Odour-Control

Project no.: 016730
Project acronym: Odour Control

Project title: Smart Odour Control system to increase product quality, occupational safety and safeguard the location and jobs, based on forward-looking tools of SMEs entering the European paper market

Instrument: Co-operative Research Project (CRAFT)
Call identifier: FP6-2003-SME-1

6.1 Publishable final activity report
24 months

Period covered: from 1st October 05 to 30th September 07

Date of preparation: October 07

Start date of project: 1st October 05

Duration: 24 months

Project coordinator name: Dr. Dieter PAULY
Project coordinator organisation name: PTS

Revision: [1]

CONTENTS

1 Project execution

Researchers from three European universities and two research institutes in collaboration with five SMEs and three big enterprises from five European countries have joined forces in a Cooperative Research Project so called ODOUR CONTROL under the umbrella of the 6th Framework Programme on Research and Technological Development of the European Commission. The aim of this project is to control odour problems in the paper industry by identifying, monitoring and controlling odour relevant micro-organisms and metabolites within paper mill water circuits and in the product.

1.1 State of the art

Increasingly closed process water circuits in the paper industry, process engineering changes, increased recovered paper utilisation rates and low quality of recovered paper lead to high levels of organic compounds and electrolytes, prolonged retention times, increased temperature and pH levels. These changes in boundary conditions promote biological activities leading to microbiological effects such as odour formation in a significant number of European paper mills.

In paper production processes, odorants affect product quality and cause odour emissions leading to complaints from customers, residents and authorities. In some cases, the occupational safety of the employees (maximum allowable concentration) may be endangered. Odour problems are associated with the ever greater closure of the water circuits and by increasing paper recovery rate. Consequently several mills are facing related to odour emissions and some declare that odour control is one major concern of their activities.

In most cases, microbial metabolic processes in the water circuit producing hydrogen sulphide, sulphur derivates, volatile organic acids and other volatile compounds are the reason for odour problems in the paper industry. A multitude of interacting micro-organisms forms the biocenosis in the water and pulp system of paper mills. As a result several paper mills are using biocides regularly for controlling the microbiology. Biocides are added at different locations, the most common is the water circuit around the paper machine followed by additives preservation, freshwater and stock. Restrictions on biocide use can result from product requirements (e.g. due to production of paper intended for food contact), effects on the wastewater treatment or environmental limits. Therefore, alternative control systems need to be developed.

1.2 Intention for use and impact

Whilst anaerobic metabolic processes have been studied comprehensively in the past, knowledge is poor when dealing with relevant influences of papermaking systems. Mostly, neither studies nor test results are available from which conclusions might be drawn for proposing tailor-made and efficient remedial measures. As a reliable Odour Control routine for the paper industry does not exist the aim of this project is to develop a system ready for monitoring and controlling odour relevant micro-organisms and metabolites. Based on advanced components to be developed the innovative SMEs are aiming at entering the new paper industry market.

1.3 Summary description of project objectives

Biological odour formation is a complex and challenging process whose full description and control requires a critical mass of disciplines. Therefore, Odour Control project combines biotechnological, physical, chemical and process engineering tools. This multi-disciplinary approach covers all subjects relevant for successful integral solutions.

The ambitious goal will be achieved by first developing rapid monitoring tools for detecting odour forming micro-organisms and odorous compounds

- FISH Fluorescence In Situ Hybridisation
- AOS Artificial Olfactory Systems

Second, by triggering tailor-made countermeasures for odour control

- mill treatment system – biokidney concept
- mill treatment system – environmentally sound additives

and finally, to be combined into an Odour Control System.

1.4 Methodologies and approaches employed relating to the achievements of the project to the state-of-the-art

A better understanding of odour formation is urgently needed which was covered in WP1. Consequently the operational goal of WP1 was to increase fundamental knowledge about mill odour problems. In this context strategies have to be prepared for gaining advanced knowledge about paper mill odour problems during 1st year. All the tasks in WP1 were successfully completed in 1st year. All gained results serve as an essential basis for identifying approaches, potential applications and boundary conditions, and, finally, for deriving the prerequisites for developing innovative monitoring systems and countermeasures in WP2 and WP3. In particular, odour formation principles, odorous compounds (analytes), odour forming environments and their characteristic microflora prevalent in paper mills have to be investigated. To achieve corresponding operational goals of WP1 following means have been used:

- System check preparation including elaboration of schedule and sampling strategy (WP1.1);
- Identification, isolation and cultivation of odour forming micro-organisms including cultivation methods, fingerprinting, delivering of isolated cultures and testing of mill-relevant micro-organisms in culture collections. Additional in situ analysis of odour forming micro-organism have been performed supported by appropriate hybridization protocol for selected micro-organism. Further developed probes have been applied in paper mill samples as well as odour forming pure cultures have been identified (WP1.2);
- Identification of target analytes, environmental conditions and sensor technologies for reliable process odour monitoring and paper odour evaluation including determination of the threshold values required to the Artificial Olfactory System AOS and screening of the sensor technologies available to address the problem as well as searching for the best sensor technology for process odour monitoring and for paper odour evaluation (WP1.3);
- Identification of odour problems to be tackled by biokidney concepts, and of their boundary conditions including elaboration of environmental parameters of importance for odour production and removal and strategy for testing biokidney concepts (WP1.4);
- Identification of an odour minimisation concept based on environmental sound additives including definition of requirements like product profile and competition features (WP1.5).

Based on WP1 tailor-made products for odour control have been developed in workpackages WP2 covering innovative monitoring tools for detecting odour forming microorgansisms and odorous compounds. WP2 aims at developing effective innovative monitoring systems. Detailed mill odour checks have been revealed specific mill conditions and process characteristics. Gene probes having the power to identify and quantify odour forming micro-organisms have been developed for process water, raw materials and paper products. Hybridization protocols for the different samples have been set up. Simultaneously non intrusive sensors (Artificial Olfactory Systems AOS as well as NIR analyses) for monitoring/controlling process odour formation (headspace or liquid phase, respectively) and for paper odour evaluation have been developed. The different methods have been

compared and correlated using multivariate data analysis. To achieve corresponding operational goals of WP2 following means have been used:

- Detailed odour check in the partners' paper mills on their current state of technology focusing on internal water and pulp systems. This includes the identification of critical points for odour development and odour emission, global and local retention times and prevalent odorous compounds (WP2.1), already performed during 1st year period;
- Development of beta-test kits for the identification of odour-relevant micro-organisms. In this context specific oligonucleotide probes have been designed and constructed. Simultaneously the beta-test kits have been validated referring to the mill samples by comparison to results obtained via culturing or fingerprinting. Additional correlation of odour relevant micro-organisms in process water, raw material and in the final product have been checked focusing on anaerobic micro-organisms (WP2.2);
- Development of monitoring systems for identification of odorous compounds and verification of sensor measurements. Based on a feasibility study for sensor-based monitoring systems a proper sensor technology has been selected and an optimised sensor configuration has been performed for odour monitoring in the paper process and finished product (off-line). This includes validation of sensor measurements by means of samples collected under real conditions, realization of a dedicated hardware and software for the sensor array prototypes as well as integration of the mechanical and electrical systems for sensor addressing (WP2.3).

Based on WP1, tailor-made products for odour control have been developed in workpackages WP3 covering appropriate countermeasures for minimising odour forming micro-organisms and corresponding odorous compounds.

The objective of WP3 is to develop innovative odour control techniques. Odour control strategies based on new environmentally sound additives are to be elaborated. Simultaneously biokidney concepts for odour reduction have been designed. Before applying advanced countermeasures for minimising odorous compounds an optimised paper mill performance referring to minimised odour formation has to be ensured (Good Manufacturing Practice GMP). Afterwards forward-looking countermeasures for odour control have been elaborated for the mills examined. To achieve corresponding operational goals of WP3 following means have been used:

- Mill process optimisation has been elaborated based on evaluation of data and key figures of mill odour check. In this context concepts have been suggested regarding to process modifications in the mills examined, without expensive investments (WP3.1);
- Development of biokidney concepts covering design, testing and optimisation of concepts with regard to reduced odour formation. Simultaneously residual odorous compounds have been analysed formed during treatment based on biokidney concept in lab scale (WP3.4);
- Development of a system based on environmentally sound additives. In this context screening and testing of environmentally sound active substances have been performed including issues like regulatory affairs, technical viability for production, safety issues, cost structure, and environmental behaviour. Finally application strategies have been defined including dosing techniques based on on-site pilot-scale trials (testing products in a by-pass system on their ability to prevent volatile fatty acid evolution; supported by using gene kits to detect specific effects) (WP3.5).

The results gained in WP2 and WP3 lay the basis for subsequent prototype implementation in WP4. The results of WP2 and WP3 allow first applications of odour control strategies to be implemented in WP4. To achieve corresponding operational goals of WP4 following means have been used:

- Testing of gene probe kits for identification of odour relevant micro-organisms. This includes raw materials testing with VIT-kits and validating by NIR or fingerprinting applied to validate also AOS (WP4.2);

- Testing of sensor array prototypes by verifying their performance in terms of paper process odour control in paper mills and of finished product odour evaluation. This includes set-up and tuning of monitoring procedures and software as well as an integration and validation of devices and relevant procedures at mill side (pilot scale) (WP4.3);
- Identification of optimised biokidney concepts for odour minimisation based on specification of process design and operating conditions as well as complementary treatments, equipment and evaluation analyses including investment cost calculations and estimation of maintenance requirements (WP4.4);
- Testing of concepts based on environmentally sound additives including identification of the right treatment strategy, installation of dosing equipment meeting EC standard, logistics management, production evaluation, quality assurance of products (9001 and 14001), and regular control of application with respect to safety, dosing amount and efficiency testing (WP4.5);

Finally a plan for using and disseminating knowledge has been elaborated covering all applications of odour monitoring and odour control strategies including discussion of the results with all partners and deriving conclusions for the application of the SME products.

1.5 Work performed – major results achieved relating to the degree to which the objectives were reached

By using the carried out multi-disciplinary approach – covering microbiology, process engineering, monitoring and chemistry – prerequisite for deriving optimisation odour control concepts was met. Thanks to FISH, T-RFLP, NIR and AOS, a fundamental and comprehensive expertise in preconditions of microbiological odour formation was elaborated accompanied by detailed knowledge of the overall paper process (water circuit assessment, biokidney and additives) and further relevant boundary conditions (paper quality).

The RTD project Odour Control has been performed as initially planned (cf. Technical Annex TA1) with only minor deviations (already discussed and adopted by the Commission) that supported meeting successfully the objectives of the project.

1.5.1 System assessment and control

A tailor-made strategy for any odour check in paper mills was elaborated, including the parameters to be analysed in the water and pulp systems and the key values to be calculated for every system. This includes the determination of environmental conditions as well as the determination of metabolism products. Further data like information on circuit design, operation modes and chemicals were also determined to allow a meaningful data interpretation. In this context a questionnaire was developed and sent to the paper mills in order to receive the required data for the odour check preparation. The mills answered the questionnaire, so that a detailed sampling plan and strategy for the system analysis was elaborated. Additionally the involved paper mill partners collected water and paper samples as an essential basis for the sensors of the artificial olfactory system, and to allow a first identification of troublesome odour relevant micro organisms in the waters process. Consequently, the odour situation in the mills was evaluated, critical locations were pinpointed and characterisation of odour formation in the mills was performed.

In parallel a research of Italian and Regional regulation was performed at the Province of Lucca, at the Regional Agency for the Environment Protection, at the Paper District and on the web. A survey of regulations at a large (25) representative (80%) sample of paper mills of the local district was carried out.

Resume and outlook:

PTS has developed an efficient and methodical approach for the identification and evaluation of critical points for odour formation in the paper mills' water and stock systems from partners. Odour checks were performed by **PTS** in cooperation with **Lucense ScpA** at three partners' paper mills, i.e. **BAR**, **SCA** and **ALC**, involved in the research project.

After a comprehensive evaluation of all gained data **PTS** was able to pinpoint critical spots and process in the water and stock systems focusing on anaerobic odour formation. This knowledge forms the basis for suggesting technological-related optimisation steps to prevent/minimise odour formation. For preventing of odour problems following three approaches are suggested:

- Elimination of odorants / reduction of odorous effect
- Prevention of odour emissions
- Prevention of odour formation

A comprehensive evaluation of the determined data was performed and the results were presented and discussed. Based on this comprehensive data evaluation it was possible to localise critical system parts. Some 20 individual measures per mill were proposed presenting tailor-made optimisation concepts elaborated by **PTS**. Most of the measures could be realised by the three involved paper mills without high investment. By reconstructing its water circuit mill C has already implemented many of the proposed measures leading to improved status regarding unpleasant odour formation.

The results of the mill investigations enable to draw conclusions on an effective and economic process optimisation. As a first step conditions favouring odour formation have to be tackled and disposed. A reduction of dwell times and the avoidance of dead zones often mean only one-time changeovers without permanent extra costs. Further improvements lead to installing effective agitators and if necessary aerators at critical chests. In case of not yet sufficient, biocides or other chemical additives can be used. Further measures have to be discussed in particular cases.

Beside a fundamental expertise of microbiological odour formation a detailed knowledge of the overall process conditions is a precondition for deriving optimisation concepts.

1.5.2 Monitoring – FISH Fluorescence In Situ Hybridisation, fingerprinting, clone libraries and NIR

Based on a first screening of different paper mill samples, using a set of group-specific oligonucleotide probes a diversity of microbial populations was detected by the gene probes. Using 16S rRNA sequences, four new gene probes for the specific identification were designed and protocols for the application of the newly designed probes on paper mill samples were developed. Additionally, a protocol for the analysis of tissue samples was elaborated and sample preparation has been successfully performed. Specificity testing is in progress. Moreover, the hybridisation protocol for the identification of *specific strains* was optimized by **VER**. No additional permeabilisation step will be necessary for the FISH-analysis.

Samples from all involved partners' paper mills (**BAR, SCA, ALC**) – when no odour problems were reported – are used as reference. DNA extraction protocol and PCR protocols for T-RFLP and clone libraries were developed and preliminary data has been received from T-RFLP analysis by **SLU**. All samples received from the different paper mills were analysed with NIR. Different methods of refining the spectra have been tested to enhance relevant information. Baseline (non-odour) spectra were established for samples from the different paper mills. Preliminary tests of the PLSR correlation between T-FRLP and NIR-spectra were successful (r=0.9). Combination of NIR analysis with T-RFLP analysis is under study. The clone libraries have been analysed and the results are carried out forming the basis for constructing beta-test kits.

Figure 1: Developed Beta-test kits

Resume and outlook:

VER supported by **SLU** has analysed the composition of microbial populations of three different partner papers' mills using the cultivation-independent FISH technology (Fluorescence in situ hybridisation). Specific fluorescently-labelled probes, targeting different microbial groups, were applied on various sample types like process water and stock preparation samples. The relative share of each population compared with the overall bacteria population was quantified and microbial populations were successfully characterised.

The analysis reveals that each plant has its own population profile. The composition of microbial populations within one paper mill is very similar to each other, irrespective of the origin of the sample within the plant. Even during several months populations varied only slightly, provided that no big rebuilding of the plant occurred. Moreover, in contrast to the rather stable population profile within a plant, the studies demonstrated great differences between microbial populations of different paper mills. The dominance of one specific bacterial group for each single paper mill was demonstrated.

Clone libraries elaborated by the department of microbiology of the Swedish university of agricultural sciences (**SLU**) of the different paper mills revealed the predominant micro-organisms in these paper mills. Based on the obtained clone library data specific probes were developed for the identification of these predominant species and included in an easy-to-use detection kit. The identified dominant species seem to be unique for each plant. So far three different detection kits were developed by **Vermicon** for the partner paper mills. VIT-*B. thermoamylovorans* for the identification of *Bacillus thermoamylovorans,* which is the dominant species of the microbial population in paper mill A. Shares of 50-80% of the total microbial population were identified as *Bacillus thermoamylovorans*. For paper mill C two kits were elaborated by **Vermicon**, VIT-"*Flavobacteria*" and VIT-"*Tepidimonas*". The developed test-kits are valuable tools for monitoring the microbial populations in the plant. They will be used in further studies on site to overcome odour problems.

Odour producing microorganisms have been identified. Comparisons have been made between clone libraries, T-RFLP data and FISH analysis that show good agreement. Based on all achieved results, beta-test kits for monitoring odour producing strains are been designed.

1.5.3 Monitoring – AOS Artificial Olfactory Systems for the process and product – an alternative to traditional analyses

SoaTec and **I.S.E.** are developing in cooperation with the **Department of Organic and Industrial Chemistry** of the **University of Parma** artificial olfactory systems (AOS) for paper odour control in order to substitute panel test evaluation of paper products with an automated and objective system. AOS is a tool made up of an array of sensors (Metal Oxide Semiconductor) with partial specificity and a suitable data processing system, capable of characterising and recognising simple and complex odours, thus reaching ratings that are comparable to human ratings.

The advantages of AOS compared to the traditional techniques (gas-chromatographic analysis or olfactory sensor analysis through panel testing) can be summarised up as follows:

- Reduced response times and hence possibility of a higher sampling rate.
- Possibility of working continuously for many hours.
- Absence of pre-treatment of the samples before the analysis.
- Results expressed in a simple, synthetic and easily interpretable manner.

SoaTec developed an AOS for the objective determination of the odour quality - divided into proper classes for convenience - of the paper product through off-line analyses and hence the organoleptic suitability of the paper for the specific product uses (e.g. healthcare or foodservice).

I.S.E. optimised the data acquisition and processing program, so as to configure the interface to make it easy to use even by a non expert user, but that at the same time leaves space for a more expert user to broaden the applicability of the system. To this purpose the program was divided up into two modules, as described as follows:

- Non expert user module - The user has the task of using the AOS for only carrying out the quality control of paper product.
- Supervisory module - If necessary the user can add (or remove) types of samples and/or products, or classes (database manager).

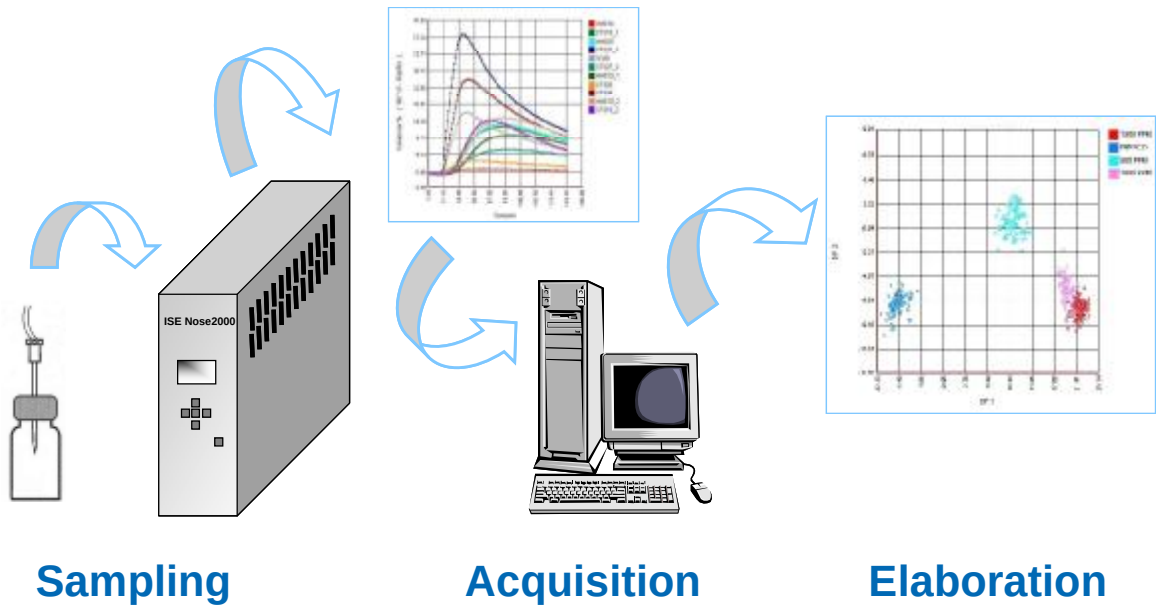

Figure 2: AOS Artificial Olfactory System

Resume and outlook:

The use of the CPS–AOS and PID technique has been confirmed for process odour monitoring in paper mills, whilst the MOS-AOS technique will be used for odour evaluation of finished product. The main odorous compounds were identified. Based on the achieved results promising monitoring devices are been designed.

The AOS judgement on unknown paper samples to be rated is easy to interpret and the results of trials in mill A and C are promising leading to the objective of introducing the AOS in the off-line quality control labs of paper mills.

1.5.4 Mill treatment system – biokidney concept

AnoxKaldnes has investigated in cooperation with **PTS** the possible use of an in-mill, biological treatment process, a so-called biokidney, to prevent and reduce the odour problems in paper mills.

Practical trials in aerobic and anaerobic laboratory scale biokidneys treating process waters from two of the partner mills showed the potential for odour removal and simultaneous decrease of soluble organic matter. The results were measured both with chemical analyses and with a trained nose panel.

Suppored by **PTS**, **AnoxKaldness** has evaluated an optimal biokidney concept, comprising both the biokidney and a solids separation unit for each of the partner mills. The elaborated combinations were depending on the specific mill conditions, process water characteristics, and the demands on the treated water. Combinations of an aerobic biokidney, as MBBR, MBR, or activated sludge process, and a solids separation unit in the form of flotation, filter or membrane were worked out.

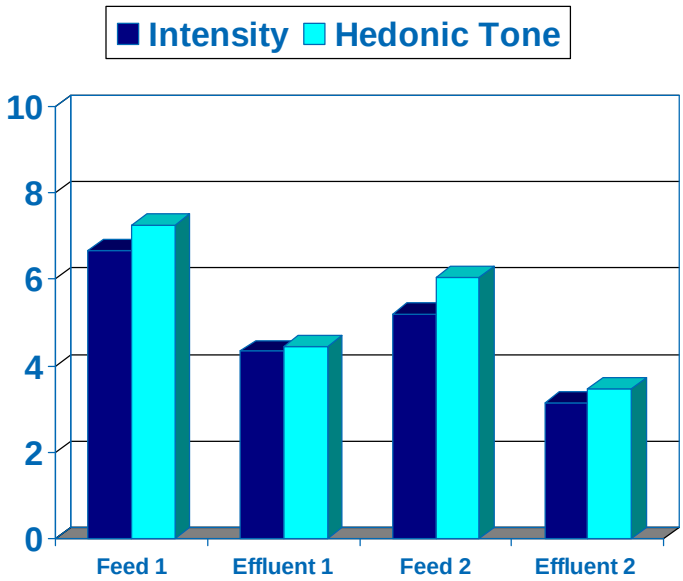

Figure 3: Very high removal of VFA; high removal of SCOD and BOD; reduction in odour

Resume and outlook:

The results have revealed that the introduction of a biokidney can efficiently prevent odour in paper mills, but will also have a potential for improved runnability due to the better over-all quality of the process water.

1.5.5 Mill treatment system – environmentally sound additives

KOLB has performed in close collaboration with UCM:

- developing a system based on environmentally sound additives, the formulation of an odour control product based on active substances showing promising positive results during the screening tasks;
- defining application dosing strategies and the use of gene kits to detect the product effects;
- in site pilot-scale trials, testing products in by-pass system on their ability to prevent volatile fatty acid evolution are performed.

KOLB bio-dispersants are surfactants with at least one ethoxylated non-ionic surfactant used in paper industry water systems to delay and/or reduce the formation of biofilms. They are divided into two functional subclasses: The first components, Bio-stabilisers, act on the initial steps of biofilm formation by reducing the probability of micro-organisms to attach to surfaces and prevent the covering of surfaces. The other components, Biowettants, act like detergents, on developing or mature biofilms, by breaking up the exopolymeric substances and enhancing the detachment of biofilms, thus reducing the thickness of existing biofilms. Since the anaerobic conditions in biofilms can lead to odour production, these approaches reduce odour problems at the place of its formation: in the biofilm.

The bio-stabilisers alter the wet ability of surfaces of the paper machine, which influences the conditioning layer. The conditioning layer is being formed of abiotic (non-living) substances, like salts such as carbonates, silicates and others, but also by polymers, stickies, process chemicals and further organic substances, which are present in the surrounding environment of a paper machine circuit. The physical modification of the surface by bio-stabilisers delays the initial adhesion of bacteria and the conditioning layer and therefore delays biofilm formation, anaerobic conditions and thus odour formation.

Biowettants act similar to cleaning agents by breaking up and thus removing existing deposits where odour can develop. Adding effective amounts of bio-dispersant leads to enhanced biofilm control and odour control without biocides.

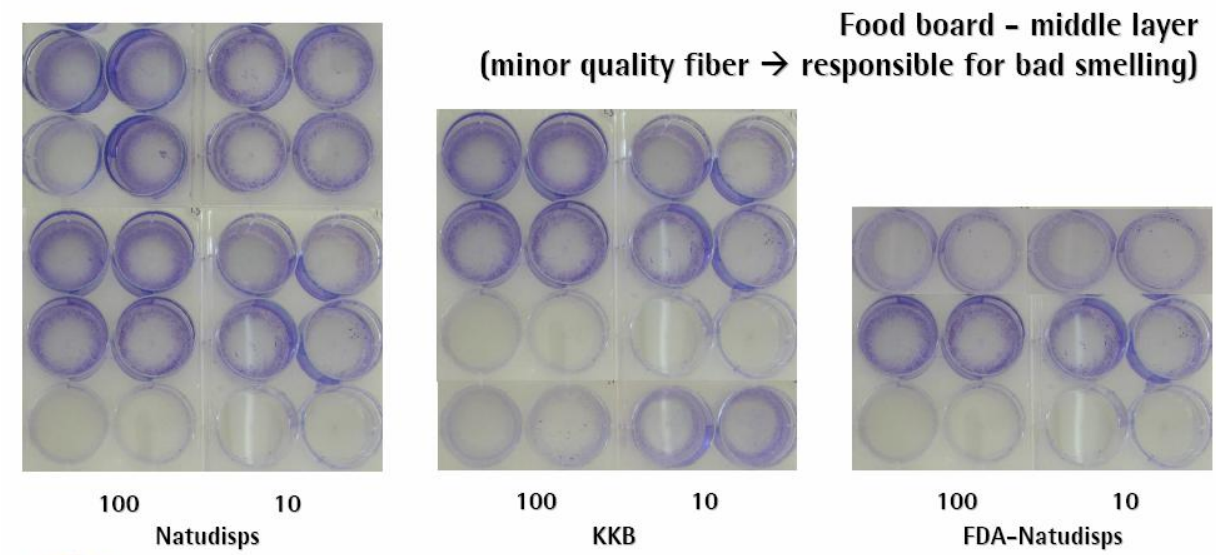

Figure 4: Absent colouring means efficient product

Resume and outlook:

KOLB, in collaboration with the **Chemical Engineering Department** of the **Complutense University of Madrid (UCM)**, has elaborated the concept of reducing odour problems due to microbiological deposits by the use of environmental sound additives, also called Biodispersants. These surfactant mixtures act by preventing the growth of biofilms on

surfaces or by reducing the thickness of biofilms. Various mixtures of surfactants were tested on process waters of paper mills with the aim of reducing odour produced by bad smell forming micro-organisms in biofilms.

1.6 End results

Especially in mills closing their water systems and using high recovered paper utilisation rates microbial activity causes the generation of odorous compounds. Odour problems are related to working conditions, emissions, i.e. air pollution of surroundings, and quality problems from a product point of view. Using unique monitoring systems, i.e. FISH and AOS, triggering proper countermeasures, i.e. tailor-made biokidney concept and environmentally sound additives, Odour Control will overcome risks and hazards as well as avoid civic and legal actions. In this context we achieved to monitor/control

- the generation of microbial odorous compounds during manufacturing;
- micro-organisms including odour formers whilst replacing high risk biocide use;
- product quality;
- emission from mill to surroundings.

1.7 Project logo and reference to the project website

Logo of project:

Website of project: www.odour-control.info

1.8 Contractors involved

Figure 5: Team of EU-project Odour Control

Figure 6 ODOUR CONTROL partners

1.8.1 Companies

Companies (SMEs and enterprises) involved in Odour Control:

- ISE Ingegneria dei Sistemi Elettronici (ISE); Vecchiano, Pisa, Italy
- Soa Tec srl (SOA); Parma, Italy
- AnoxKaldnes AB (ANO); Lund, Sweden
- Vermicon AG (VER); München, Germany
- Dr. W. Kolb AG (KOL); Hedingen, Switzerland
- F.LLI Bartoli SpA (BAR); Carraia, Lucca, Italy
- SCA Hygiene Products AB (SCA); Göteborg, Sweden
- ALCE SpA (ALC); S. Michele Mondovi, Cuneo, Italy (Mill in Fornoli, Lucca, Italy)

1.8.2 Institutes

- Papiertechnische Stiftung (PTS); Munich, Germany
- Lucca Centro Servizi per l´Economia ScpA (LUC); Lucca, Italy

1.8.3 Universities

- Sveriges Lantbruksuniversitet; Department of Microbiology (SLU); Uppsala, Sweden
- Complutense University ; Department of Chemical Engineering (UCM); Madrid, Spain
- Universita degli Studi di Parma; Department of Organic and Industrial Chemistry (UOP), Parma, Italy

1.9 Co-ordinator contact details

Dr Dieter Pauly

Senior European R&D Manager / R&D-Controlling
Papiertechnische Stiftung
Hess-Strasse 134, 80797 München (Germany)

Tel: +49-89-12146-160;
Fax: +49-89-12146-560;
E-mail: dieter.pauly@ptspaper.de

1.10 Acknowledgement

This project was sponsored by the European Commission under the umbrella of the sixth Framework Programme on research and technological development. We would like to express our warmly gratitude for this support.

2 Dissemination and use

2.1 Plan for using gained knowledge

Table 1 Publishable summary of each exploitable result

No.	Exploitable knowledge	**PUBLISHABLE** **result description** (products, envisaged, functional description, main advantages, innovations)	**Possible market application** (sectors, type of use) or how they might be used in further research (including expected timings)	**Stage of development –** prototype, demonstrator, Industrial product	**Collaborator details** Responsible of result description, supported by stated partners	**Collaboration sought or offered** (manufacturing agreement, financial support or investment, information exchange, training, consultancy), **type of partner sought and task to be performed**	**Contact details** e-mail
1	Data base of odour producing micro-organisms in the paper industry Report on odour producing micro-organisms in paper mill environment	Data base	Paper mills	Consultancy	ANO, VER, PTS, BAR, SCA, ALC LUC	Consultancy projects with paper mill training of personnel	christl.johnsrud@telia.com
2	Data base of prevalent odour compounds in the paper industry • Report on odour criteria, odorous micro-organisms and odorous compounds • Target organisms selected	Data base	Paper mills	Consultancy	ANO, VER, PTS, BAR, SCA, ALC LUC	Consultancy projects with paper mill training of personnel	christl.johnsrud@telia.com

3	General strategy for paper mill odour investigation: • Data base of critical location in paper mills, measurement points • Systematic odour check • General countermeasures	The proceeding in optimisation of water circuits can be divided into several steps: • Preparation of the system analysis • Determination of the current state of the water circuit: Data acquisition and analysis • Data evaluation and assessment of the water circuit • Derivation of optimisation measures Precondition of a system optimisation is the determination of the current state of the mills. Know-ledge about the stock and water system is the basis for a correct optimisation concept. An efficient and methodical approach is necessary to determine and document the problem areas that exist in a paper mills water circuit. Within this project a global strategy for any odour check at paper mills was developed.	Consultancy	Consultancy product	PTS, BAR, SCA, ALC	Consultancy projects with paper mills. Further collaborations with suppliers of measuring instruments in discussion.	dieter.pauly@ptspaper.de
4	Manual with countermeasures for odour reduction: 3 mill cases (general countermeasures) • Systematic and tailor-made odour check for each case • Tailor-made countermeasures suggested to the specific paper mill boundary conditions	For the prevention of odour problems there are possible measures which prevent the odour formation and subsequent measures, which can be classified into three groups: • Elimination of odorants / reduction of odorous effect • Prevention of odour emissions • Prevention of odour formation The results of the mill investigations enable to draw conclusions on an effective and economic process optimisation. The first step to prevent and eliminate odour problems should be to affect the conditions which favourite odour formation by pro-cedural measures. Further measures have to be discussed in particular cases.	Consultancy	Consultancy product	PTS, BAR, SCA, ALC	Consultancy projects with paper mills.	dieter.pauly@ptspaper.de

5	Characterisation of different process waters from involved mills • Chemical, biological and microscopical analyses (confidential) • Data base of process water characteristics (confidential)	By determination of the current state of the water circuit (analysis of up to 40 samples each mill) a database of process water characteristics was composed.	Consultancy	Data base has to be expanded in further research and consultancy projects.	PTS, BAR, SCA, ALC, LUC	Consultancy projects with paper mills.	dieter.pauly@ptspaper.de
6	First design of suitable biokidney for each type of process water (general) • Based on chemical characterisation • Based on results from lab scale trials	Knowledge about the stock and water system process and the water conditions are very important when identifying the most suitable biokidney process design. Dependent on these conditions and the quality demand on the treated water the biokidney design must be tailored for each individual mill. The analyses and evaluation of the treated and untreated process waters show a high removal efficiency regarding most odour compounds.	Consultancy	Consultancy product	ANO, PTS	Consultancy projects with paper mills	Asa.malmqvist@anoxkaldnes.com
7	Fingerprinting of odour producing microbial communities, comparisons between biofilms and surface waters in a paper mill (general)	Publication of SLU			SLU VER,		Ulf.Granhall@mikrob.slu.se
8	Fingerprinting of microbial communities. Comparisons between process waters from recycled paper and chips in a paper mill (general)	Publication of SLU			SLU VER,		Ulf.Granhall@mikrob.slu.se
9	NIR models for odour forming environments in paper mills - correlations with microbial community structures			Paper mills in collaboration with named Universities	SLU, UOP		Ulf.Granhall@mikrob.slu.se
10	VIT kit “Tepidimonas”	Kit for the fast in situ identification and quantification of odour former	Paper mill	Industrial product	VER, SLU	Consultancy projects with paper mill training of personnel	beimfohr@vermicon.com
11	Hybridisation protocol “for analysis final tissue product”		Paper mill	Industrial product	VER		beimfohr@vermicon.com

12	VIT kit “Clostridia”	Kit for the fast in situ identification and quantification of odour former.	Paper mill	Industrial product	VER	Consultancy projects with paper mill training of personnel	beimfohr@vermicon.com
13	VIT kit “VIT-B. thermoamylovorans”	Kit for the fast in situ identification and quantification of odour former.	Paper mill	Industrial product	VER, SLU	Consultancy projects with paper mill training of personnel	beimfohr@vermicon.com
14	VIT kit “Flavobacteria”	Kit for the fast in situ identification and quantification of odour former	Paper mill	Industrial product	VER, SLU	Consultancy projects with paper mill training of personnel	beimfohr@vermicon.com
15	Sensor system specification for selectively monitoring target analytes present at low concentration in the air		Paper mills	Prototype	ISE, SOA, UOP	Training and consultancy (SOA and users)	soatec@unipr.it
16	NIR system specification for on-line quality measurements of final products		Paper mills	Prototype	SLU, SOA, UOP, SCA	Consultancy	Ulf.Granhall@mikrob.slu.se
17	Sensor system specification for off-line quality control in final product.		Paper mills	Demonstrator	ISE, SOA, UOP	Training and consultancy (SOA and users)	soatec@unipr.it
18	Identification of sensor technology for process odour control		Paper mills	Industrial product	ISE, SOA, UOP	Consultancy (SOA and users)	soatec@unipr.it
19	Identification of sensor technology for paper odour evaluation		Paper mills	Industrial product	ISE, SOA, UOP	Consultancy (SOA and users)	soatec@unipr.it
20	List of prevalent odorous compounds in the water circuits and paper samples (general).		Paper mills		ISE, SOA, UOP ALC, BAR, LUC		soatec@unipr.it
21	Prototype of odour evaluation sensor. Process odour control in paper mills.		Paper mills	Prototype	ISE, SOA, UOP	Training and consultancy (SOA and users)	soatec@unipr.it
22	Prototype of odour evaluation AOS. Assessment of usability of the MOS-AOS device for off-line monitoring of odours in paper and paperboard samples.		Paper mills	Demonstrator	ISE, SOA, UOP ALC, BAR, SCA, LUC	Selling (SOA and users)	soatec@unipr.it

23	Prototype of odour evaluation sensor: definition of sampling procedures and development of dedicated implementations to match off-line monitoring requirements.		Paper mills	Prototype	ISE, SOA, UOP	Training and consultancy (SOA and users)	soatec@unipr.it
24	Software for data analysis: execution of a off-line classification of paper/paperboard samples based on a dedicated data base aimed at simplify the quality control procedures.		Paper mills		ISE, SOA, UOP		soatec@unipr.it
25	Instruction manual and specification of sensor for the MOS-AOS Device (covering hardware and software)		Paper mills	Demonstrator	ISE, SOA, UOP	Offered to end users (SOA)	soatec@unipr.it
26	Instruction manual of sampling procedures for the off-line paper sample monitoring		Paper mills	Demonstrator	ISE, SOA, UOP	Offered to end users (SOA)	soatec@unipr.it
27	New environmental sound additive for odour control “A.”	The new additive is a non toxic environmentally friendly product to prevent odour in paper mills	Applications in paper mills	Prototype	KOL, UCM		Ivo.naegeli@kolb.ch
28	New environmental sound additive for odour control “B”	The new additive is a non toxic environmentally friendly product to prevent odour in paper mills	Applications in paper mills	Prototype	KOL, UCM		Ivo.naegeli@kolb.ch
29	Manual of application techniques and services for the new environmental sound products		Application for paper mills		KOL, UCM		Ivo.naegeli@kolb.ch
30	Standards, EU directives and regulations relevant to odour control	Data base	Paper mills	Consultancy	ANO PTS	Consultancy information exchange training	Christl.johnsrud@telia.com

2.2 Plan for disseminating gained knowledge

Table 2: Knowledge used and disseminated

covering WP X.Y	Overview of workpackages' output – based on Annex I	date	Responsible participant	Partners' contributions	draft/ final evaluation of success	performed
WP0	Project presentation (2-3 pages, based on the instructions of Appendix 2 of Commission)	02/06	PTS	All partners	02/06	12/05
WP0	Knowledge used / disseminated via: • After acceptance, present the knowledge to potential customers and others through publications, presentations and courses. • Homepage of AnoxKaldnes advertising for OdourControl • Publication in Nordic P&P Research Journal • Publication in "Ny Teknik" • Publication in Nordic Paper Journal • Presentation at Pulp & Paper 5-7 June 2007 Helsinki Finland	09/06-09/07 10/05 09/07 09/07 09/07 07/07	ANO	SLU, VER	09/07 09/07 10/07 10/07 period 03-09/07	2006-2007 11/05 03-07/07
WP0	Knowledge used / disseminated via: • Knowledge acquired within the project will be used to implement optimised configurations of AOS for paper • http://www.ise-srl.com • Publication on ISE website and dissemination using existing mailing list of potentially interested institutions • Presentation at ISOEN Conference on AOS	03/06 09/06 09/06 05/07	ISE	UOP	04/06 09/06 09/06 06/07	in progress 06/07 12/06 12/06 Cancelled
WP0	Knowledge used / disseminated via: • Knowledge acquired within the project will be used for consultancy of customers (worldwide; papermills facing odour problems) • Using odour control homepage provided by partner LUC • PTS-News PTS-News • Environmental Conference	09/07 09/06-09/07 09/06 09/07 09/07	PTS	All partners	09/08 period 09/06-09/07 10/06 10/07 11/07	in progress 07/06 05/06 12/06
WP0	Knowledge used / disseminated via: • Homepage of partner advertising for OdourControl • Publication in specialised journals • Presentations at conferences and workshops • Presentation in specialised seminar/PhD courses	10/05-09/07 09/06-09/07 09/06-09/07 03/06-09/07	UCM	PTS	each 6m 09/06 + 09/07 09/06 + 09/07 09/06 + 09/07	12/06 12/06 02/06 + 04/07
WP0	Knowledge used / disseminated via: • workshops and seminar • sectorial and generalist local press • web • meetings at the Industrialist association	09/06+09/07 09/06+09/07 11/05-11/06 11/05+	LUC	ALC, BAR	10/07 09/06 12/05 + 12/06 02/06 +	19/04/07 06/06 June 07

	• sectorial exhibition (in particular the most relevant one: MIAC	11/06 01/06+ 01/07			02/07	2007 10/06
WP0	Knowledge used / disseminated via: • meetings at the Industrialist Association • sectorial exhibition (in particular the most relevant one: MIAC	 11/05+ 11/06 01/06+ 01/07	ALC	LUC	 12/05 + 12/06 02/06 + 02/07	 cancelled 09/07 10/06
WP0	Knowledge used / disseminated via: • The knowledge shall be used to improve odour in tissue mills using recycled paper within SCA. • Using odour control homepage provided by partner • Pulp and paper conference	 09/07 09/06- 09/07 09/07	SCA		 09/08 09/07 09/07	 in progress
WP0	Knowledge used / disseminated via: • Knowledge acquired within the project will be used for potential customers (worldwide; papermills facing odour problems) • Homepage www.vermicon.com • Publications in specialised journals (applied as well as basic microbiological/environmental journals) • Presentations at seminars and workshops for interested customers	 09/07 09/06- 09/07 03/07- 09/07 09/06- 09/07	VER	 ANO PTS	 03/09 period 10/06- 09/07 09/08 period 10/06- 09/07	 01/07 in progress 12/07
WP0	Knowledge used / disseminated via: • The knowledge acquired within the project will be disseminated to the potential users and the public through publications, presentations and courses. • http://ftpwww.cce.unipr.it/~chimorg/dalcanale • Publication in specialised journals • Presentations at conferences and workshops • Presentation in specialised seminars/PhD courses	 09/07 10/05- 09/07 09/06- 09/07 09/06- 09/07 03/06- 09/07	UOP		 10/06 + 10/07 every 6m 10/06 + 10/07 10/06 + 10/07 10/06 + 10/07	 01/07- 10/07 05/06 in progress 05/06 + 04/07
WP0	Knowledge used / disseminated via: • The knowledge acquired will be implemented in new AOS instruments to be sold to the potential costumers • http://www.soatec.it/ • Publication on SOA website and dissemination using existing mailing list of potentially interested institutions • Presentation at ISOEN Conferences on AOS • Presentations to potential costumers	 03/07- 09/07 10/05- 09/07 09/06 05/07 09/07	SOA		 10/06 + 10/07 every 6m 03/06 + 09/06 05/07 10/06+10/07 +03/08	 04/06 in progress
WP0	Introduction performed at: • support and complementary description of odour forming environments and microorganisms • www.mikrob.slu.se • Publication on departmental website and dissemination to organisations interested in odour problems • Publication in international microbiological journal • 14th Int. Diffuse Reflectance (IRDC) Conference, Chambersburg, USA, Aug. 2008	 12/05 09/06 03/07 08/08	SLU		 12/05 10/06 12/07	 01/06 in progress in progress 08/08