NEPTUNE

New sustainable concepts and processes for optimization and upgrading municipal wastewater and sludge treatment

Contract-No. 036845

A Specific Targeted Research Project

under the Thematic Priority 'Global Change and Ecosystems'

1st Periodic Activity Report, Publishable Executive Summary

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1 Publishable executive summary

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1.1 Strategic objective

The scope of sewage treatment is changing: Up to date municipal wastewater treatment plants (WWTP) were seen as an end-of-pipe treatment just before discharge, having the aim to avoid eutrophication and hygienic health hazard in surface water. Due to the global demographic trends as well as new legislations (e.g. the Water Framework Directive, WFD) increased focus is put on quantity and quality of effluents: more and more seen as interface between sanitation and environment, **WWTP are delivering resources to the environment and for human activities** (recharge of drinking water reservoirs, recycling of nutrient, efficient energy use). This focus shift has implications on the quality goals set for WWTP products:

Existing focus:	New focus:
● nutrient removal	● nutrient recycling
● pathogens removal	● micropollutants and ecotoxicity removal
● energy optimization	● energy production
● sludge disposal	● reuse of sludge and of its resources

NEPTUNE will approach these tasks by focusing on **technology solutions** allowing to meet present and future standards via **upgrading of existing municipal infrastructure** (new control strategies with online sensors; effluent upgrading with oxidation, activated carbon or wetland treatment; safe sludge processing and reuse) as well as via **new techniques** (fuel cell applications; new oxidation processes; production of polymer and phosphate from sludge). By including pathogens and ecotoxicity aspects into life cycle assessment studies (LCA), the project is helping to improve the **comparability of various technical options** and propose a suitability ranking.

WWTP are the major pollutant point source for surface water, and consequently impact on the new focus legislated by the WFD. The emerging interest on organic (eco-)toxic compounds requires characterizing treated effluent and treatment technologies concerning ecotoxicologic aspects and micropollutants. NEPTUNE is contributing to this discussion by **ecotoxicity assessment** and micropollutant fate studies.

By directly **involving European players of the water management sector**, the generated know-how is expected to contribute to the export oriented knowledge based EU eco-industry. Further NEPTUNE will contribute to **sustainable growth** in the EU by helping to remove the barriers faced by new environmentally friendly integrated solutions, a) by covering knowledge gaps of new solutions and b) by evidencing pros and cons of technologic alternatives through direct comparison.

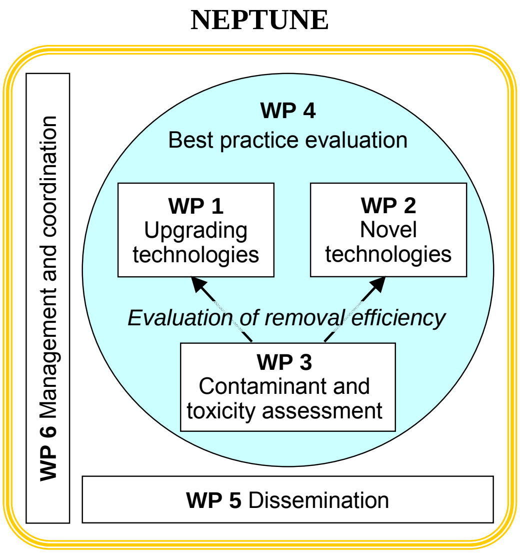

Fig. 1.1: General project structure as subdivision into workpackages (WP).

The project is structured into two technical workpackages (WP1 and WP2; Fig. 1.1) focusing on optimizing of existing technologies and forward-looking processes. Some key technologies studied in WP1 and WP2 are looked at for their micropollutant and pathogen removal capability (WP3) and compared for holistic impact with Life Cycle Assessment tools (WP4). Workpackages 5 and 6 support the project scope by disseminating the work done respectively by taking care of management and coordination. A summary of the detailed topics approached is given in Fig. 1.2.

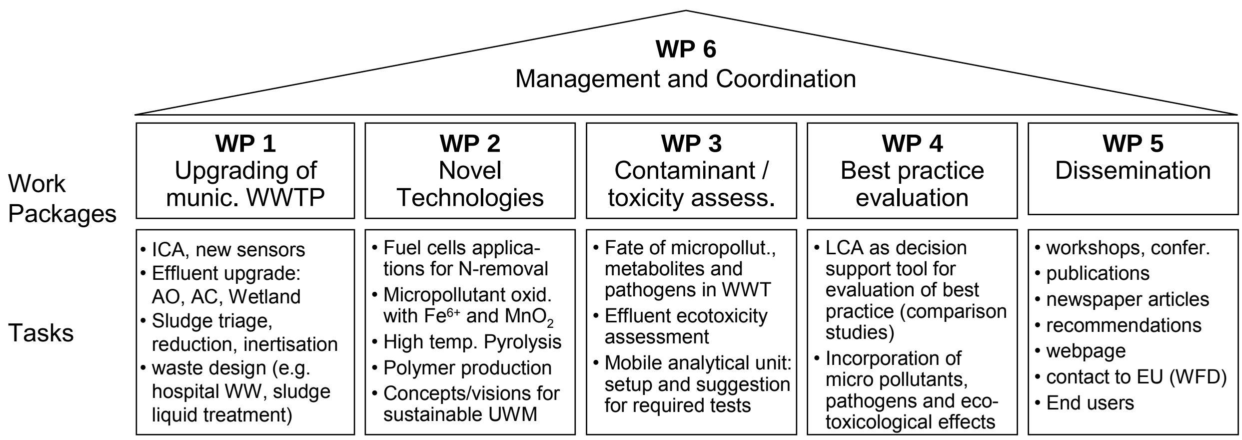

Fig. 1.2: General project structure as subdivision into workpackages (WP).

1.2 List of partners

Partic. Role[1]	Partic. no.	Participant name	Participant short name	Country	Date enter project[2]	Date exit project[2]
CO	1	Eidgenössische Anstalt für Wasserversorgung, Abwasserreinigung und Gewässerschutz	Eawag	Switzerland	Month 1	Month 36
CR	2	Bundesanstalt für Gewässerkunde	BfG	Germany	Month 1	Month 36
CR	3	Laboratory of Microbial Ecology and Technolgy, University of Gent	LabMET	Belgium	Month 1	Month 36
CR	4	Consiglio Nazionale delle Richerche (CNR)	IRSA	Italy	Month 1	Month 36
CR	5	University of Frankfurt	UniFra	Germany	Month 1	Month 36
CR	6	Technical University of Denmark	DTU	Denmark	Month 1	Month 36
CR	7	National Institute of Research and Development for Isotopic and Molecular Technology	INCDTIM	Romania	Month 1	Month 36
CR	8	Aquafin NV	Aquafin	Belgium	Month 1	Month 36
CR	9	Deutsche Projekt Union	DPU	Germany	Month 1	Month 36
CR	10	Institute for Product Development	IPU	Denmark	Month 1	Month 36
CR	11	SILUET B	SILUET B	Bulgaria	Month 1	Month 36
CR	12	Pyromex PLC	Pyromex	Greit Britain	Month 1	Month 36
CR	13	Gebrüder Hunziker AG	Hunziker	Switzerland	Month 1	Month 36
CR	14	SCAN Messtechnik GmbH	S::can	Austria	Month 1	Month 36
CR	15	CAMBI A/S	CAMBI	Norway	Month 1	Month 36
CR	16	AnoxKaldnes	Anox	Sweden	Month 1	Month 36
CR	17	Université Laval	Model*EAU*	Canada	Month 1	Month 36
CR	18	Advanced Wastewater Management Center, The University of Queenland	AWMC	Australia	Month 1	Month 36

[1]: CO = Coordinator; CR = Contractor.
[2]: Month 1: start of project, Month 36: end of project

The project is coordinated by the Engineering Department of the Swiss Federal Institute of Aquatic Science and Technology. The coordinators contact details are:

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Neptune FP6 Project

1.3 Work performed: first year

The major activities within Neptune during first project year were establishing analytical methods and devices as well as installation and operation of pilot-scale and full-scale plants.

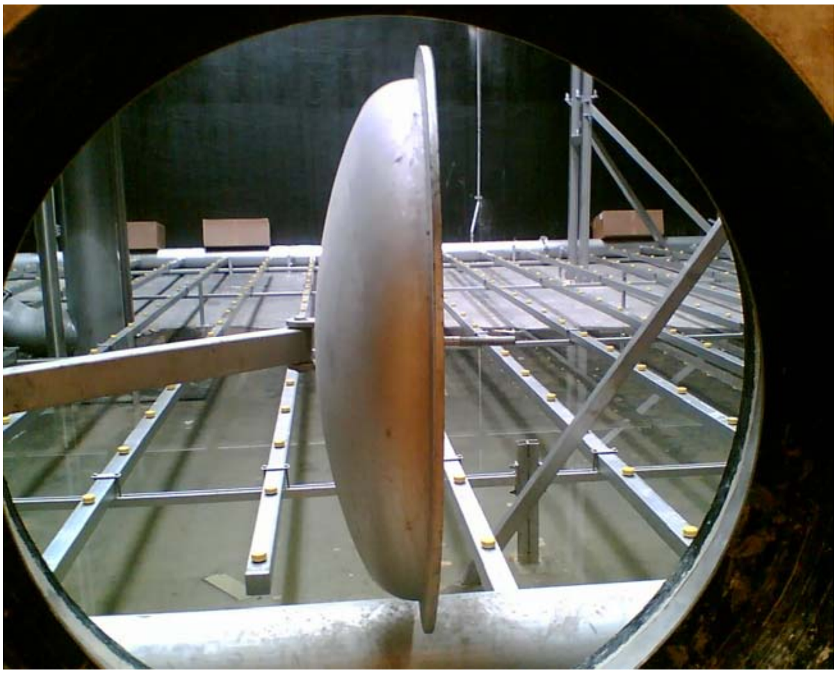

Fig. 1.3 Separate sludge liquid treatment, SBR in WWTP Zurich

The following **full scale demonstration** plants have been put into operation:

- The zeolite addition has been tested on Bulgarian WWTP with strong seasonal load variation
- for single stage SBR anammox two reactors (volume of 300 m^3 and 1400 m^3) have been equipped and started operation (Fig. 1.3).
- the ozonation of secondary effluent of a 25’000 person equivalent municipal wastewater treatment plant in cooperation with the Swiss project Micropoll

The following **experimental setups** and demonstration reactors have been put into place:

- The spectral s::can probe (Fig. 1.5) has been installed at different locations at Aquafin and Eawag
- Effluent upgrading: a BioMac pilot (combined granular activated carbon and ultrafiltration) is being set up on a WWTP operated by Aquafin. DPU has equipped a two lane pilot for testing effluent upgrading with powder activated carbon.
- Sludge hydrolysis: a Cambi pilot plant is being set up at Aquafin’s location

- Anammox upscaling: two pilot scale reactors (0.4 m^3 and 8 m^3) have been set up and operated by Eawag
- One semi-continuous fermenter and two parallel, lab-scale SBRs for growing biopolymer producing bacteria have been built and put into operation at AnoxKaldnes and one fermenter is operated at AWMC.
- Microbial fuel cells for wastewater treatment have been set up and studied at LabMet and at AWMC.
- Two types of lab scale unit to study micropollutant removal with manganese oxide has been set up and operated
- Spectral probe: the fingerprint database for the s::can probe has been enlarged to enable discussing the interpretation of the spectra for influent toxicity monitoring and for new control strategies
- Modelling of thermal sludge hydrolysis was achieved with IWA Anaerobic Digestion Model No. 1
- Anammox: dynamic model formulated based on a modified ASM3 model

Fig. 1.4 Microbial fuel cell pilot plant

The following **knowledge base tools** and **analytical methods** have been set up:

- Six nitrate sensors have been tested according to the ISO15839 standard with the aim of a critical review.

- The analytical methods and respective analytical capacity for analyzing more than 150 different micropollutants in raw wastewater, treated effluent and sludge has been made available for the scope of the project
- Protocols for quantifying microbial and viral contamination have been chosen and the corresponding analytical capacity has been made available for the project scope
- The following protocols for assessing ecotoxicity have been optimized for the scope of the project: Whole Effluent Testing, endocrine screening tests (YES, YAS, YAES and YAAS), mutagenicity, cytotoxicity, reproduction toxicity, developmental toxicity and plant toxicity
- Defining overall methodological LCA framework in agreement with Innowatech.
- First modelling of LCA scenarios have started up. Neptune inventory data on sludge incineration and literature data on sand filtration have been used up for the first modelling of the unit processes within GaBi (computer software) tool.

Dissemination activities

- The homepage of the project (www.eu-neptune.org) as well as the project flyer have been created.
- Workshop on actions required for integrated management micropollutants in the water cycle, held at the 6th conference on Wastewater Reclamation and Reuse for Sustainability (October 2007, Antwerp, Belgium)
- 8 presentations at Conferences have been made

1.4 Results achieved so far

Work performed during the first project year generated following results:

- For municipal WWTP with recurrent overloading due to strong seasonal load variation zeolite addition may represent a cost effective (temporary) solution to avoid or allow postponing plant refurbishment
- WWTP effluent ozonation: 3 mgO_3/L suffice for a wide reduction of micropollutants at the Swiss demonstration site and with the positive side-effect of 2 to 3 log unit pathogen reduction, although regrowth occurs due to generation assimilable organics during ozonation

Fig. 1.5 S:CAN spectral probe

- Sludge triage: segregation of primary and secondary sludge looks interesting according to preliminary results, due to lower micropollutant but higher nutrient content of secondary sludge.
- Sludge disintegration may lead to intense coloration of the hydrolysate, affecting WWTP effluent disinfection due to high UV absorbance
- Sludge combustion: pyrolysis emits an order of magnitude more organic compounds as compared to combustion with oxygen and PAH free off-gas is achieved at 800°C for secondary sludge while ≥900°C is required for primary sludge.
- Hospital wastewater: Preliminary results indicate that the cytostatics load in hospital wastewater is very small (ambulant treatment) while for the X-ray contrast media about half of the amount consumed is excreted within the hospital.
- For single stage SBR anammox the following key parameters need to be controlled: oxygen ≤1 mgO_2/L, pH between 6.8 and 8.3, temperature range of 15°C to 35°C is feasible after the start-up phase, at reactor start-up only sludge free of nitrite oxidizing organisms shall be used, ion selective ammonia sensor is very suitable for online control, fluorescent oxygen electrode should be used as an O_2 probe (Clarke type electrode not suitable)

- Pretreatment with thermal sludge disintegration (Cambi process) increases the potential for volatile fatty acid production during fermentation and is therefore expected also to enable biopolymer production from secondary sludge

1.5 Expected end results

- Technical solutions for upgrading a quantitatively significant water resource: municipal wastewater.
- Options for sludge processing and disposal, allowing to evaluate feasible and safe solutions for nutrient recycle.
- Improved energy efficiency of municipal wastewater treatment.
- Reduced pollutant load discharged into the aquatic environment, by improving nutrient and micropollutant removal and by evaluating wastewater treatment options with new (eco-) toxicological methods.
- Best practice ranking based on life cycle assessment (LCA) and cost efficiency assessment.
- Catalogue with criteria for evaluating technologies.

1.6 Use of the results and expected impact

Results of Neptune will be used to reduce environmental impact while at the same time reducing overall costs of the environmental protection. New analytical tools for micropollutants detection will enable better management of the whole effluent toxicity. By comparing existing as well as new technologies developed within Neptune, using LCA, it will be achievable to find best combination of technologies for each specific demand in WW sector.

The impact NEPTUNE is going to have can therefore be summarized in two main focuses:

- environmental impact: improving the quality of European water and the efficiency of its management (aquatic environment and drinking water resources)
- economic development: strengthening the competitive position in exporting wastewater technology