td>Tapioca Starch, Ethanol Distillery Waste, other waste streams</td> </tr> <tr> <td>MEP</td> <td>Palm Oil Mill Effluent</td> </tr> <tr> <td>PCL</td> <td>Palm Oil Mill Effluent (patent pending)</td> </tr> <tr> <td>PCL-UASB</td> <td>Ethanol Vinasse, Sewage (patent pending)</td> </tr> <tr> <td>CHEAP™-Solids</td> <td>High solids waste streams, Manure, Slurries</td> </tr> </table> <p>PCL-UASB in particular is set to become one of the most innovative products as it allows</p>	CHEAP™	Tapioca Starch, Ethanol Distillery Waste, other waste streams	MEP	Palm Oil Mill Effluent	PCL	Palm Oil Mill Effluent (patent pending)	PCL-UASB	Ethanol Vinasse, Sewage (patent pending)	CHEAP™-Solids	High solids waste streams, Manure, Slurries
CHEAP™	Tapioca Starch, Ethanol Distillery Waste, other waste streams									
MEP	Palm Oil Mill Effluent									
PCL	Palm Oil Mill Effluent (patent pending)									
PCL-UASB	Ethanol Vinasse, Sewage (patent pending)									
CHEAP™-Solids	High solids waste streams, Manure, Slurries									



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
37/100

anaerobic treatment of dilute wastewater streams (such as domestic wastewater) in metropolitan settings in tropical countries, thereby dramatically reducing or eliminating negative environmental and sanitary impact of discharge of domestic sewage, generating large bioenergy potential and dramatic reduction of uncontrolled emissions caused by degradation of sewage in open waterways.

Other applications for PCL-UASB are industrial waste streams such as beer, winery, fruit and vegetable processing, sugar, starch processing and ethanol distillery effluents.

#### **Current state of development**

Some of the mentioned products are ready for design and construction for commercial plants, others such as PCL-UASB are in need for semi-technical scale piloting to establish the most (cost) effective methods of construction

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#### 14. Biomar® AHP, high-rate anaerobic reactor with gas recirculation

<b>Title and name of product or technology</b>
Biomar® AHP: High-Rate Anaerobic Reactor with gas recirculation
<b>Abstract</b>
The Biomar AHP is a new type of high-rate anaerobic reactor, originally developed by the Technical University of Hamburg-Harburg (Prof. Märkl). It combines low footprint and effective mixing through recirculation of biogas, which is virtually non-dependent on biogas formation during anaerobic degradation. Inlet concentrations of more than 100.000 mg COD/L may be treated.
<b>Description including main features/advantages</b>
The anaerobic reactor is vertically staged (so called modules). Typically three modules are implemented at a total height of around 20 m. Modules are shaped as loops with inner and outer sections. Biogas is partially collected at the top of each module. Biogas from the lowest module is recirculated to the bottom of the reactor, inducing mixing in the vessel. Additionally the reactor may be equipped with external pressurized settling for improved effluent sludge separation.
<b>Innovative aspects</b>
<ul style="list-style-type: none"> <li>- Multi-stage design (typically three modules)</li> <li>- Level-controlled removal of biogas at different reactor heights</li> <li>- Biogas recirculation for mixing</li> <li>- External biogas purification possible for reduction of H<sub>2</sub>S partial pressure</li> <li>- Patented pressurized settling (external)</li> </ul>
<b>Current and potential industrial users/domains of application</b>
<ul style="list-style-type: none"> <li>- Biofuel production</li> <li>- Chemical industry</li> <li>- Pharmaceutical industry</li> <li>- Treatment of concentrates / monosubstrates (e.g. glycerine, glycol...)</li> </ul>
<b>Current state of development</b>
Full scale, patented

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## 15. Biopaq Anaerobic Flotation Reactor (AFR®)

<b>Title and name of product or technology</b>
BIOPAQ AFR®, Anaerobic Flotation Reactor
<b>Abstract</b>
<p>The commonly known UASB and the high-rate IC reactors are the industry-standard for treatment of wastewater with higher concentration COD but this water also should be relatively 'clear' in terms of very little suspended solids and nearly no FOG (Fat, Oil and Grease). In typical situations where content of solids and FOG in the waste water are too high one always needs pre-treatment steps such as settling tanks and/or DAF units in order to remove FOG. These pre-treatment steps are a necessity and therefore critical. They make the whole installation more vulnerable to malfunctioning; they require chemical dosing and produce a sludge layer from the DAF unit that often can not be treated on site.</p> <p>For solid waste streams or for heavy slurries the current option is to digest it in a CSTR. These can only treat low loads, are large due to long retention times and can not be used for water. The digested material leaves the CSTR as a mixture of digested matter and water and needs a post treatment (dewatering) to separate the water from the digested material.</p> <p>Paques now has developed the AFR reactor: a new and innovative technology that <i>fills in the longtime existing gap</i> between the CSTR-digesters (for fat and solids containing slurries) and the high-rate IC reactor (which always need a DAF when waste water contains FOG). The new AFR reactor is a single reactor system where slurries and water containing biodegradable solids, fat, oil, grease and SCOD are all together mixed and digested into biogas and clean effluent.</p>
<b>Description including main features/advantages</b>
<p>The AFR combines the pre-, main- and post treatment in a one-stage system with flocculent sludge. The physical or chemical pre-treatment as well as the post-treatment to remove sludge can be skipped due to an integrated flotation unit.</p> <p>The flotation unit supports the biomass retention and therefore a high biomass density in the reactor so that the HRT can be shortened, whereas the SRT remains high. This will contribute to a compact, space saving design of the reactor. The increased SRT will enable the system to deal with the fat and the solid content of the wastewater that normally causes difficulties in granular anaerobic biological treatment. The retention of the compounds due to flotation facilitates the anaerobic digestion and will contribute to their conversion into biogas.</p>
<b>Innovative aspects</b>
<p>The BIOPAQ AFR® is a completely new technology that makes it possible to treat wastewater rich in COD and FOG in a single reactor whilst biogas is generated both from the soluble COD in the water as from the solids and FOG part.</p> <p>One single AFR reactor can replace a train of DAF+EGSB+CSTR.</p>
<b>Current and potential industrial users/domains of application</b>
<ul style="list-style-type: none"> <li>- tankcleaning companies (that clean tankertrucks carrying food-stuff)</li> <li>- dairy processing industry</li> <li>- industries processing food, fats, vegetable oil, proteins etc</li> </ul>
<b>Current state of development</b>
<p>A first prototype has been built at a tankcleaning company. Paques is now ready to research the applicability in other industries. A mobile AFR pilot unit is available to do on-site testing with specific streams.</p>



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
40/100

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## 16. BIODIGAT-SB, anaerobic treatment

<b>Title and name of product or technology</b>
BIODIGAT - SB
<b>Abstract</b>
The BIODIGAT-SB Process is suited to the anaerobic (pre-) treatment of effluent that mainly has a dissolved content of pollutants, and large volume flows or high COD loadings.
<b>Description including main features/advantages</b>
The key component of the BIODIGAT-SB is a special EGSB Reactor (Expended Granular Sludge Bed). This is a further development of the well-known UASB Process (Upflow Anaerobic Sludge Blanket). As a result of selective recirculation in the reactor, as well as by enhanced effective phase separation devices, greater volumetric loadings can be achieved in this manner.
The advantages of anaerobic bioreactors are: <ul style="list-style-type: none"> <li>• No aeration is necessary.</li> <li>• A gain in energy use as a result of biogas.</li> <li>• The production of excess sludge is about 80 % less than with aerobic processes.</li> <li>• The plant can be quickly put back into service, even after long downtimes.</li> <li>• Several substances are only able to be degraded by using anaerobics (e.g. pectin).</li> </ul>
<b>Innovative aspects</b>
The process is characterised by a high yield of biogas, whilst having at the same time low operating costs. The 3 Phase Separation (the ACS Process) for which several patents have been applied, which takes place completely inside the reaction vessel, increases the efficiency of the performance of the system with a low cost of construction by comparison with other EGSB systems.
<b>Current and potential industrial users/domains of application</b>
The applications of the BIODIGAT-SB are for example: <ul style="list-style-type: none"> <li>• Food Industry</li> <li>• Paper effluent</li> <li>• Beverage Industry</li> <li>• Processing of fish</li> </ul>
<b>Current state of development</b>
During 2009 Wehrle Umwelt has built up two Biodigat SB Processes for the food and food processing wastewater, respectively. The commissioning is due to October 2009.

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17. Active Filter Media (AFM) based on glass

<b>Title and name of product or technology</b>
AFM
<b>Abstract</b>
Active sand filtration with AFM 30-80% improvement in sandfilter performance
<b>Description including main features/advantages</b>
AFM is an advanced filtration media designed to replace sand in pressure filters and gravity flow filters. AFM is far superior to a good quality filter sand. Changing from sand to AFM will result in some major improvements to the performance of your filtration system.  AFM will provide better water clarity and quality AFM will remove smaller particles form water compared to the equivalent grade of sand AFM is less likely to become contaminated by fats, lipids and biological growth AFM is much less likely to block or channel compared to sand In chlorinated systems, chlorine levels will become lower and less coagulant will be required.
<b>Innovative aspects</b>
Less use of backwash water and less use of chlorine in chlorinated systems
<b>Current and potential industrial users/domains of application</b>
Industrial water treatment / Swimming pools / Drinking water - industry
<b>Current state of development</b>
On the market

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## 18. Spruce Multi Media Filtration

<b>Title and name of product or technology</b>
Spruce Multi Media Filtration
<b>Abstract</b>
Filtration of (waste) water with 4 layers of natural material. With this patented technology can be filtered till 0,2 micron in several conditions. The load of suspended solids and the bed velocity can be much higher than fast sand filtration. The backwash quantity is much lower. The filter bed can't mix up during backwash. This technology is able to compete with or support membrane technology. The filter can also be used as barrier for legionella, algae or other bacteria. This technology is cheaper in investment and cheaper in operations than membrane technology. There is no use of chemicals. The filter works with a filter modus and a backwash modus. The filtered water can be used for backwashing.
<b>Description including main features/advantages</b>
See abstract
<b>Innovative aspects</b>
<ul style="list-style-type: none"> <li>- sustainable fast filtration with no use of chemicals</li> <li>- direct filter performance of 0,5 micron after backwash</li> <li>- usable for clean water production, waste water treatments and re-use</li> <li>- simple and easy to operate</li> </ul>
<b>Current and potential industrial users/domains of application</b>
<ul style="list-style-type: none"> <li>- potential in all segments of industrial domains, usable in clean water production, waste water treatments and re-use</li> <li>- also usable for waste water treatment for domestic waste water</li> <li>- upgrade of existing waste water treatment installations with polishing facilities</li> </ul>
<b>Current state of development</b>
<p>Finished product application for polishing of domestic effluent Full scale piloting in industrial and domestic domains for re-use and waste water treatment.</p>

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## 19. Filter media Aqualite™

<b>Title and name of product or technology</b>
Josab Aqualite™ System, Filter media Aqualite™
<b>Abstract</b>
Compact Water purification Systems without addition of chemicals, Natural filter media for different applications.
<b>Description including main features/advantages</b>
Purifies the water without addition of Chemicals, is simple and versatile. High efficiency and capacity/equipment volume ratio.
<b>Innovative aspects</b>
<ul style="list-style-type: none"> <li>➤ Less environmental impact</li> <li>➤ Lower cut-off</li> <li>➤ Significant water clarity</li> <li>➤ Improved T10-value</li> <li>➤ Reduced energy need</li> <li>➤ Improved backwashing efficiency</li> <li>➤ Longer filter cycles</li> <li>➤ Reduced water consumption</li> <li>➤ Less consumables</li> </ul>
<b>Current and potential industrial users/domains of application</b>
<p>Process water purification – e.g. removal of heavy metals, ammonium etc.</p> <p>Purification of waste water from carpet cleaning facilities</p> <p>Polishing of “old” traditional wastewater plant to meet new and higher requirements on wastewater quality.</p> <p>Polishing of Oily bilge water – reduction of petroleum products.</p> <p>Purification of ground water at construction sites.</p>
<b>Current state of development</b>
Drinking water- and industrial process water systems are in use, waste water treatment systems are in use (polishing build-on systems), ground water purification are in use, oily bilge water separators are in use. New methods for removal of Arsenic under research & development.

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## 20. Fuzzy filter for removing suspended solids

<b>Title and name of product or technology</b>
Fuzzy Filter for removing suspended solids
<b>Abstract</b>
Is it possible to use the Fuzzy Filter for other applications then effluent polishing by communal waste water treatment plants.
<b>Description including main features/advantages</b>
The Fuzzy Filter can remove the suspended solids with a very high filtration rate. The Fuzzy Filter media is a compressible filter media, with a big solids storing capacity. The advantage of the Fuzzy Filter is the very high filtration rate Compressible filter media Low wash water production
<b>Innovative aspects</b>
The Fuzzy Filter is a compressible filter media, and so we can use this filter for a lot of different applications.
<b>Current and potential industrial users/domains of application</b>
The current users are locations for effluent polishing for communal wastewater treatment plants and stormwater basins. We think that there is potential for industrial applications where they are producing a lot of water and in this water are suspended solids, this can be in the chemical, paper, food or textile industry.
<b>Current state of development</b>
At this moment we have a test installation available with a capacity of 15 m <sup>3</sup> /hour. Whit this installation we can do testing by different industries.

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## 21. MT-IBA microfilter technology

<b>Title and name of product or technology</b>
MT-IBA microfilter technology
<b>Abstract</b>
By using fibres, of specific thickness and number of twinings , which are being spun around a special designed support, a filter cassette has been created. This cassette is able to filter particles down to 0.5 micron and a special designed mechanism is also able to clean this cassette for 100% in a very short time by spraying clean water.
<b>Description including main features/advantages</b>
V&T Group designed small units out of PP which can be serial produced, are simple in construction, reliable in operation and easy to service. Because of the production method the price level of the filters is within everybody's reach. Bigger flow rates with the advantage of the single filter can be created by parallel construction in a frame. In this way a flexible system can be created which can be easily adapted to changes in the application ( more or less demand).
<b>Innovative aspects</b>
Fully automatic 3 micron filter technology at the price level of a static cartridge filter with manual cleaning and cartridge disposables
<b>Current and potential industrial users/domains of application</b>
Small (mobile) systems for Waste water – Drinking water ( private sector) Pre-filtration for RO systems Re-use of wash water in swimming pools – food packing Fish farm industry Rinse bad cleaning in the galvanising industry Cleaning of condensate and gas wash systems Polishing of waste water from a biological WTP in maritime sector Cleaning of special liquids in the metal construction sector Removal of heavy metals and dioxin connected to fines from waste water
<b>Current state of development</b>
The filters are operational in most of above mentioned fields and reliable Preparation of tools for serial production is under study and ready for investment

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
47/100

## 22. 3FMTM Filtration System, Flexible Fibre Filter Module

<b>Title and name of product or technology</b>
3FM™ Filtration System (Flexible Fibre Filter Module)
<b>Abstract</b>
<p>3FM (Flexible Fibre Filter Module) is a high speed filtration device that can be substituted for conventional solid-liquid separation process such as coagulation, settling and sand filtration. Suspended solids are filtrated by the flexible fibres, which have softness, elasticity and a degree of surface roughness. The filter is packed with bundles of fibres along the module length and influent flow is introduced to the bottom of 3FM. Utilising all of the filter area through deep bed filtration suspended solids particles are captured. The optimum operating parameters are managed according to the influent characteristics desired quality of the treated water.</p> <p>Although an innovative process, 3FM™ operation is easy as a sand filter. Head-loss increases during the filtration cycle and the filtration capacity is recovered by periodic backwashing with a small amount of influent waste water and scouring air.</p>
<b>Description including main features/advantages</b>
<p>The 3FM™ system involves high speed tertiary filtration radially through a bundle of flexible polyamide fibres adapted specifically for water treatment. The fibre bundles are loaded into a porous distribution jacket which is housed in specifically designed stainless steel vessels.</p> <p><u>Process description</u> <i>Filtration process:</i> Raw water is fed through the inlet pipe of the lower part of the filter module and introduced uniformly into the flexible fibre filter layer. During the filtration process, the suspended solids are captured on the media surface and in the pores crated among the fibres flowing in the co-current direction. Filtered water is discharged to upper port. <i>Backwash process:</i> When the differential pressure reaches a pre-set value, or the timer is reached, then the backwash process is initiated. The suspended solids collected in the 3FM filter are displaced and removed by the turbulent flow and shearing force created by alternate cycles of air and water. The dirty backwash water is discharged from an upper port.</p> <p><u>Principle</u> <i>Filtration</i> Method: Up-flow rapid deep filtration (up to 125 l/sec per filter) Principle: Filtration of suspended solids by filter &amp; capillary phenomenon. Filter run time: ~2-3 hours between backwashing (varies according to flux) Cut-size: 2~5 µm (varies according to flux) <i>Backwashing</i> Method: Alternate Air and Water cycles Principle: The effect of turbulent water flow and shearing force from air and water Time: ~2-3 minutes Reject water volume: Less than 1% of the maximum treated volume <i>Media</i> Material: Flexible fibre (Polyamide) Fixing method: Upper-free / Lowe-fixed Packing density: Design options according to quality and volume of filtrated water Media replacement period: +5 years, simple to change <i>Operating method</i></p>



Control panel: Fully automatic operation with manual override

### Core technologies

#### *Rapid filtration*

Flux rate: 2,000~5,000 m<sup>3</sup>/m<sup>2</sup>/d

Comparison: More than 10 times than sand filter alternative

Space: Compact footprint, requiring up to 1/10th the space of sand filters

#### *Deep bed filtration*

Head loss: 0.2~0.6 kgf/cm<sup>2</sup>

Cut size: 2~5 µm

SS removal efficiency: 70~90%

SS Output: Typically < 5 mg/l

BOD removal efficiency: over 60% (excludes soluble)

#### *Large capacity filtration*

Single module: 10,000 ~ 12,000 m<sup>3</sup>/day with single module based on 3FM-C020 (Ø2000 mm)

Multiple modules: Unlimited capacity

#### *Minimum by-product*

Backwash: Less than 1% of the maximum treated water volume

Media: Recyclable polyamide

#### *Simplicity*

Control: Fully automatic control triggered by pressure differential or timer

Maintenance: Minimal maintenance

Ancillary equipment: Only requires feed pump and air compressor

### **Innovative aspects**

#### *Uses flexible fibre as media*

A media that has been developed using a flexible fibre made from polyamide. Suspended solids are filtered by the flexible fibres which have softness, elasticity and a degree of surface roughness.

#### *Principle of solid-liquid separation by media-filtering & capillary phenomenon*

The flexible fibre media is available in several fibre sizes and packing densities according to the application. The 3FM filtration incorporates the use of the capillary phenomenon within the filtration principle.

#### *Deep bed filtration*

The flexible fibre media is packed along the length of the filtration module and the flow travels in the same direction, which makes it possible to operate as deep bed filter ensuring excellent effluent quality that can be maintained.

#### *Treat large capacity*

Compared with existing rapid sand filters, the 3FM filtration velocity is considerably higher, more than 10 times faster at 160 m<sup>3</sup>/hr. The 3FM system has a small footprint for a high flow capacity compared with the sand filter alternatives.

#### *Possible to adjust quality and capacity*

Adjusting the type of flexible fibre, packing density, filtration velocity etc, the effluent quality can be controlled.

#### *Simple backwash*

The backwash uses cycles of air and water and takes less than 3 minutes to complete. On some applications the influent can be used as backwash water.

### **Current and potential industrial users/domains of application**

Applicable fields:

- o SS removal from sewage/wastewater treatment plant



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
49/100

- o Tertiary treatment & reclamation of sewage/wastewater
- o Alternative to sand filtration
- o SS removal from industrial and agricultural water
- o Water re-use
- o Algae removal from river and reservoir
- o Preliminary treatment of drinking water

**Current state of development**

Commercialized.

References in:

- o Industrial WWTP (coal mine, steel...)
- o Drinking WTP
- o Municipal WWTP

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
50/100

### 23. Back flushable filter cassette Flow-Cel® for biotech applications

<b>Title and name of product or technology</b>
New back flushable filter cassette FLOW-CEL® for biotech applications
<b>Abstract</b>
MICRODYN-NADIR GmbH from Wiesbaden/Germany will introduce a new development for the filtration demands of the biotech industry.
<b>Description including main features/advantages</b>
This development is a cassette system for the ultrafiltration of highly viscous media like fermentation processes. With a membrane area of 10m <sup>2</sup> and a 10kDa molecular weight cut-off, this FLOW-CEL® module is optimally designed to filter protein-containing liquids with high solids content.
<b>Innovative aspects</b>
The innovation of this cassette-system is the ability to clean by permeate-sided backwashing. This increases the cleaning effectiveness and saves chemicals, time, and manpower. The modular design with different feed side heights allows the system to be modified based on the particular needs of each operator.
<b>Current and potential industrial users/domains of application</b>
Food industry and pharmacy. Fermentation processes, all protein-concentration applications with a high amount of solids, for example cream cheese, are possible to handle.
<b>Current state of development</b>
FLOW-CEL® is not yet commercially available. To guarantee easy handling and operation, the FLOW-CEL® has been developed and tested together with operators in the biotech industry. Microdyn-Nadir wants to test other applications with this FLOW-CEL®, therefore they ask for industrial partners in the neighbourhood of Wiesbaden if they are interested to test it together.

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## 24. BioBooster Pressurised Biofilm Reactor and Membrane Bioreactor

<b>Title and name of product or technology</b>
Grundfos BioBooster PBR (Pressurised Biofilm Reactor) Grundfos BioBooster MBR (Membrane Bioreactor)
<b>Abstract</b>
<p>Grundfos BioBooster's revolutionary technology is marking a new paradigm in decentralised wastewater treatment with its compact, scalable and movable treatment plant.</p> <p>The BioBooster technology enables process industries or municipal WWTPs to treat their wastewater on site with direct discharge to receiving waters or reuse the water for service purposes.</p>
<b>Description including main features/advantages</b>
<p>BioBooster's value drivers – apart from enabling wastewater treatment at the point source of pollution – are a reduction of water consumption by reuse of wastewater, a significant reduction of infrastructure investment, accelerated implementation time, flexibility for both industry and municipality to grow or move, and an overall reduction in wastewater treatment costs.</p> <p>The system is compact and has a minimal foot-print, fitting within very limited space requirements.</p> <p>The system is modular which means that there is no need to plan for extra capacity; when production volumes are increased, additional components can be added much to the principle of plug-and-play. Also, the system is odourless and the treatment plant can therefore be located in residential areas.</p> <p>The system is delivered in standard building blocks of 20" containers. This enables industrial manufacturing while ensuring the quality of the solution and minimising the risk of prolonged implementation period. Implementation time is therefore limited to a few months and remote monitoring ensures stable operations and constant documentation of wastewater data.</p> <p>The system is movable which means that when the production site is shutting down the plant can be moved to another location. Alternatively, it can be moved about at the manufacturer's premises, thereby ensuring the vested capital.</p>
<b>Innovative aspects</b>
<p>Technological advancements in both PBR and MBR translate into a compact system uniquely designed with CIP functions that allow for continuous treatment. The enclosed reactors ensure an odour-free environment outside. Furthermore:</p> <p>PBR: compactness achieved by a unique cycloidal rotation of a disc system, which allow for biofilm growth to reduce the COD content in the wastewater. A rasping effect prevent blockage of the discs. The sheer number of discs in each reactor covers an area of 190 m<sup>2</sup>, thereby contributing to the compactness of the system.</p> <p>MBR: Ultra filtration via a unique combination of ceramic discs and cross flow impellers. These prevent fouling of the discs and ensure bacteria free permeate. The high concentration of biomass reduces the required process volume and the fact that the reactor is pressurised result in high flux leading to the compactness of the reactors.</p>



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
52/100

#### **Current and potential industrial users/domains of application**

- Various process industries within the following segments: food and beverage, pulp and paper, pharmacy, textile, laundry industry
- Municipal wastewater treatment plants in the small to medium size range

#### **Current state of development**

The BioBooster treatment plant is fully commercialised with several turn-key installations both in Denmark and abroad.  
Development is carried out with our R&D team in cooperation with universities and Grundfos' in-house development capacities.

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
53/100

25. Envopur® spiral-wound membrane modules with new type of spacer (tubular spacer)

<b>Title and name of product or technology</b>
Envopur® Spiral-wound membrane modules with new type of spacer (tubular spacer)
<b>Abstract</b>
The tubular spacer technology joins economics of spiral-wound modules and free flow of capillary modules. The feed spacer forms free flow channels within the module without any obstruction because of ligaments across the direction of flow (like in parallel spacers or diamond spacers).
<b>Description including main features/advantages</b>
Tubular spacers are made by thermoplastic forming. Width of spacer may be varied according to specifications up to 50 mil. Tubular spacers may be introduced in 4" and 8" spiral wound modules, compatible to conventional equipment in UF, NF and RO treatment. Tubular spacers may be favourably used for filtration of complex heterogeneous wastewaters which tend to form precipitates or agglomerates during concentration of the feed.
<b>Innovative aspects</b>
<ul style="list-style-type: none"> <li>- Beneficial combination of properties of spiral wound and capillary membrane elements</li> <li>- Interchangeable with conventional spiral wound elements</li> <li>- Improved tolerance towards colloidal and suspended organic matter</li> </ul>
<b>Current and potential industrial users/domains of application</b>
Industrial wastewater (paper industry, surface refinement, photovoltaic's...), leachate treatment, acid filtration
<b>Current state of development</b>
Pilot scale, patent pending

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## 26. Multibore® membranes for water treatment with ultrafiltration

<b>Title and name of product or technology</b>
Multibore® membrane
<b>Abstract</b>
<ul style="list-style-type: none"> <li>– Multibore® membrane - highly flexible and resistant membrane for the water treatment with Ultrafiltration technology of inge AG</li> <li>– dizzer® module series with Multibore® membrane - optimum flow distribution, first-class purification efficiency and variable operating modes at low pressure ensure consistently high quality for the water treatment with Ultrafiltration technology of inge AG</li> <li>– T-Rack® - revolutionary rack solution equipped with dizzer® XL modules for the water treatment with Ultrafiltration technology of inge AG</li> </ul>
<b>Description including main features/advantages</b>
<p>Compared to conventional water treatment methods, use of the ultrafiltration technology of inge AG offers numerous advantages: the modules can be easily and quickly installed in the system, the membrane fibres are extremely robust and stable. UF solutions developed by inge have been successfully installed in more than 500 facilities worldwide without a single case of fibre breakage – even after eight years of operation. inge UF solutions provide highest security: the small-pore sized filters of the patented Multibore® membrane reliably reject particles, micro-organisms, bacteria and viruses out of the water, thus securing germ-free and clean drinking water. Such exceptional advantages ensure reductions in operation costs as well as in investment costs.</p>
<b>Innovative aspects</b>
<p><i>Multibore® membrane</i></p> <p>Features</p> <ul style="list-style-type: none"> <li>▪ Highly flexible and resistant membrane</li> <li>▪ Optimized adhesive and anti-fouling characteristics</li> <li>▪ In-to-out Filtration</li> <li>▪ Active layer and foam structure are formed in a single production step (same material) – no de-lamination</li> <li>▪ &gt; 99,999% rejection for bacteria and viruses</li> <li>▪ pH resistance between pH 1 and pH 13</li> </ul> <p>Benefits of the Multibore® fiber</p> <ul style="list-style-type: none"> <li>▪ operation with reduced transmembrane pressures (TMP) due to a high permeability</li> <li>▪ high recovery</li> <li>▪ Very good membrane cleanability, fewer chemicals usage</li> <li>▪ high levels of virus and bacteria retention</li> <li>▪ high resistance under heavy load</li> <li>▪ no downtimes due to fiber break repairs, no fiber breakage for the last 8 years</li> <li>▪ Low fouling tendency</li> <li>▪ Long life time</li> <li>▪ Low operational costs</li> </ul> <p><i>dizzer® module series</i></p> <p>Features</p> <ul style="list-style-type: none"> <li>▪ 60m<sup>2</sup> membrane area (dizzer XL)</li> <li>▪ Low packing density</li> <li>▪ Hydrodynamically optimized design</li> <li>▪ Integrated pressure housings including enc-caps and connecting ports</li> </ul>



- Vertical installation
- Operation in different modes – flow from top or from bottom

Benefits of the dizzer modules

- Reduction in capital costs due to high capacity and less footprint
- Less wearing of the membrane thus longer life time
- Simple module installation, allows footprint savings
- Improved flow distribution along module
- Low OPEX, high operating flexibility and very high operating safety

*T-Rack® - the ultra-compact & modular UF solution*

Features

- Up to 80 dizzer modules in one T-Rack
- Integration of feed and drain pipes in the modules' end-caps
- 50% less footprint compared to conventional racks
- Modular design allows individual configuration of the T-Rack
- Easy capacity expansion by adding further modules

Benefits of the T-Rack

- Reduction in civil works costs
- High flexibility in case of limited floor space
- Reduction in commissioning costs
- Significant reduction in capital and operating costs

**Current and potential industrial users/domains of application**

UF solutions for the treatment of drinking water, sea water, process water and waste water

**Current state of development**

New innovations in the membrane design followed by a new generation of dizzer modules allow for further improvements in efficiency and reliability thus capital costs as well as operating costs can be reduced.

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
56/100

## 27. Cross-flow ceramic membranes with permeate conduits

<b>Title and name of product or technology</b>
CoMeTas CoMex – Cross-flow SiC ceramic membranes with permeate conduits
<b>Abstract</b>
Silicon Carbide (SiC) ceramic membrane elements utilizing cross-flow filtration principle. The ceramic membranes are available for MF and UF. The membrane elements show superior flux, filtration properties and energy/construction savings compared to traditional ceramic membranes. An increase of five (5) times the flux of traditional SiC cross-flow membrane elements has been recorded. The membranes are suitable in a vast variety of applications where cross-flow is applied today, i.e. produced water, waste water, industrial processes, ballast water etc.
<b>Description including main features/advantages</b>
The membrane elements provide high filtration capacity per unit volume. One element (Ø144mm x L865mm with 0,04 micron pore size) yields 23 m <sup>3</sup> /h permeate flux at 0.2 bar TMP (water at 20°C). SiC allows for harsh operating conditions: chemically resistant in pH 0-14, temperature resistant +1000°C and mechanical robust with TMP up to 10 bar.
<b>Innovative aspects</b>
The ceramic membrane is a further development of existing cross-flow membrane elements. The new improved design with permeate conduits excel with higher energy efficiency compared to traditional cross-flow systems due to higher flux rates, while maintaining the robust filtration properties. The membrane elements are an ideal alternative to traditional cross-flow membranes in existing and new installations. Installed Comex membranes elements will potentially reduce power consumption in membrane installations worldwide.
<b>Current and potential industrial users/domains of application</b>
The membranes are currently installed at operating sites in Canada (oil sand) and The Netherlands (surface water). Potential industrial fields of application are: Oil and gas, waste water treatment, industrial processes, water supply, etc.
<b>Current state of development</b>
The membrane elements are manufactured in varying geometries with different pore sizes according to the application. The membrane elements have been tested in-house and externally. The membranes still need to be tested on a number of applications like sea/surface water and industrial waste waters.

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
57/100

## 28. Dead-end SiC ceramic membranes

<b>Title and name of product or technology</b>
CoMeTas Aqua Solution – dead-end SiC ceramic membranes
<b>Abstract</b>
Silicon Carbide (SiC) ceramic membrane elements utilizing dead-end filtration principle. The ceramic membranes are available for MF and UF. The membrane elements show superior flux, filtration properties and energy/construction savings compared to sand filters. +90 % reduced water consumption for backwash has been recorded compared to sand filters. The membranes are suitable in applications for pre-filtration before RO and pool/spa.
<b>Description including main features/advantages</b>
The membrane elements provide high filtration capacity per unit volume. One element (Ø144mm x L300mm with 3 micron pore size) yields 35 m <sup>3</sup> /h permeate flux at 0.2 bar TMP water at 20°C). SiC allows for harsh operating conditions: chemically resistant in pH 0-14, temperature resistant +1000°C and mechanical robust with TMP up to 10 bar.
<b>Innovative aspects</b>
The dead-end ceramic membrane is a further development of existing cross-flow membrane elements. The new dead-end elements excel with higher energy efficiency compared to cross-flow systems due to higher flux rates and the lack of a re-circulating loop. The membranes are an ideal alternative to sand filters. The number of sand filters installed worldwide is innumerable and water consumption for backwash overwhelming – full-size public pools alone accounts for a <i>registered</i> usage of 190 mill. m <sup>3</sup> waste water per year.
<b>Current and potential industrial users/domains of application</b>
The membranes are currently installed at larger public pools in Denmark and in household units for domestic waste water. Potential industrial users besides the pool industry, are desalination and industrial RO plants with the need of pre-filtration.
<b>Current state of development</b>
The membrane elements are manufactured in varying geometries with different pore sizes according to the application. The membrane elements have been tested in-house and pool systems have been verified by an external accredited approval institute. The membranes still need to be tested on a number of applications like sea/surface water and industrial waste waters.

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## 29. MEDOX®, membrane bioreactor with pure oxygen

<b>Title and name of product or technology</b>	
MEDOX®	
<b>Abstract</b>	
MEDOX® is a MBR process with pure oxygen that works sequentially with oxic and anoxic cycles for nutrient removal.	
<b>Description including main features/advantages</b>	
<p>This technology offers as a whole the advantages from each systems, MBR, pure oxygen and oxic/anoxic cycles :</p> <ul style="list-style-type: none"> <li>▪ High quality effluents, free of suspended solids and with a relevant micro organisms removal.</li> <li>▪ Space requirements are significantly reduced because it allows working with a very high solids concentration and removing secondary clarifiers.</li> <li>▪ They allow working at high sludge retention times, producing less waste sludge, and more stabilized sludge.</li> <li>▪ The utilization of pure oxygen allows transfer optimally the oxygen demand, improve the response to organic load fluctuations and reduce the stripping effect. Also allows the online estimation of the oxygen uptake rate, the oxygen transfer rate and the oxygen efficiency, which offer interesting information about the WWTP state.</li> <li>▪ The utilization of anoxic/oxic cycles optimize the nutrient removal efficiency according to the wastewater fluctuations</li> </ul>	
<b>Innovative aspects</b>	
This technology offers a qualitative step forward for the biological processes as it allows working at high solids concentration, improve the oxygen transfer in the reactor and design a very flexible process for nutrient removal.	
<b>Current and potential industrial users/domains of application</b>	
Currently the MEDOX® technology is applied to the food, chemical and paper industry. It could be applied also to treat municipal waste water in little communities.	
<b>Current state of development</b>	
The MEDOX® technology is completely developed and R&D is dedicated to the optimization of its performance in terms of water quality and operational cost reduction.	
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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
59/100

### 30. Enviolet®, UV oxidation process

<b>Title and name of product or technology</b>
Enviolet®
<b>Abstract</b>
Enviolet® UV oxidation process → Cold combustion in the water phase.
<b>Description including main features/advantages</b>
Enviolet® is an UV + H <sub>2</sub> O <sub>2</sub> oxidation process, an AOT which is optimized, by means of reactor design, lamp control (optimal UV performance, prolongation of lamp life ) , automation (energy control, chemical control and performance control) and quality of the unit components (corrosion free). Possible to upscale from lab test to industrial unit, with small costs.
<b>Innovative aspects</b>
The reactor design with rotational flow, lamp control via identity card for each separate lamp. For some projects the unit can be used to treat different waste streams. Possibility to reuse the reaction heat and water, the latter is very pure and disinfected.
<b>Current and potential industrial users/domains of application</b>
Chemical industry, Pharmacy, surface treatment, textile, paper industry etc. Applications: COD reduction, elimination active substances, waste gas cleaning, Foto-Fenton applications, Cu and Ni recycling, detoxification of e.g. Cyanide (Cyanomat®), Complex elimination etc.
<b>Current state of development</b>
Commercially available in different industries.

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
60/100

### 31. Ozone process

<b>Title and name of product or technology</b>
Water reuse with ozone as oxidant
<b>Abstract</b>
Regarding the new challenges coming with anthropogenic micropollutants and future regulations, the ozonation can be an option to solve these tasks especially in combination with biological treatment. Ozone has the ability to oxidise and disinfect simultaneously. Today, 40 technical applications of ozonation in combination with biological treatment already exist but a few are published. The experiences show, that treatment of wastewater with ozone and biology is an economical and promising technology, even in large scale.
<b>Description including main features/advantages</b>
Especially in combination with biological treatment, the ozonation is able to oxidise target compounds as pathogens, colours, pharmaceutical pesticides, herbicides at low dosage rates and other persistent COD at higher dosage rates meeting future standards as described in the European Water Framework Directive.
<b>Innovative aspects</b>
Combination of ozone and biological treatment.
<b>Current and potential industrial users/domains of application</b>
<p>The water treatment plant Kalundborg treats mixed sewage consisting of 20% municipal and 80% industrial wastewater. The industrial fraction largely derives from a international pharmaceutical company, which operates one of the largest insulin production plants worldwide at this site. Due to this, the treatment plant is designed to purify and clarify the wastewater of nearly 350,000 inhabitants resulting from the adjacent pharmaceutical company, although Kalundborg is a smallish town. The wastewater contains difficult-to-degrade organic impurities monitored as COD value.</p> <p>Due to the extension of production scheduled by the pharmaceutical company, it was decided to redevelop the treatment plant completely.</p> <p>As the last treatment step an ozone treatment was projected within the recirculation system, for degrading a load of up to 1.250 kg COD per day. Therefore the ozone system was designed for 180kg Ozone/h (2 times 90 kg/h).</p> <p>After passing through treatment steps typical for conventional wastewater treatment plants, the biologically pre-clarified wastewater is treated by ozone within the recirculation system. This ozonation takes place in six reaction vessels with a total volume of 300 m<sup>3</sup>. Within a period of only 15 minutes of total contact, a drastic reduction of the persistent organic impurities occurs. The COD could be reduced by 38 % from in average 120 mg/l to 75 mg/l in average. At the end of the trials, the COD could be reduced to approx. 68 mg/l. To improve the overall reduction capacity, a H<sub>2</sub>O<sub>2</sub> dosage and an additional biological filtration after the O<sub>3</sub>/H<sub>2</sub>O<sub>2</sub> has been installed.</p> <p>A complete removal of furosemid, sulfamethizol and ibuprofen could be detected at ozone dosages of 21.5 to 53.5 gO<sub>3</sub>/m<sup>3</sup>. These dosages are much lower than approx 180 gO<sub>3</sub>/m<sup>3</sup> needed for the elimination of the COD.</p> <p>Assuming energy costs of 0.07 €/kWh and costs for the oxygen-supply of 0.12 €/m<sup>3</sup> oxygen, an exemplary rough cost-estimation of the ozonation step delivers specific operation-costs of approximately .to 01 to 0.3 €/m<sup>3</sup> water treated.</p>
<b>Current state of development</b>
Waste water treatment plant is running with ozone treatment.



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
61/100

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
62/100

## 32. Spiral plate technology separator

<b>Title and name of product or technology</b>
Evodos spiral plate technology (SPT) separator
<b>Abstract</b>
<p>Evodos SPT is a new approach to separation or clarification. Instead of a conventional conical disk stack, spiralized vertical plates are used. This solution allows a free interface level making SPT machines self adapting to changes in process parameters. Long delay times in the SPT pack and avoiding cross- or counterflow of the liquids leads to high separation efficiency.</p> <p>The patented method to discharge the collected material leads to high dry solid content of the discharged material.</p> <p>Evodos SPT may be equipped as a liquid-liquid separator (Trenner), as a liquid-solid clarifier (Klärer) or a liquid-liquid-solid separator.</p> <p>The Evodos rotor carries the SPT pack and a sliding cylindrical drum. All parts run on a vertical shaft at the same speed, giving an artificial gravity of 3000xG. The feed enters the rotor at its lower end. Clarified liquids are discharged from the top end of the rotor by one or two paring disks.</p> <p>The curved SPT pack is flexibly hinged to the rotor core. The SPT pack rests with its free end against the inner side of the sliding drum. The sliding drum is hooked to the rotor, giving all components the same rotational speed.</p> <p>As mentioned before, two neighbouring plates of the SPT pack form an enclosed, vertical and curved, banana shaped channel with large length and width but with very limited height. Whilst the feed flows from the bottom of the rotor upwards through these channels, it is separated in two liquids. Both liquids flow parallel, allowing Y-flow instead of cross-flow or counter-flow as seen in conventional stacked disk separators. This Y-flow highly supports the separation efficiency of the Evodos SPT separators.</p> <p>Particle separation efficiency is a result of settling distance and delay time. Together with the Y-flow in the channels, the combination of the limited distance (in the direction of the artificial gravity) a particle has to travel before settling and the large delay time in the rotor leads to high separation efficiency.</p> <p>Since the feed flows upwards over the whole area of each channel, Evodos SPT separators have no adjustable interface level. There is no gravity disk or electronic system to set or adjust the interface level.</p> <p>The heavier liquid moves towards the outer diameter of the rotor, from where it is guided to its discharge channel. The lighter liquid moves towards the center and is discharged also.</p> <p>Separation of two liquids with different specific gravity might even be combined with removal of particles. Whilst separating the mixture into two separate liquid flows, particles deposit inside the SPT pack. Once the quantity of deposited cake gets to large, this cake is discharged.</p>
<b>Description including main features/advantages</b>
Separation efficiency is equal or above industry standard. E.g. in processing primary municipal waste water sludge, Evodos reaches the maximum theoretical values as predicted by Degrémont.



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
63/100

Liquid content in the drum is removed before discharging the collected solids, so the dry solid content of the discharged cake is far above industry standard. E.g. in processing primary municipal waste water sludge, Evodos reaches a dry solid% of 25% without adding flocculants.

Designed to handle sticky/greasy/fatty and sharp/abrasive materials. E.g. Evodos easily separates grease from fish waste out of the centrate which is processed by a decanter.

No need to add flocculants, chemicals or polymers.

A minimal energy consumption of only 1.6 kWh/m<sup>3</sup>

Self adjusting on changes in process parameters (temperature, viscosity, mixture changes), no fixed interface level to be set

Simple, compact and rugged design, leading to minimal operational cost

#### **Innovative aspects**

The discharge method is innovative. It combines the use of a spiral plate pack with a separation efficiency higher than industry standard with discharging the collected solids as dry as possible with centrifugal technology. The spiral plate pack is made flexible. Therefore it functions well whilst separating. And it can open itself to let the collected solids out whilst discharging. This is truly innovation and patented.

#### **Current and potential industrial users/domains of application**

Industrial waste water treatment  
Municipal waste water treatment (In practice Evodos separates primary sludge to the maximum theoretical values as defined by Degrémont, without adding flocculants)  
Textile industry (decoloring wash water, reusing wool wash water, removing latex out process water in the carpet industry, cleaning cotton waste water without chloride)  
Oil/water/sludge separation (e.g. slop oil, bottom oil, tank oil, bilge oil, lube oil, drilling mud,...) in three phases  
Processing digestate of biogas plants as pre-treatment for membrane units  
Processing animal manure (e.g. Pigs, cows, ...) into clear liquid without suspended solids  
Processing slaughterhouse waste (after munching) mixed with slaughterhouse waste water  
Algae harvesting

NOTE 1: All processing is done without flocculants/chemicals/polymers

NOTE 2: List is not limited. These are only examples which are applied in practice with the Evodos technology

#### **Current state of development**

In production

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
64/100

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### 33. AguaCure electro-coagulation

<b>Title and name of product or technology</b>
AguaCure EC - Electro-coagulation
<b>Abstract</b>
Electrochemical water treatment techniques primarily replace chemical treatment to remove contaminants from waste and raw water streams. The immediate benefit of electro-coagulation (EC) is the reduction of the chemical input into a waste stream, which has advantages not only in terms of reduced generation of waste sludge, but also simplification of the chemical composition of the waste and, therefore, further processing and disposal of the sludge. In addition the system reduces the requirement to store/handle chemicals onsite and reduces the potential impacts caused by chemical supply chain issues.
<b>Description including main features/advantages</b>
Induced precipitation of metal ions using low levels of electricity: <ul style="list-style-type: none"> <li>• Chemical 'free' water treatment</li> <li>• Space saving</li> <li>• Waste reduction – reduced environmental impact and disposal cost</li> <li>• Energy efficient</li> <li>• Modular – Easy to expand with increased process requirements</li> <li>• Capital and operational cost saving</li> </ul>
<b>Innovative aspects</b>
System design resulting in: <ul style="list-style-type: none"> <li>• Improved energy efficiency;</li> <li>• Continuous operation;</li> <li>• Reduction of maintenance requirements.</li> </ul>
<b>Current and potential industrial users/domains of application</b>
<ul style="list-style-type: none"> <li>• Industrial Wastewater - Potentially any industrial waste water as a replacement for chemical coagulants and flocculants e.g. paper industry, dairy processing, leachate, metal finishing, fruit and vegetable processing, food/meat processing, textile/dyes</li> <li>• Municipal wastewater</li> <li>• Drinking water</li> </ul>
<b>Current state of development</b>
Large scale operational pilot plants

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
66/100

#### 34. Biofilm bioreactor using naturally immobilized tailor-made microorganisms

<b>Title and name of product or technology</b>
Technology for treatment of toxic wastewaters in biofilm bioreactor using naturally immobilized tailor-made microorganisms.
<b>Abstract</b>
A new modular technology for wastewater treatment applies tailor-made microorganisms with ability to create natural biofilm. Technology use natural immobilization of special xenobiotics biodegraders in the form of natural biofilm on the carrier (AnoxKaldnes or newly developed nanofibres). Natural immobilization increase resistance of microorganisms to the toxic compounds and extreme physiological conditions and allows survival of slowly growing microorganisms. The evaluation of this technology take place in Chemical-biological wastewater treatment plant from production of diphenylguanidine (DPG) containing cyanides, aniline, phenylurea, DPG, other accompanying organics and extremely high salinity.
<b>Description including main features/advantages</b>
<p>Main goal of this technology, developed in the frame of R&amp;D project EUREKA E! 3100 CAWAB, is to provide the tools needed by water bio-treatment designers and operators to manage a tailor-made innovations creating more efficient wastewater treatment processes. Involving university based and company research from tree countries the CAWAB meets the need to construct aimly attached consortia of prokaryotic or eukaryotic degraders to remove very complex and rare mixtures of organic water contaminants.</p> <p>Results of the project as the technology verification were implemented for the treatment of wastewaters in the chemical industry: Lucebni zavody Draslovka Kolin (Cyanides producer). Wastewaters containing cyanides, aniline and phenylurea from parts of the production facilities (production of diphenylguanidine – accelerator of rubber vulcanization) were not being treated properly. Small-scale biological treatment of wastewater, subsequent pilot tests carried out in the plant revealed satisfactory results and the construction of a wastewater treatment plant was planned, projected and subsequently carried out. This wastewater treatment plant is currently in the full scale operation after successful 2years testing phase. All produced wastewaters are treated in accordance with designed effluent concentrations. Present xenobiotics are the only carbon and nitrogen source for microorganisms.</p> <p>The implementation of the new technology contributes to general objectives of sustainable development. Implementation of biological treatment of wastewater also resulted in the possibility to innovate production of the plant. Innovation of production will lead to an increase in production. Therefore, the plant management decided to combine the innovation of production with the construction of the new water treatment plant. The whole investment deals with modernization of Chlorcyane and Diphenylguinidine (DPG) production with the aim of increasing process safety, production capacity, and continuity of Chlorcyane production. The environmental safety of production is secured by non-waste combined physico-chemical and biological treatment of wastewater in the newly established wastewater treatment plant. Diphenylguinidine is a highly sophisticated component used in the rubber industry (tire production) costing approx. 2500 EUR per ton. The reconstruction of the production unit enables the plant to increase production twofold (from 900 t/year to almost 2000 t/year) together with the implementation of a safety system for wastewater treatment. Implementation of new water treatment technology enables the plant to fulfill the requirements of the Integrated Pollution Prevention and Control (IPPC) Act, as well as the requirements of the new Water and Waste Acts.</p> <p>The company produces about 20 % of the worldwide production of DPG. The DPG market is</p>



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
67/100

stable and has an annual increase of approx. 5 %. The prognoses revealed the same increase in demand of DPG in the coming years. Investment into modernizing the production and improvement of the wastewater treatment create the possibility for sustainable development of the company, maintain existing jobs, and bring the possibility for new jobs in the coming years.

#### **Innovative aspects**

Engaging of tailor-made microorganisms creating natural biofilm under extreme physical-chemical conditions to common wastewater treatment lines. Application of the nanofibres as a carrier for microorganisms.

#### **Current and potential industrial users/domains of application**

Lucebni zavody Draslovka a.s. Kolin ([www.draslovka.cz](http://www.draslovka.cz)) –current user

Potential users:

producers of wastewaters containing toxic xenobiotics or extremely high salinity with negative impact on common biological treatment plants.

#### **Current state of development**

Evaluated, verified

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### 35. One step ANNAMOX®

<b>Title and name of product or technology</b>
One-Step ANAMMOX®
<b>Abstract</b>
<p><b>NITROGEN (AMMONIA) REMOVAL FROM CONCENTRATED WASTEWATER</b></p> <p>Many industrial and other processes emit nitrogen compounds into the environment, thereby disturbing the nitrogen balance. Especially from high concentrated streams the nitrogen compounds such as ammonium and ammonia must be removed. Up till now physical/chemical processes like stripping and precipitation and conventional biological nitrification/denitrification have been the processes most commonly applied for the removal of ammonium. Those processes however are expensive in operational costs and often take up a large area.</p> <p>Paques has developed the innovative, cost effective and sustainable <i>One-Step ANAMMOX</i>® process to treat this high strength water in a single reactor. Operational cost are reduced significantly since no external carbon source is necessary, the power consumption is reduced by approx. 60% and the production of excess sludge is reduced by 80%. Several full scale installations are in operation treating nitrogen loads up to 11,000 kg N/d.</p>
<b>Description including main features/advantages</b>
<p>The <i>One-Step ANAMMOX</i>® process, which is in essence a shortcut in the nitrogen cycle, makes advanced use of anammox bacteria that directly convert <math>\text{NH}_4^+</math> into <math>\text{N}_2</math> gas in one-step and in one single reactor <i>without the addition of an expensive carbon source!</i></p> <p>The Anammox bacteria live in the reactor in granular form, covered with a layer of nitrifying bacteria. This makes it possible to operate the single reactor in a constant process flow (so no need for sequential batch start-stop operation).</p> <p>The granular bacteria also allow easy separation between granules and other suspended solids.</p> <p>High nitrogen removal efficiency (up to 90%!) makes re-use of treated effluents possible. Compared to conventional nitrification/denitrification the operational costs are reduced by up to 90%, while <math>\text{CO}_2</math> emission is reduced by 88%. Furthermore the plant requires only half the space taken up by nitrification/denitrification.</p>
<b>Innovative aspects</b>
<p>Although the Anammox process was developed already more than 10 years ago to be applied in combination with a nitritation process, it was later developed as a one-step process without any need for such nitritation pre-treatment. Nowadays the ammonium-rich rejectwater can be fed directly into the One-step ANAMMOX reactor.</p>
<b>Current and potential industrial users/domains of application</b>
<p>Treatment of reject water coming from dewatered sludge from digesters.</p> <p>Treatment of effluent from anaerobic pre-treated wastewater in e.g. potato processing industry.</p> <p>Treatment of other ammonium rich streams from different industries.</p>
<b>Current state of development</b>
<p>Development is finalised; First full scale plants are in operation. Paques is now ready to apply / roll-out this technology in a much broader range of industries. A mobile anammox pilot unit is available to do on-site testing with specific streams.</p>



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
69/100

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### 36. Jet Zone Reactor (JZR), high performance aerobic biological treatment

<b>Title and name of product or technology</b>
JZR (Jet Zone Reactor)
<b>Abstract</b>
The JZR Technology is an aerobic high-performance biological treatment based on a novel mass transfer design
<b>Description including main features/advantages</b>
<p>Aerobic purification of effluents in highly loaded reactors (small reactor volumes) has only been possible until now under conditions of increased use of energy.</p> <p>The JZR (Jet-Zone-Reactor) developed in cooperation with the Institute for Environmental Technology of Bremen University, overcomes this limitation by intensifying the mass transfer in the reactor.</p> <p>This slim, high-performance reactor that is especially space saving can be combined, if needs be, both with conventional sedimentation and also with membrane filtration (Ultra-Filtration: this gives a very high potential for the saving of space and outstanding discharge output values).</p> <p>Particular advantages of the JZR Technology</p> <ul style="list-style-type: none"> <li>• A greater proportion of active biomass in comparison with conventional treatment processes.</li> <li>• A very high rate of conversion.</li> <li>• Compact design, minimum space requirement.</li> <li>• Can be integrated into existing equipment without any problem.</li> <li>• Optimum energy requirement (low operating cost).</li> <li>• No moving components, no wear and low maintenance requirements.</li> <li>• Totally enclosed housing.</li> <li>• Simple to operate.</li> <li>• Easy extendable (modular concept) in the case of a change in limit values, increases in capacity and new standards</li> </ul>
<b>Innovative aspects</b>
As a result of the vast improvement in its geometry, the optimised hydrodynamic and its patented nozzle technology, the JZR ensures to the maximum the dissolving process of oxygen and enhances the activity of the microorganisms in the reactor system.
<b>Current and potential industrial users/domains of application</b>
The JZR Technology is specially fitted for the treatment of high load wastewaters from the paper, food or textile industries.
<b>Current state of development</b>
First JZR plants were built in 2007.



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
71/100

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### 37. AiRO, air/water cleaning to control membrane fouling

<b>Title and name of product or technology</b>
AiRO, air/water cleaning to control membrane fouling
<b>Abstract</b>
Spiral wound membranes are often fouling and need to be cleaned. Using air instead of chemicals in a vertical positioned membrane fouling can be controlled.
<b>Description including main features/advantages</b>
<p>Spiral wound membrane processes, i.e. reverse osmosis (RO) and nanofiltration (NF), are increasingly used in water treatment for the production of water for drinking water, process water for industrial uses and for waste water re-use. One of the largest problems using membrane processes, however, is membrane fouling. This results in loss of performance (capacity/ quality) and increasing the total cost of ownership. The innovative AiRO process uses air/water cleaning in vertically positioned membrane elements to control membrane fouling. Thus less chemical cleaning has to be used to protect the environment and call also be done during production.</p> <p>Often only the first membrane in a system is fouled. By making a separate skid with only one membrane in a vessel upfront a membrane system fouling on the other membranes can be minimised.</p>
<b>Innovative aspects</b>
<p>Spiral wound membranes are not cleaned with air at the moment. Only known for tubular of capillary membranes (mostly MF en UF). 1) Less membranes have to be cleaned. Only the first membrane instead of whole stack. 2) less (to no) additional chemical cleaning/ sanitation chemicals have to be used 3) environment friendly 4) can be done automatically without attendance. 5) total cost of ownership will decrease</p>
<b>Current and potential industrial users/domains of application</b>
All membrane systems can be equipped with upfront systems using AiRO. All over the world.
<b>Current state of development</b>
<p>First idea cam from Vitens and was developed further by KIWA. Pilot tests where done by KIWA ( now KWR) and showed promising. At the moment a technical scale pilot unit is made by Logisticon Water Treatment and will be tested. If successful high capacity units for a total capacity of 1600 m<sup>3</sup>/h will be built.</p> <p>Furthermore: PhD research will be done by KWR &amp; University of Twente The main research questions are:</p> <ul style="list-style-type: none"> <li>(i) the mechanical/physical understanding of air/water cleaning of membrane elements,</li> <li>(ii) the effectiveness of the air/water cleaning process in relation to different feed components,</li> <li>(iii) the long term behaviour of air/water cleaning.</li> </ul>



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
73/100

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
74/100

### 38. Novopure, biodegradable and sustainable water treatment chemicals as antiscalants

<b>Title and name of product or technology</b>
NovoPure, biodegradable and sustainable water treatment chemicals
<b>Abstract</b>
As a result of a long term research project Holland Novochem developed the “NovoPure-technology”, an environmental friendly product line of water treatment chemicals. NovoPure products are based on sustainable biopolymers and contain exclusive biodegradable components. The product line comprises corrosion-inhibitors, antiscalants and dispersing agents for process and cooling water systems. For sterilization and pasteurization systems specific corrosion-inhibitors are available which protect packaging as well as the process system. For membrane systems there is a range of antiscalants and development is still being made in a new research program.
<b>Description including main features/advantages</b>
To prevent corrosion of metal equipment and packaging (food industry) in process- and cooling water systems, small amounts of chemicals -corrosion inhibitors- are being dosed. Traditional corrosion inhibitors are based on poorly or non biodegradable raw materials, like polyacrylates and phosphonic acids. Also ecotoxic high levels of phosphate, zinc or even molybdate are being used. These components burden the aquatic environment by discharge of the water. To prevent deposition of organic or inorganic (e.g. lime) material in all kind of water systems, small amounts of chemicals -antiscalants or dispersing agents- are being dosed. Like corrosion inhibitors these chemicals are being based on poorly biodegradable polymers and phosphonic acids With NovoPure corrosion inhibitors, antiscalants and dispersing agents, the environmental burden is substantial being reduced compared to traditional water treatment chemicals. Due to biodegradability and low phosphorus content NovoPure meets today’s most severe criteria with respect to both environment and legislation. Based on biopolymers from renewable sources, the technology can be characterized as sustainable. Other advantage of NovoPure is that it improves the biocide operation and no separate biodispersant is needed.
<b>Innovative aspects</b>
NovoPure chemicals are based on biopolymers from renewable sources. All components are biodegradable and the content of phosphorus and nitrogen is (very) low.
<b>Current and potential industrial users/domains of application</b>
Current users are cooling water systems in different kind of industries, process water in the paper industry, membrane systems and sterilization or pasteurization systems in the food industry. Potential application area is the chemical industry, power stations and desalination plants.
<b>Current state of development</b>
Main development at this moment is being made in the yield of membrane systems.



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
75/100

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
76/100

### 39. BIO-CEL®-MCP, chemical free mechanical cleaning of submerged membranes in a MBR

<b>Title and name of product or technology</b>
BIO-CEL®-MCP, chemical free cleaning of MBR wastewater treatment plants
<b>Abstract</b>
MICRODYN-NADIR GmbH located in Wiesbaden, Germany and Darmstadt University of Technology have developed a new, environmentally friendly cleaning process for submerged membranes in membrane-bio-reactor (BIO-CEL®) applications.
<b>Description including main features/advantages</b>
Due to their small footprint and superior effluent quality, MBR plants are the next generation of biological wastewater treatment. The driving force for this technology is the request for cleaner, more environmentally friendly cleaning of the membrane modules. In 2005, MICRODYN-NADIR developed the first back washable flat sheet membrane. This only requires a simple pre-treatment of the feed flow and exhibits extended operation between cleaning cycles. However, even with this novel development, some chemicals are needed for intensive cleaning. The newly developed mechanical cleaning process (BIO-CEL®-MCP), which uses granulates for continuous cleaning, can now be integrated into the BIO-CEL®.
<b>Innovative aspects</b>
BIO-CEL®-MCP allows a chemical free operation and a more important point is a significant enhancement of the flux. The usage of the MCP is even suitable for external membrane cleaning of the fouled membranes in any condition. In terms of sustainability with this cleaning process the environment can be protected (no usage of chemicals and therefore no chemical by-products). Additionally the cost can be reduced. The granulates are staying in the BIO-CEL® basin, when sludge goes out.
<b>Current and potential industrial users/domains of application</b>
Chemical industry, Pharmacy, textile, food industry, communal waste water treatment etc. where biological treatment is needed and reuse is an issue and/ or a high quality of the discharge water is necessary.
<b>Current state of development</b>
BIO-CEL® is commercially available for different industries for treatment of bio-degradable waste water. Pilot tests were done with BIO-CEL®-MCP during 18 months on efficiency and wear off of the membrane, both test were successful. Tests are still going on.

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#### 40. FACT, Filtration Assisted Crystallization Technology

<b>Title and name of product or technology</b>
FACT, Filtration Assisted Crystallization Technology
<b>Abstract</b>
FACT, which stands for Filtration Assisted Crystallization Technology, is a hybrid process based on heterogeneous crystallization and filtration. During the process development heterogeneous seeds are selected, which enable a combination of fast crystallization and easy filtration. In the FACT-concept a small amount of an ion/molecule to be removed on the surface of a small amount of heterogeneous (i.e. of another chemical composition than the material to be removed) seeds in a crystallizer. Next, a filter separates the seeds with the layer of crystallized material from the solvent (often but not exclusively water). The grown seeds are then recycled to the crystallizer as a concentrated suspension. Consequently, the heterogeneous seeds grow during the FACT process until the moment that they are bled off when they reached the required size. FACT is compact due to the fast crystallization and easy filtration and it has been shown for water softening – one of the many possible applications of FACT – that it can compete technically and economically with alternative softening technologies like the pellet reactor and ion exchange.
<b>Description including main features/advantages</b>
FACT, a new generic process developed by TNO, can amongst others be applied for the removal of hardness by means of the precipitation of calcium carbonate ( $\text{CaCO}_3$ ) on heterogeneous seeds. During the development heterogeneous seeds are selected by Medium Throughput Screening techniques, which accelerate the crystallization and which can easily be separated from the treated liquid. The acceleration of the crystallization is caused by stimulation of the heterogeneous nucleation. Examples of interactions between the seed and the material to be crystallized that can stimulate heterogeneous nucleation are preferential adsorption of the reacting ions and/or a good lattice matching between the seed and the crystal. The size of the seeds, which determines the surface area available for crystallization, is not only important for the crystallization kinetics, but also for the solid-liquid separation. In FACT the heterogeneous seeds are typically in the range between 5 and 50 $\mu\text{m}$ . This seed size is large enough to enable an easy and cheap S-L separation by standard filters and small enough to accelerate crystallization by providing a sufficiently large active surface area for crystallization.
<b>Innovative aspects</b>
<p>The innovation in FACT-concept is the use of a relatively small amount (about 1 g/l) of heterogeneous seeds which create process advantages like a significant increase of the crystallization kinetics, while at the other hand a compact and cheap filter can be utilized for the S-L separation. The heterogeneous seeds are recycled to the crystallizer after filtration. TNO has applied for a patent on the FACT process.</p> <p>An important advantage of FACT is that it is a generic applicable hybrid process. For the application of FACT in the softening of water the following advantages were demonstrated:</p> <ul style="list-style-type: none"><li>• <math>\text{Ca}^{2+}</math>-ions could be removed very efficiently with FACT. The removal could be tuned at levels between 50 and 98%, thus also creating the possibility of split stream treatment.</li><li>• FACT has the potential to be cheaper than competing – state of the art – softening techniques like the Pellet Reactor</li><li>• FACT is much more flexible in the choice of the process conditions/-concepts and the type of seed material than the Pellet Reactor</li><li>• The combination of a fast crystallization kinetics (5-10 times faster) and the low height of the unit operations ensure that FACT-installations can be much more compact than the Pellet Reactor.</li></ul>



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
78/100

- Both the softened water and the removed  $\text{CaCO}_3$  can be (re)used easily, so it is a potential water free process.

#### **Current and potential industrial users/domains of application**

Until now the development of FACT has been focused on the softening of ground-/drinking-/process-water. The FACT-concept is generic and can for instance also be applied for the removal of  $\text{F}^-$ , heavy metals or  $\text{PO}_4^{3-}$  from process- or wastewater. A further promising application of FACT is to use the concept for a controlled change of the shape and/or size and/or polymorph of solid products like fine chemicals and/or pharmaceuticals.

#### **Current state of development**

On site pilot plant experiments have been carried out for the FACT concept for two industrial ground- and process water streams at a scale of up to  $5\text{-}10 \text{ m}^3/\text{hour}$  using calcium silicate as heterogeneous seed and a Pulse Tube Filter for the solid-liquid separation. In these tests the water streams were softened successfully with FACT: the  $\text{Ca}^{2+}$ -concentrations could be decreased by 80-85%, the solids content in the filtrate was below specification and high filtration fluxes between  $2.5$  and  $4 \text{ m}^3/\text{m}^2.\text{hr}$  could be realized with the Pulse Tube Filter at relatively low pressures between 0.2 and 2.5 bar.

The experimentally measured crystallization and filtration data were used in a rough economic evaluation of the costs for the softening of groundwater with FACT. This evaluation showed that FACT could be about 30% cheaper than the costs for softening with the pellet reactor, the state-of-the-art technique for the production of Dutch drinking water. FACT has reached the status of proof of concept and is close to implementation. Main points of attention during the further development are solving unwanted scaling on some components in the installation – potential technical solutions have been identified but not yet tested – and to demonstrate long term stability and robustness of the FACT process.

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
79/100

#### 41. Enzyme based membrane cleaning and biofilm removal

<b>Title and name of product or technology</b>
Enzyme based membrane cleaning and biofilm removal
<b>Abstract</b>
<p>REALCO propose an enzyme based range of products dedicated to membrane cleaning. These products are used on various kind of filtration (dead-end, cross-flow), material (ceramic, organic) and application field (food industry, wastewater...). As an enzymes specialist for over 20 years, REALCO has the expertise and lab equipment to develop and propose tailor made solution for specific substrates or applications.</p> <p>Other enzyme application is the removal of biofilms. Enzyme-based process allow to efficiently remove biofilm and subsequent contamination risk from open or closed surfaces, without any risks for the users or the equipment.</p>
<b>Description including main features/advantages</b>
<p>REALCO, founded in 1968, is a SME company located in the scientific park of Louvain-La-Neuve. The company was involved in traditional products commercialization (detergents, disinfectant and descaling agent) for ten years before it developed its activity in biotechnologies applied to water treatment and cleaning. REALCO is now expert in developing process and manufacturing products based on enzymes or enzymes/bacterias complex (EBC).</p> <p>REALCO research on enzymes allowed to optimize their use in industrial cleaning (surfaces, CIP,...) and to get involved in a leading field like filtration membrane cleaning. REALCO propose responsible products which meet the specific needs of professionals in maintenance. These products are recommended for their cleaning performances, their safety for the operator and their non-aggressiveness for the machinery and tools. They also have a positive - and patented - impact on the environment.</p> <ul style="list-style-type: none"> <li>- High cleaning performances</li> <li>- Optimal flow recovery</li> <li>- Energy savings (lower temperature)</li> <li>- Injuries risk reduction</li> <li>- Material preservation</li> <li>- Membrane lifetime increase (till 100%)</li> <li>- Safe for the environment</li> </ul>
<b>Innovative aspects</b>
<p>Compared to classic solutions like caustic soda that might be efficient but that damages equipment, enzymes detergents show also high or even higher efficacy but without damaging these equipments. That is very attractive for expensive equipment like membranes or for application like biofilm removal that need very aggressive tools. On top of this, is also the environmental aspect.</p>
<b>Current and potential industrial users/domains of application</b>
<ul style="list-style-type: none"> <li>- Food industry process (dairy, fruit juice, protein extraction/concentration, wine,...)</li> <li>- Wastewater treatment (MBR)</li> <li>- Water desalination</li> <li>- Drinking water</li> </ul>
<b>Current state of development</b>
On the market



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
80/100

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42. Oxycon®, aerated activated carbon filtration for wastewater applications

<b>Title and name of product or technology</b>
OXYCON® aerated activated carbon filtration for wastewater applications
<b>Abstract</b>
Aerated activated carbon filtration for waste-water applications
<b>Description including main features/advantages</b>
<p>Activated carbon is used in the food, pharmaceutical and (petro-) chemical industry, air and gas treatment, in gas masks, air-conditioning, cigarette filters, waste, drink and process water treatment and groundwater remediation.</p> <p>In the wastewater purification systems, activated carbon is often used in the tertiary purification phase, together with membrane filtration, ultra filtration, reverse osmosis, ozonisation, peroxidation, evaporation, ion exchange, sand filtration, etc.</p> <p>Activated carbon is frequently used to remove recalcitrant, non-biodegradable compounds from wastewater. The adsorption capacity of activated carbon, with respect to certain molecules like phenol, increases when the treated water contains high concentrations of oxygen. This is due mainly to a chemical oxidation of the adsorbed molecules by the dissolved oxygen with activated carbon acting as a catalyst.</p> <p>Activated carbon is also an excellent support material for bacteria to grow and to form a biofilm (layer). The growth of bacteria on activated carbon can cause negative effects: an activated carbon filter can blind by an excessive growth or where anaerobic bacteria form sulphides, can cause an undesired odour and colour. But if the COD parameters are known the system can be designed and controlled to produce positive results.</p> <p>Bacteria can reduce the impurities from the wastewater, dissolved in the water and adsorbed on the activated carbon. The normally biologically difficult to degrade molecules are adsorbed on the carbon so that a slower biodegradation occurs.</p> <p>Adding powder activated carbon to a classic aerobic biological water purification plant, known as the PACT-process, is a comparable application.</p> <p>The OXYCON®-system stimulates a synergy of different reactions, adsorption, filtration, biological purification and oxidation.</p> <p>The Oxycon-system offers the following benefits:</p> <ul style="list-style-type: none"> <li>• Extended/Permanent activated carbon bed life.</li> <li>• A rapid stabilisation of the system biology within the carbon bed that is able to cope with toxic shocks.</li> <li>• Recalcitrant non-biodegradable molecules in the wastewater are metabolised as well as the easily biodegradable organics.</li> <li>• Nitrification (only at very low loads).</li> </ul>
<b>Innovative aspects</b>
<p>Specific for wastewater treatment applications the OXYCON®-technology has been developed to add an accurate and efficient amount oxygen (from air) to a classic activated carbon contactor (even if already in use). As well as adsorption and filtration, the activated carbon acts as a catalyst for chemical oxidation processes. By addition of oxygen aerobic bacteria are encouraged to grow and metabolise difficult biodegradable molecules (bio-</p>



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
82/100

regeneration in-situ).

**Current and potential industrial users/domains of application**

References and applications: landfills/tips, textile industry, waste treatment industry, wood industry, chemical and food industry, ground remediation, truck and tank cleaning, etc...

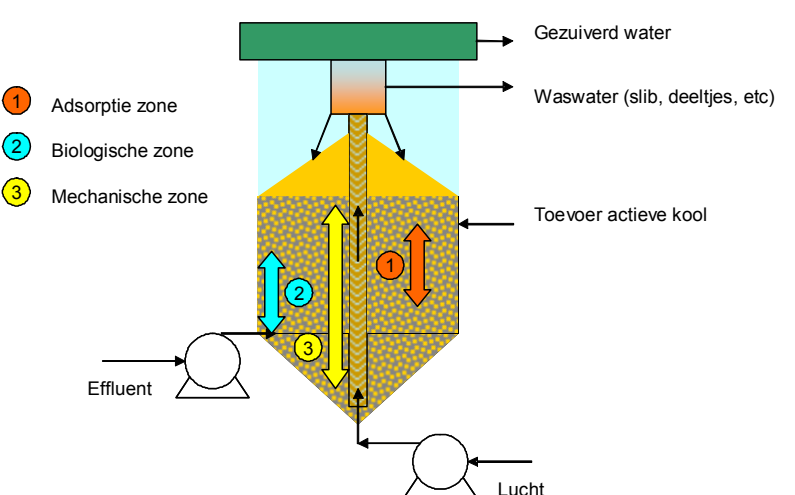
**Current state of development**

Pilot + some full scale installations

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### 43. Moving Bed Adsorption

<b>Title and name of product or technology</b>	
Moving Bed Adsorption	
<b>Abstract</b>	
Removal of suspended particles and dissolved organics in one step, using a moving sand bed with a small amount of carbon adsorption particles.	
<b>Description including main features/advantages</b>	
<p>Combination of two techniques in one apparatus: a) moving sand bed filtration and b) carbon adsorption; this leads to low investment costs. Basically, both the sand and carbon particles move counter currently with the water flow (note: other configurations are also possible). Best type of carbon sorption particles will be determined by laboratory experiments.</p>	
	
<b>Innovative aspects</b>	
Low investment costs, because suspended particles and dissolved organics are removed in one, robust piece of equipment.	
<b>Current and potential industrial users/domains of application</b>	
<p>Selective removal of suspended particles and dissolved organics on milligram and microgram per litre levels. Especially suitable for medium and large flows (&gt; 10 m<sup>3</sup>/h) and for cleaning requirements of the organics between approx. 50 and 98%. Potential applications:</p> <ul style="list-style-type: none"> <li>- effluent cleaning/polishing (meeting the standards of the Water Framework Directive)</li> <li>- recycling of streams in textile industry (color removal).</li> </ul>	
<b>Current state of development</b>	
The technology has been demonstrated in pilot tests on urban wastewater effluent (Horstermeer, Netherlands).	



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
84/100

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
85/100

#### 44. Membrane contactor, removal of dissolved contaminants by using a suitable extracting solvent

<b>Title and name of product or technology</b>
Membrane contactor
<b>Abstract</b>
Removal of dissolved contaminants, by using a suitable extracting solvent. The water flow and the solvent stay completely separated by using a membrane. The solvent flow is in principle much smaller than the water flow (approx. factor 1000 or more).
<b>Description including main features/advantages</b>
The water flow and the solvent flow move counter currently through one or more membrane modules. The counter current modus may result in very high removal of the contaminant using very low amounts of solvent. Commercial membrane modules are preferred for a cost effective process. Selection of best type of solvent may need laboratory experiments and market evaluations. Typically, one prefers: <ul style="list-style-type: none"> <li>a) low cost solvent in the case waste disposal is required (incineration)</li> <li>b) a solvent which allows recycling/recovery in the process (e.g. by distillation)</li> <li>c) a solvent to produce a valuable product</li> </ul> In order to reduce cross contamination of the water with the solvent, the solvent should show very low water solubility. In a specific variant of the process, the membrane acts as an air gap. This variant is only suitable for (very) volatile contaminants, such as halomethanes. But also it is also suitable for ammonia (after pH adjustment).
<b>Innovative aspects</b>
Ease of separating the two phases, when compared to conventional extracting processes. Foaming and other operational problems are avoided. Very low energy requirements for the 'mixing' step.
<b>Current and potential industrial users/domains of application</b>
Various applications may be found in chemical industry.
<b>Current state of development</b>
First applications have been successfully introduced in the market: <ul style="list-style-type: none"> <li>- recovery of valuable chemicals by using an common solvent in chemical industry</li> <li>- recovery of ammonia from wastewater</li> </ul>

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
86/100



#### 45. Innovative UV systems

<b>Title and name of product or technology</b>
Quality improvement in production processes due to disinfection with Microlight®, Microfloat®, Microspear®
<b>Abstract</b>
Water is in a lot of production processes a raw material, which can influence the production quality if germs are present in it.
<b>Description including main features/advantages</b>
Germs are growing very fast when settled in a any production process. Their metabolism products are starting chemical processes, which can attack the production quality and/or the produced products. The moment we can observe the presents of germs, due to the presents of slime and algae's, we are already to late. Cleaning is then a temporary solution, while we should prevent the problem, by keeping the germs under control from the start. UV disinfection doesn't change the water composition, there is no chemical interaction and it doesn't form by-products, it is just breaking down their DNA structure, so that they can't reproduce. Germs do not adapt themselves to UV at 254 nm (low pressure only).
<b>Innovative aspects</b>
Microlight®, is a flow through system with rotational flow around centralised UV lamp(s), which means, compact systems with high performance, even in dark or suspended solids containing liquids or in other words liquids with high SAC value or low UV transmission. Microfloat® (floating UV systems) and Microspear® (submergible UV systems) for in situ disinfection (storage disinfection) in tanks and rinsing baths etc., air disinfection (odour removal) and surface disinfection.
<b>Current and potential industrial users/domains of application</b>
Chemical industry, Pharmacy, surface treatment, electronic industry, textile, food industry etc. Applications: Cooling towers, chemical poor membrane filtration, rinsing baths, filling machines, storage tanks etc.
<b>Current state of development</b>
Commercially available for different industries and in many applications. Fit to customers needs.

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46. Atlantium, hydro-optic UV technology

<b>Title and name of product or technology</b>
Atlantium – Hydro-Optic Disinfection™ technology
<b>Abstract</b>
Atlantium Technologies has re-invented ultraviolet-based water disinfection. By leveraging the mechanics of <i>Total Internal Reflection</i> , Atlantium has created Hydro-Optic Disinfection™, the most efficient UV microbe inactivation technology available anywhere. Atlantium’s environmentally-friendly systems attain unprecedented levels of disinfection, helping industry and drinking water suppliers worldwide to provide healthier, safer products.
<b>Description including main features/advantages</b>
<p><i>Key operating principles lead to high microbial inactivation</i></p> <p>The units adapt the physics principle of Total Internal Reflection and are engineered to achieve uniform dose distribution - design changes that lead to unprecedented performance. These two fundamentals have resulted in demonstrated and validated attainment of high microbial inactivation levels.</p> <p><i>Real-time monitoring and control maintain required disinfection dose</i></p> <p>The Hydro-Optic Disinfection system consistently delivers the required dose. Its Monitoring and Control software provides real-time, continuous reading of the water flow, continuous measurement of UV transmissivity and UV lamp intensity, and adjusts the required disinfection dose as conditions change. This saves energy while still providing the required protection for the microbial challenges.</p>
<b>Innovative aspects</b>
<ul style="list-style-type: none"> <li>• Superior microbial inactivation resulting from uniform dose distribution (UDD)</li> <li>• Environmentally-friendly; no disinfection by-products</li> <li>• Low operating costs</li> <li>• Simple maintenance</li> <li>• Simple integration</li> <li>• System performance validated according to EPA protocols</li> </ul>
<b>Current and potential industrial users/domains of application</b>
Through excellent results combined with ever-growing expertise, Atlantium is building its concentration in a number of market sectors where the need for non-chemical, highly effective disinfection methods is especially important. The company's systems are currently used by businesses in the aquaculture, aquaculture, food & beverage and dairy industries and by municipalities for a broad range of applications such as flow-through / firewall, non-thermal pasteurization and post-GAC disinfection, drinking water and more. In the near future, Atlantium will be entering additional markets where demand from the field, combined with research results that show the effectiveness of Atlantium's systems for the required applications, are demonstrated.
<b>Current state of development</b>
The <i>R-series</i> Hydro-Optic Disinfection system was launched in 2005, and in 2008 Atlantium launched its <i>RZ-series</i> .



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
89/100

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47. EcoClearProx®, innovative H<sub>2</sub>O<sub>2</sub> solution

<b>Title and name of product or technology</b>
EcoClearProx®, innovative stabilised H <sub>2</sub> O <sub>2</sub> solution
<b>Abstract</b>
EcoClearProx® is an innovative stabilised hydrogen peroxide solution which was developed by ABT Belgium for use in different sectors where efficacy, quality and safety are primordial. The stabilisation of the product differs substantially from concurring H <sub>2</sub> O <sub>2</sub> -based solutions.
<b>Description including main features/advantages</b>
EcoClearProx® is a worldwide patented, innovative stabilised hydrogen peroxide solution of foodgrade quality. The stabilisation of the product requires minimally a sugar alcohol. The product is especially useful for many applications where disinfection by-products are of concern and where classical H <sub>2</sub> O <sub>2</sub> -stabilisers (e.g. silver nitrate) or active substances different from H <sub>2</sub> O <sub>2</sub> (e.g. peracetic acid) are not wanted or accepted.
The advantages of EcoClearProx® summarised:
<ul style="list-style-type: none"> <li>• Is of foodgrade quality and has a high stability especially when compared with chlorine.</li> <li>• Is authorised for various applications in Belgium, while authorisation procedures in several other countries are in a final stage or ongoing.</li> <li>• Has a broad spectrum of activity (oxidation, disinfection, etc.) and is at least equal or more effective as chlorine.</li> <li>• Is less corrosive than chlorine after dissolving in water and can be used in combination with many materials without adverse effects.</li> <li>• Does not generate dangerous compounds during reaction with organic materials or acids.</li> <li>• Generates H<sub>2</sub>O during its oxidising activity. No harmful substances remain after disinfection.</li> <li>• Has less environmental impact than for example chlorine-based biocidal products.</li> <li>• Is odourless before, during and after its application, and by this differs substantially from many other disinfection products.</li> </ul>
<b>Innovative aspects</b>
<ul style="list-style-type: none"> <li>• High stability</li> <li>• Broadspectrum activity</li> <li>• 100% foodgrade quality</li> <li>• No generation of disinfection by-products</li> <li>• Useful for a non-limitative list of various applications, including (drinking) water treatment next to many other applications</li> </ul>
<b>Current and potential industrial users/domains of application</b>
In the field of water treatment EcoClearProx® can be used as oxidant and disinfectant in: <ul style="list-style-type: none"> <li>- drinking water production</li> <li>- process water treatment</li> <li>- irrigation water (agriculture/horticulture)</li> <li>- waste water treatment</li> <li>- eradication of <i>Legionella</i> in sanitary installations</li> <li>- room/space/surface/tools/apparatus decontamination through vaporising</li> <li>- decontamination of food products (vegetables, meat, fish, etc.),</li> <li>- various applications including air purification, toxin removal, plant protection, bioremediation (including removal of pesticides, hydrocarbons, etc.), veterinary applications and human care applications including pharmacy, parapharmacy, general cosmetics, body care, dermatology and hair care (non-limitative list).</li> </ul>
<b>Current state of development</b>



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
91/100

EcoClearProx<sup>®</sup> is already commercialised directly by ABT Belgium or under different brand names through various subcontractors in many European and non-European countries, while further innovations and authorisations are still ongoing.

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
92/100

#### 48. USO<sub>3</sub>, ultrasound based technology

##### Title and name of product or technology



##### - ULTRASOUND BASED DISINFECTION TECHNOLOGY

##### Abstract

Usable water is the most significant precious resource on earth and is quickly becoming the scarcest. Over the coming decades increased demand for hygienic clean water is reaching a critical point. The availability of usable sanitary water is an explosive issue and has strong impact on the economic situation.

This premise underlies the drive to improve water and waste water treatment capabilities and its attendant economics. Wastewater treatment challenges apply to all industries, businesses – public and private - national, regional and local in scope.

The diminution of water quality coupled with the high cost of treatment expresses the necessity to develop new technical solutions offering lower operation cost and increased performance.

The internationally patented **USO<sub>3</sub>** technology covers most aspects of today's water and waste water treatment problems.

The **USO<sub>3</sub>** consists of two implemented processes, leading to excellent results by a unique combination of ultrasound and ozone. This combination allows a utilization of the **USO<sub>3</sub>** for different waste water problems, such as disinfection, EDC reduction, upgrading biological treatment plants by improving the aeration and therefore reducing the overall discharge parameters such as COD, Nitrogen and Phosphate etc.

The fundamentals for the conceptual and the final series engineering were derived from pre-tests with a technical scale model and industrial scale models supported by an EU LIFE project. The technology was awarded as one of the Best LIFE-Environment Projects 2006 – 2007 by the European Commission.

##### Description including main features/advantages

The liquid enters the system through a pump or the hydrostatic pressure. The first treatment step is the exposure of the liquid to ultrasound in a resonance section.

In contradiction to state of the art applications the ultrasound is introduced directly into the water through ceramic transducers. This leads to low power consumptions while at the same time high frequencies can be transmitted to the water. A monitoring system controls and

levels the frequency tolerances of the ceramic transducers by utilizing a digital synthesis.

The second treatment step is the ozone-gas-injection. Besides the ultrasound treatment and the alignment of the ceramic transducers inside the resonance chamber the quality of the ozone-gas dissolving is playing a very important role in the overall efficacy of the **USO<sub>3</sub>**. The optimized gas dispersion is accomplished by a specially developed mixing disc – the **OPTIMIXER**. The **OPTIMIXER** dissolves gases, such as ozone, at atmospheric pressure extremely efficient at low power consumption rates.

In the third treatment step the liquid is exposed to another ultrasound section following the **OPTIMIXER**.

Hence the **USO<sub>3</sub>** utilizes the cavitation phenomenon as well as the efficiency of an AOP (advanced oxidation process). The cavitation generated through the use of ultrasound causes extremely high local pressures and temperatures without increasing the liquid temperature above ambient level.

The complete unit is computer controlled and can be monitored and operated remotely.

The main advantages of the **USO<sub>3</sub>** are:

General:

1. It can be operated in a system overlapping manner - meaning one technology offers multiple solutions which normally would need more than one technology component.
2. It reduces cost for water treatment at improved cleaning efficacy.
3. In addition to solving current problems the technology also offers problem solutions for the future, e.g. EDC's and PPCP's without the necessity to invest in additional equipment.
4. The technology offers a modular, compact and flexible design with easy implementation in existing processes.
5. The maintenance and personnel demands are very low.

Specific:

1. Destruction of all pathogenic bacteria, fungus and viruses
2. Degradation of DNA
3. Reducing EDC's and PPCP's
4. Odor elimination
5. Discoloration
6. Inactivation of algae
7. Micro flocculation
8. COD reduction
9. Effective oxidation
10. Effective in clear and turbid waters

#### **Innovative aspects**

There are two different innovative aspects:

1. Ultrasound:

The way to use and to introduce the ultrasound to the water is unique and extremely successful. In contradiction to the current market-ready and available ultrasound systems, the ultrasound is applied directly into the effluent via a ceramic piezo instead of using a sonotrode.

Therefore a significantly lower amount of energy is necessary and higher frequencies can be generated. Due to the direct application of the ultrasound, the specific generated frequencies can be controlled and adjusted to the given design variations of the ceramic transducers by a digital synthesis. The created acoustic field compresses and expands the liquid in the rhythm of the generated frequency leading to extreme pressure changes.

The liquid exposed to such pressure loads is disrupted within the dilution phase and creates small vapour bubbles with a diameter of up to 100 micrometers. These so called cavitation bubbles collapse rapidly and create additional pressure waves. On the inside of the bubbles a vacuum with extreme pressure conditions is created. In the following positive pressure phase the cavitation bubbles implode – these characteristics contribute to the distinguished cleaning effect of the **USO<sub>3</sub>**.

2. **OPTIMIXER**

A fast rotating disc with a defined profile, surface and hole-pattern dissolves the ozone gas into water through an inverted venturi effect. Due to the high circumferential speed, which is integrated over the whole surface area of the disc, a turbulent flow is created. This flow optimizes the inverted venturi effect leading to high gas dissolving rates.



In combination with the ultrasound a special water condition is generated originating in a direct correlation between efficiency of the gas dispersion and a combination of ultrasound and the mixing disc.

One of the major advantages is the small weight of the disc which is the only moving part. Other systems either move great amounts of water through a small nozzle or press air with high pressures through porous membranes.

The low weight of the disc and the direct operation in the actual water stream of the **USO<sub>3</sub>** lead to very low energy consumptions.

The major novelty is the shape, the profile and the hole-pattern of the mixing disc in conjunction with the ultrasound. They all contribute to the ideal efficacy of the **USO<sub>3</sub>**.

#### **Current and potential industrial users/domains of application**

- Food & beverage industry
- Fish-farming
- Chemical industry
- Pharmaceutical industry
- Hospitals
- Drinking water works
- Pulp and paper industry
- Municipal treatment plants
- Industrial treatment plants
- Each application in need of water/liquid disinfection
- Each application in need or already using ozone.

#### **Current state of development**

After 10 years of development two series products in different sizes are already available and are actively being marketed. A 4inch unit and a 12 inch unit each for gas-injection or as complete **USO<sub>3</sub>** system.

With these two sizes throughputs from 1-5 m<sup>3</sup>/h up to 50m<sup>3</sup>/h can be covered. Higher throughputs can easily be provided by parallel operation allowing high performance safety.

Higher throughput might be developed in the middle-term.

The R&D department is currently concentrating on various different projects such as turbidity control of the **USO<sub>3</sub>** operation, MAP flocculation and MAP recycling set-ups, two sided piezo design and oxygen gas recovery for reuse for the ozone generator operation.

For the near future special research on the effect of antibiotics should be an interesting field for the R&D group of Ultrasonic Systems.

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
95/100

#### 49. TA-Aqua+ UV system in combination with photo-catalyst

<b>Title and name of product or technology</b>
TA-Aqua+, oxidation process in combination with photo-catalyst
<b>Abstract</b>
The TA-Aqua+ is a water purifier proven to be extremely efficient in breaking down micro-organisms. The technology used in the TA-Aqua+ is based on the patented Advanced Oxidation Technology (AOT). AOT is based on the creation of hydroxyl radicals by photonic energy at several wavelengths in combination with a photo-catalyst.
<b>Description including main features/advantages</b>
<ul style="list-style-type: none"> <li>- Breakdown of micro-organisms</li> <li>- Breakdown of organic contaminants</li> <li>- Hydroxyl radicals only exist for a few micro- to nanoseconds</li> </ul>
<b>Innovative aspects</b>
The UV-light not only destructs DNA but also reacts with the titanium casing to create hydroxyl radicals. Both the DNA and the cell are broken-down.
<b>Current and potential industrial users/domains of application</b>
For use in process water to prevent micro-organisms, like <i>Legionella</i> .
<b>Current state of development</b>
The TA-Aqua+ is on the market.

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
96/100

## 50. Dynamic Vacuum Recompression

<b>Title and name of product or technology</b>
Dynamic Vacuum Recompression
<b>Abstract</b>
The Dynamic Vacuum Recompression is a energy effective way for the evaporation of process liquids with a high concentrations of salts.
<b>Description including main features/advantages</b>
The DVR is an optimized version of the standard mechanical vacuum recompression, with a patented evaporation technology it is possible to an energy optimal evaporation without the rise of scaling insight the unit. With the DVR technology it is possible to concentrate salt and carbon rich liquids up till concentration level.
<b>Innovative aspects</b>
With the DVR technology it is possible to concentrate salt and carbonate rich liquids up till concentration level.
<b>Current and potential industrial users/domains of application</b>
The DVR can be applied anywhere where salts liquids needed to be concentrated for further processing or value creation with waste components. <ul style="list-style-type: none"><li>• Concentration cheese production water till 34% TDS.</li><li>• Salt waste water from industries till 34 %TDS.</li><li>• Concentration of brine streams out of RO units.</li><li>• Concentration of anaerobic digester liquids.</li><li>• Production of artificial fertilizer out of digester liquids.</li></ul>
<b>Current state of development</b>
The DVR is tested for several applications in the industry and agro applications, sales of 1-3 m3/h is started.

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
97/100

## 51. Memstill, membrane distillation

<b>Title and name of product or technology</b>
Memstill, membrane distillation
<b>Abstract</b>
The technology produces high quality water in one step from polluted water and/or salt water, using (waste) heat as driving force.
<b>Description including main features/advantages</b>
The technology is based on membrane distillation. New improvements has made the technology competitive with other desalination techniques, like reversed osmosis. The best results are found for influents below approx. 60 C and waste heat at. 80 C or higher.
<b>Innovative aspects</b>
Energy losses inside the module have been reduced (leading to higher energy yields) and the technology have been scaled up to modules of 1 m by 2 m. Salt can be rejected by at least a factor 10,000 when compared to the salt concentration in the influent .
<b>Current and potential industrial users/domains of application</b>
Very useful technology in any situation where process water of (very) high quality is required and where waste heat (around 100 C) is readily available. Less useful for some organically polluted streams, especially when membrane wetting may be expected.
<b>Current state of development</b>
The technology has been demonstrated for desalination on sea water and brackish water in three location (Singapore, E.ON, AVR) at 2 m <sup>3</sup> /h level. First full scale, commercial plants are expected in 2010.

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
98/100



Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
99/100

## 52. Small units for desalination of seawater by electro dialysis

<b>Title and name of product or technology</b>
Small units for desalination of sea water by electro dialysis
<b>Abstract</b>
PCCell develops an advanced sea water desalination device based on the ED200. The unit should be capable to produce 20 – 50 l/h drinking water and the device size should fit into a small case.
<b>Description including main features/advantages</b>
At the moment intensive research is conducted on the development of a sea water desalination device based on the ED200 type of cells in a continuous mode. This combination of small ED units with continuous desalination should combine low operational costs, high efficiency, long life time of membranes, low energy costs with a low technical effort. To achieve these characteristics, membrane properties are optimised to this particular application.
<b>Innovative aspects</b>
Renewable energies can be used to drive a plant. Technical, operational and energy costs are low. The membranes feature a high durability and a long life time and such an unit is lightweight and very compact.
<b>Current and potential industrial users/domains of application</b>
As drinking water issues are generally regulated on governmental level / public authorities, we want to enter this application field from the “small side”. The units should directly be used by the end consumer on place.
<b>Current state of development</b>
At the moment a pilot plant driven to optimise process parameters. An industrial plant will be developed on base of the obtained values within 2009.

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Deliverable No.  
Deliverable Title  
Issue date  
Page

D6.1.1  
Knowledge and Technological Portfolios  
09-02-2010  
100/100

### 53. Fully coupled heat integrated distillation column

<b>Title and name of product or technology</b>
Fully coupled heat integrated distillation column
<b>Abstract</b>
<p>The invention is a heat integrated distillation column with a new method to control and cooling the distillation process. Also included is a method to optimize distillation columns, which are "state of the art".</p> <p>The heat integrated column can be coupled with a solar thermal power plant, to build for example, an autonomous seawater desalination plant.</p>
<b>Description including main features/advantages</b>
<p>The distillation process is cooled internally in counter current, to win the process energy back. The energy content of the cooling medium is increased by the heat integration to a utilizable size. For the purpose of treatment of water are two stages as a middle size plant ( 500 m<sup>3</sup>/d ) suitable.</p>
<b>Innovative aspects</b>
<p>The inventions can reduce the energy consumption from 30% till 95 %. For this a Patent Cooperation Treaty (PCT)-application ( WO 2009/010250 A2 ) is filed.</p>
<b>Current and potential industrial users/domains of application</b>
Chemical industry, seawater desalination, cleaning waste water, energy supply companies
<b>Current state of development</b>
Two technologies are tested in the production ( Fatty alcohol distillation plants ), but the heat integrated distillation column must be developed.

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