Content

Institute for Sanitary Engineering, Water Quality and Solid Waste Management

Chair of Sanitary Engineering and Waterrecycling
Wastewater Technology | AWT
Industrial Water and Wastewater Technology | IWT
Urban Drainage | SE
Water Quality Management and Water Supply | WGW

Chair of Waste Management and Emissions
Solid Waste | SIA
Hazardous Waste and Contaminated Sites | SOA
Measuring in Air Pollution Control | TAL
Biological Air Purification | ALR

Chair of Hydrochemistry and Hydrobiology
Hydrochemistry | CH
Biology | BIO

Sewage Treatment Plant for Research and Education | LFKW
Institute for Sanitary Engineering, Water Quality and Solid Waste Management | ISWA

Institute for Sanitary Engineering, Water Quality and Solid Waste Management

Bandtäle 2
70569 Stuttgart
Germany

Tel.: ++49 (0) 711/685-63711
Fax: ++49 (0) 711/685-63729
www.iswa.uni-stuttgart.de
The Institute for Sanitary Engineering, Water Quality and Solid Waste Management (ISWA) is a research and training facility of the University of Stuttgart (Universität Stuttgart) within the faculty of “Civil and Environmental Engineering Sciences”. The University’s Sewage Treatment Plant for Research and Teaching, which is situated within the institute, is unique throughout Europe.

Experts from various engineering and natural sciences work together at our institute on an interdisciplinary basis. Our principal areas of expertise are the classical engineering tasks in the environmental fields of water, wastewater, solid waste, soil and exhaust air.

The continuous development of technical facilities and practical methods in the fields of industrial and municipal supply and disposal are the focus of our interest. Our experience is also incorporated in the monitoring and development of quality assurance measures and management systems.

Our institute, which is known today as the Institute for Sanitary Engineering, Water Quality and Solid Waste Management (ISWA), was founded as the “Institute for Sanitary Engineering and Health Technology” in the early 1950s. At that time it was the first educational establishment in Germany for civil engineers in the field of water and solid waste in urban development. In the 1970s the first chair of solid waste management at a German university was created. Today, our institute is one of the largest of its kind in the world.

We offer a large variety of study courses

The four chairs at the ISWA – Sanitary Engineering and Water Quality Management, Sanitary Engineering and Water Recycling, Solid Waste Management and Exhaust Air, Hydrochemistry and Hydrobiology in Sanitary Engineering – represent the broad spectrum of environmental issues that occupy us in two departments and seven sections. Our institute offers numerous courses and internships in basic and specialized studies as well as student research projects, dissertations, Bachelor- and Master’s theses for the following courses of study:

- Civil Engineering
- Environmental Engineering
- WAREM (Water Resources Engineering and Management)
- WASTE (Air Quality Control, Solid Waste and Waste Water Process Engineering)
- Infrastructure Planning
- Geography
- Technical Biology
- real estate technic and -industry
- EDUBRAS-MAUI

For the first time, ISWA introduced a M. Sc. course under German administration at the public university UFBR of Curitiba, Brazil. The project named „Export of German university education“ is funded by DAAD. Therewith, courses of ISWA are also offered overseas.

In addition there are courses for students of process engineering, real estate management, biology and chemistry. We also participate in the international doctoral candidate programme ENWAT (Environment Water) of
the University of Stuttgart (Universität Stuttgart), as well as in programmes for extracurricular training and continuing professional development.

Scientific collaboration

Under the auspices of the ISWA, scientific colloquia and congresses on current topics of national significance relating to sanitary engineering and solid waste management have been held since 1957. Our academic employees are represented on numerous national and international boards as well as on technical and standardization committees of various technical-scientific organizations.

The ISWA facilities

The institute currently employs around 120 people; five professors and about sixty academic employees, supported by a considerable number of academic and student assistants as well as technical and administrative staff.

All necessary facilities, from the research treatment plant, laboratories and lecture rooms, to the technical library and computer workstations equipped with specialist applications, are available for university teaching and research. One of the special features of our institute is the sewage treatment plant for research and education, which routinely also cleans the wastewater from the campus in Vaihingen and the district Stuttgart Büsnau.

Our laboratories are excellently equipped for extensive investigations in a wide variety of environmental fields (water, wastewater, solid waste/soil, air). We have a large amount of (online) measuring equipment available for experiments on a laboratory scale, semi-technical scale and technical scale. In particular, this includes equipment for organic trace analysis; in part, these are operated using special coupling techniques for mass spectrometry (GCMS-MS, HPLCMS-MS). We also utilize computer supported prediction methods. With the aid of specially designed computer applications, modelling of processes in water and wastewater treatment is possible; measures in the fields of rainwater management and waste management concepts can be modelled, as well as geochemical simulations being carried out. The continuously improved computer simulations serve process control or decision making at various levels.

Focal points of teaching and research

Our activities under the chairs of sanitary engineering and water quality management and Sanitary Engineering and Water Recycling are concentrated around the minimization of the anthropogenic influence on water bodies and the natural hydrologic cycle during water extraction, and are engaged in the optimized treatment and sustainable use of water resources, as well as effective, environmentally friendly wastewater discharge and treatment. Internationally, water resources management in particular is of increasing importance in the rapidly growing urban areas of the developing and emerging countries in different climatic zones.

The chair of solid waste management and exhaust air develops solutions ranging from waste avoidance to routes for material recycling and energy exploitation of waste, and their environmentally friendly disposal, including controlling the resulting emissions. Waste management is interdisciplinarily embedded in both a
scientific-technical and socio-economic context. Here, too, international cooperation projects are highly valued, but also regional integration, e.g. via the Kompetenzzentrum Umwelttechnik – KURS e.V. (Competence Centre Environmental Engineering).

The chair of Hydrochemistry and Hydrobiology in Sanitary Engineering addresses questions on sanitary engineering and solid waste management using natural scientific methods. In particular, the occurrence and behaviour of environmental chemicals (e.g. eliminability, accumulation, mobility) in surface waters and groundwater, in water and wastewater treatment, as well as in soil and waste, are investigated. Moreover, analytical quality assurance takes a high priority. The close association of interdisciplinary research, teaching and practice in all areas of our institute is achieved by a constant discourse with external partners and research facilities as well as with clients, public and private facilities. Beside work on research and development projects, we offer external partners numerous services, consulting and expert’s advisory services as well as continuing education programmes.

The professors of ISWA together with their colleagues from IWS founded the „Wasserforschungszentrum Stuttgart“ - wfz (Water Research Center Stuttgart) end of 2007. The wfz is an international engineering center for water research that supports and interdisciplinarily networks teaching (academic studies), instruction (PhD students), research and practice.
# Institute for Sanitary Engineering, Water Quality and Solid Waste Management

**Managing Director:**

- o. Prof. Dr. rer. nat. habil. Jörg W. Metzger

**Board of Management:**

- Full professors — Department Heads
- Manager of the Waste Water Treatment Plant — Head of Administrativ Office

---

## Chair of Sanitary Engineering and Water Recycling

- **o. Prof. Dr.-Ing. Heidrun Steinmetz**

<table>
<thead>
<tr>
<th>Wastewater Technology</th>
<th>Industrial Water and Wastewater Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dipl.-Ing. Carsten Meyer, Regierungsbauinspektor</td>
<td>Prof. Dr.-Ing. Uwe Menzel, Akad. Direktor</td>
</tr>
<tr>
<td>Urban Drainage</td>
<td>Water Quality Management and Water Supply</td>
</tr>
</tbody>
</table>

## Chair of Waste Management and Emissions

- **o. Prof. Dr.-Ing. Martin Kranert**

<table>
<thead>
<tr>
<th>Biological Air Purification</th>
<th>Solid Waste Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof. Dr. rer. nat. Karl-Heinrich Engesser</td>
<td>Dr.-Ing. Klaus Fischer</td>
</tr>
<tr>
<td>Hazardous Waste and Contaminated Sites</td>
<td>Measuring in Air Pollution Control</td>
</tr>
<tr>
<td>Prof. Dr.-Ing. Erwin Thomanetz, Akad. Oberrat</td>
<td>Dr.-Ing. Martin Reiser, Akad. Oberrat</td>
</tr>
<tr>
<td>Dipl.-Ing. Gerold Hafner</td>
<td></td>
</tr>
</tbody>
</table>

## Chair of Hydrochemistry and Hydrobiology

- **o. Prof. Dr. rer. nat. habil Jörg W. Metzger**

<table>
<thead>
<tr>
<th>Hydrochemistry</th>
<th>Biology</th>
</tr>
</thead>
<tbody>
<tr>
<td>o. Prof. Dr. rer. nat. habil Jörg W. Metzger</td>
<td>Dr. rer. nat. Bertram Kuch, Akad. Rat</td>
</tr>
<tr>
<td></td>
<td>Dr.-Ing. Wolf-Rüdiger Müller, Akad. Oberrat</td>
</tr>
</tbody>
</table>

**Demonstration and Research Wastewater Treatment Plant**

- Dipl.-Ing. Peter Maurer

**Administrative Office ISWA**

- Dipl.-Ing. Stephan Mollweide, Akad. Oberrat

www.iswa.uni-stuttgart.de
Chair of Sanitary Engineering and Water Recycling

Research

The Chair of Sanitary Engineering and Water Recycling is engaged in a wide spectrum of activities both in the fields of fundamental and applied research. The activities also include consulting of state and municipal authorities, as well as contract research on behalf of private, industrial and public clients.

The Chair’s four departments “Wastewater Engineering”, “Industrial Water and Wastewater Technology”, “Urban Drainage” and “Water Quality Management and Water Supply” have individual core competencies and cooperate closely in order to achieve the goals of modern sanitary engineering and water management, that is achieving high levels of comfort in water supply and wastewater disposal and equally applying the best possible practice in terms of water protection, sustainable resources management and energy management.

Being integrated in expertise networks and participating in standardization committees, trade associations and professional bodies, the Chair has many national and international contacts and collaborates with public and industrial research institutions both in Germany and abroad.

Main focus of the activities of the department "Wastewater Engineering" (AWT) is the optimisation and development of methods for biological and advanced wastewater treatment. Special emphasis is put on anaerobic treatment, measurement and control technologies, wastewater disinfection, wastewater recycling and membrane technology. Aiming at contributing to the goal of sustainable water supply and wastewater disposal the department investigates and proves future-oriented concepts and technologies to minimise energy consumption in wastewater treatment plants by using alternative energy sources, and to recover valuable materials and nutrients from the material flows in wastewater treatment processes. Customised water reuse concepts are designed for worldwide application, and dimensioning principles are developed in order to use existing technologies in other climatic regions, e.g. in the tropics. Highly practice oriented is also the offered non-committed performance evaluation of wastewater treatment plants, as well as the evaluation of individual process steps, e.g. oxygen supply in aeration tanks.

The department “Industrial Water and Wastewater Technology” (IWT) deals with all problems related to process and production-integrated environmental protection, as well as minimisation of industrial emissions via internal recirculation and treatment of process wastewater, also at international level. Due to systematic approach and many years of experience, it is possible to provide customers from various industry branches with a wide range of solutions to improve their environmental and economical potential. Main focus is put on consulting clients from the textile finishing industry, paper industry, catering and food industry, cosmetics and pharmaceutical industry, chemical, metal and automobile industry. Besides internal, decentralised solutions, the department also develops centralised solutions for advanced co-treatment of pre-treated industrial wastewater at municipal wastewater treatment plants. Therefore, antecedent aerobic and anaerobic biological degradation tests are carried out. Further focus of the work is the treatment of landfill leachate by means of biological and physico-chemical processes. For example, customised modular processes are developed for the aftercare of landfills at reduced levels of leachate and pollutant concentrations. In this respect, the use of activated carbon adsorption and membrane technology plays an essential role. The IWT department also deals with topics such as recycling of water and valuable materials, as well as conservation of resources. For instance, the department offers an expert’s assessment of the suitability to use industrial residues as alternative fuel in the cement industry, as well as co-incineration of sewage sludge in cement plants. In an official testing laboratory neutral performance evaluations of plants are carried out to reduce hydrocarbons in wastewater containing mineral oil.

In 2009 the department of „Urban Drainage“ was founded. Research and consulting activities focus on the development of drainage concepts, stormwater drainage and treatment, real-time control strategies for drainage systems and infiltration water management. A topic of rising importance is heat recovery from sewer systems. Main methods in all research projects are monitoring of rainfall, flow rate and runoff quality in drainage systems as well as simulation of the rainfall-runoff process and the associated pollutant transport.

The department „Water Quality Management and Water Supply“ (WGW) works on researching and modeling the water quality status of flowing and stagnant waters. Special emphasis is put on the effect of water saving measures, measures related to the rainwater harvesting, as well as on the influence of residual pollution loads from treated municipal and industrial wastewater and agricultural sources. Significant importance has the work related to preventive protection of drinking water resources such as the research of the input pathways of pesticides in surface waters and the interaction of wastewater pre-treatment processes and wastewater management practices in in-
distry with the wastewater treatment processes at municipal wastewater treatment plants. The department has special expertise in modeling and simulating the behavior of industrial indirect discharge during the wastewater transport and co-treatment in municipal wastewater treatment plants. Further focus is the development of a process technology, ecologically and economically optimised water recycling and wastewater pre-treatment approaches in a variety of different industry branches such as textile finishing, leather, paper, dairy, pharmaceutical, chemical and beverage industries. The department is very active in the area of transfer, adaptation and implementation of drinking water and wastewater treatment technologies in Southeast Asia (India, China, Vietnam).

Another issue handled in the field of water supply is the subterranean treatment of groundwater for the removal of iron, manganese, arsenic and nitrification. The department also investigates the application of membrane technology, advanced oxidation and anaerobic-biological processes for the treatment of drinking water and process water for industrial purposes. In addition, WGW deals with all problems related to transport, storage and distribution of drinking water, e.g. the hygienic problems that may arise as a result of long hydraulic residence time in the public water supply network.

Courses and Lectures

Chair professors, assistant professors and researchers supervise students in the following courses:

- In the basic course "Sanitary Engineering" and in the specialised courses "Water Quality and Water Supply" and "Wastewater Technology" for German graduands of the civil engineering course. Thereby, the following core lectures are offered: "Water Quality Management", "Water Treatment", "Design of Water Treatment Plants", "Construction and Operation of Sewer Systems", "Highly Efficient Biological Wastewater Treatment", "Industrial Wastewater", "Design of Wastewater Treatment Plants" as well as "Sewer Systems and Stormwater Treatment". Besides, the following complementary courses are offered: "Water Supply in Remote Areas", "Practical Work on Location for Water Quality and Water Supply", "Water Supply Networks", "Control and Simulation of Wastewater Treatment Plants", Monitoring and Operation of Wastewater Treatment Plants" and "Practical Work on Wastewater Treatment Plants".

- In the basic courses "Water Management I" and "Sanitary Engineering, Disposal Techniques I" for German graduands of the environmental engineering course. The main course is divided into three specialised areas: "Water Supply and Water Quality Management", "Wastewater Treatment" and "Industrial Wastewater" along with numerous core and complementary lectures.

- In the Master-Program Infrastructure Planning in English language in the courses "Water Supply and Water Distribution", "Water Quality Management", "Wastewater Technology" and "Water Treatment".

- In the Master-Program Water Resources Engineering and Management (WAREM) oriented for foreign students with "Water Quality Management", "Waste Water Technology", Biological and Advanced Wastewater Treatment", "Water Supply and Water Distribution" as well as "Water Treatment" and as optional lectures "Design of Sewer Systems and Stormwater Treatment", "Treatment of Industrial Wastewater" as well as "Water Quality Measurements on Location".

- In the Master-Program Air Quality Control, Solid Waste and Waste Water Process Engineering (WASTE) oriented for foreign students with core and optional lectures in all fields of domestic and industrial wastewater disposal and treatment as well as of water quality and management.

- In Curitiba/Brazil, the Master-Program "EDUBRASMAUI" (Meio Ambient Urbano e Rural – Domestic and Industrial Environment Protection) was introduced by the department IWT with German standards and co-ordination. In this new Master-Program, Brazilian students are qualified in the scope of the German Program "Study Proposals by German Faculties Overseas", sponsored by the German Academic Exchange Service (DAAD). The title "Master of Science" shall be acknowledged in Brazil and Germany and its accreditation shall be aimed.

Furthermore, some lectures are offered for students of process engineering. The proposed lectures are completed by various excursions of one or more days, practical works as well as by the periodic seminar "Wastewater Technology" and "Water Supply and Water Quality Management".

Beside the education of students from different programs of study, this chair is also integrated in a structured education of postgraduates, in the International Doctoral Program in the field of "Environment Water" (ENWAT). The ENWAT program aims to thoroughly prepare doctoral students for their dissertation.
research through classes and workshops taught by faculty, mandatory participation in a seminar where research progress is discussed with all ENWAT doctoral students and supervisors, and the recruiting of a co-advisor, as well as the preparation of a research proposal and framework early in the program.

By means of seminars and colloquia, a high number of events for continuing education are offered. These are preferably organised in co-operation with DWA, DVGW and BWK. Other events to be emphasised are the periodic colloquia for Wastewater Treatment and Potable Water, the course for Water Sampling by order of The Ministry for Environment of Baden-Württemberg as well as the lectures in the scope of the correspondence course "Water and Environment" at the Bauhaus Universität Weimar.

The chair’s international activities continuously increase in importance. Apart from the Master-Programm "EDUBRAS-MAUI", the department IWT offers other courses internationally. In the scope of the Program "Export of German Study Proposals" of the model project "Study Proposals on Environmental Engineering in Brazil – Summer School" by DAAD, classes are offered during three weeks in different Federal States of Brazil.

Last but not least, the supervision of study seminars, independent studies, master theses and design works is an important aspect for the formation of junior researchers.

Excursion with international students to decentralized stormwater discharge and infiltration facilities; here open channel in a housing area
Dissertations


Publications


Contact

o. Prof. Dr.-Ing. Heidrun Steinmetz
Tel.: +49 (0)711/685-63723
Fax: +49 (0)711/685-63729
E-Mail: heidrun.steinmetz@iswa.uni-stuttgart.de

Secretary’s office

Gabriele Glaßmann
Tel.: +49 (0)711/685-63711
Fax: +49 (0)711/685-63729
E-Mail: gabriele.glassmann@iswa.uni-stuttgart.de

Dörte Hahn
Tel.: +49 (0)711/685-63721
Fax: +49 (0)711/685-63729
E-Mail: doerte.hahn@iswa.uni-stuttgart.de

Wastewater Technology

Dipl.-Ing. Carsten Meyer, Reg.Baumeister
Tel.: +49 (0)711 / 685-63754
Fax: +49 (0)711 / 685-63729
E-Mail: carsten.meyer@iswa.uni-stuttgart.de

Industrial Water and Wastewater Technology

Prof. Dr.-Ing. Uwe Menzel, Akad. Direktor
Professor coláborador (Universidade Blumenau)
Tel.: +49 (0)711/685-65417
Fax: +49 (0)711/685-63729
E-Mail: uwe.menzel@iswa.uni-stuttgart.de

Urban Drainage

Dr.-Ing. Ulrich Dittmer, Akad. Rat
Tel.: +49 (0)711 / 685-65420
Fax: +49 (0)711 / 685-67637
E-Mail: ulrich.dittmer@iswa.uni-stuttgart.de

Water Quality Management and Water Supply

Dipl.-Ing. Ralf Minke, Akad. Oberrat
Tel.: +49 (0)711/685-65423
Fax: +49 (0)711/685-63729
E-Mail: ralf.minke@iswa.uni-stuttgart.de


Our working department „Wastewater Engineering“ teaches, researches and advises on the diverse field of municipal wastewater treatment.

Main research topics:

- Membrane processes for wastewater treatment and water reuse
- Elimination of persistent organic pollutants
- Use of fuel cell technology at wastewater treatment plants
- Biogenic hydrogen production
- Process and plant optimisation
- Nutrients recovery from sewage sludge
- Treatment of process water from sludge treatment
- Biological wastewater treatment in fixed-bed reactors
- Infiltration water in municipal wastewater treatment plants
- Methods for wastewater disinfection
- Decentralized wastewater treatment processes
- Concepts of integrated urban water management

Main focus of our activities is the academic training of students in the field of sanitary environmental engineering, the research on current issues in wastewater technology, education and training of personnel for wastewater treatment plants and sewerage networks, as well as independent consulting of plant operators and engineering companies regarding all aspects of the operation and planning of wastewater treatment plants. The aim of our training, consulting and research activities is to achieve a sustainable water resources protection, by taking economic aspects into account as well.

Our department contributed to significant developments in the wastewater treatment field in Germany. For example, in 1982, the first experiments on the separation of activated sludge by membranes took place here. This method has considerably increased its importance later on. In research projects we deal with the application of membrane technology for the retention of pathogens and persistent organic pollutants.

Besides improvement of the treatment efficiency of the sewage treatment plants, we are developing and testing strategies for the future use of energy and material flows in settlement areas. The feasibility of closing energy and material flow circuits are both subject of fundamental, as well as applied research. Current research topics include the production of secondary fuels, such as hydrogen from wastewater and the recovery of resources, such as phosphorus from sewage sludge.

But we also deal with problems related to the daily wastewater practice, such as the impact of infiltration water on the operation of wastewater treatment plants or the optimisation of phosphorus elimination. Therefore we provide concepts and solutions.

In addition, the department has a certified test field for small wastewater treatment plants according to DIN EN 12566-3 and the requirements of the Deutsches Institut für Bautechnik.
We also carry out a wide range of educational activities and advanced training of foreign and local wastewater specialists. The long-term goal of our training courses is to enable the foreign WWTP personnel to achieve the same level of qualification as it is common in Germany. Hence, the continuously improving technical standards of foreign wastewater treatment plants can only be optimally used by properly qualified personnel. This training is also of great importance for opening up new markets for German companies, due to the fact that approved German technologies are communicated within the framework of such educational activities.

Projects

Development of a treatment process for nanofiltration and reverse osmosis concentrates from industrial waste waters (paper mill sewage treatment)

The papermaking industry is one of the biggest water consumers in Germany and also in the world. Through recirculation, reuse and saving methods the consumption could be drastically reduced up to 10,4 l/kg produced paper (2007) in the last few decades. However, there remains a great potential in the closure of internal process water cycles and the associated possibility of saving fresh water. The elimination of suspended solids is already realized by the flotation process, filtration and sedimentation. Dissolved substances, which disturb the process of paper making, can not be eliminated through this procedure. Here the use of membrane technology can find application. This failed mainly because of the expensive disposal of the nanofiltration- and reverse osmosis concentrates. In this research project a treatment concept for the retentates will be developed. The study examines various wastewater treatment processes in different sequences. In addition to aerobic and anaerobic treatment, oxidation methods like Ozonation and Fenton Process (Hydrogen peroxide & iron as a catalyst) will be applied. The advantages of anaerobic treatment are little sludge production, no use of energy for aeration and the production of biogas which can be used for energy recovery, is one of the main processes. The aerobic purification process is required to reach the desired outflow values for the cleaned wastewater. Oxidative cleaning processes can eliminate resistant compounds on one hand. On the other hand the BOD5/COD-ratio can be increased through Ozonation or Fenton process. The main goal of the research project is to develop a suitable adaption of each process and to find out an appropriate order of each process to clean the retentates.

Funding:
Willi-Hager-Stiftung

Funding Period:
07/2008 - 06/2011

Responsible Person:
Prof. Dr.-Ing. Heidrun Steinmetz

Project coordinator:
Dipl.-Ing. R. Minke, AOR

Contact Persons:
Dipl.-Ing. C. Locher
Dipl.-Ing. S. Tews

Internet:
http://www.iswa.uni-stuttgart.de/awt/forschung/index.html

Figure: Scheme of the paper industry wastewater treatment processes
Investigations on Nutrient Recovery from Anaerobic Digestion Residues with Different Compositions

The goal of the project is to investigate the feasibility of using struvite precipitation to recover nutrients from digestion residues. The investigation mainly consists of laboratory scale experiments and comparative evaluations using computer applications. Practical investigations have been completed within the past months and the project is currently in the evaluation phase.

The practical investigations were conducted by two institutions. Ortadogu Teknik Üniversitesi operated laboratory scale batch anaerobic reactors for the digestion of poultry manure and wastewater treatment plant sludge mixtures in different ratios, and conducted struvite precipitation experiments in both solid and fluid phases of digestion residues. The resulting products were examined using microscope and X-ray diffraction techniques. Additionally, the concentrations of N, P, Mg and other significant metals were determined to create a mass balance. In the first phase of the project the University of Stuttgart conducted struvite precipitation experiments in synthesised digestion liquor in order to understand the system and determine the mechanisms. Meanwhile, the results were transferred onto a chemical model together with the chemical data from the analyses of the partner institution to estimate the potential reactions in the investigated complex type of process waters. The modelling phase was followed by a short verification phase applying struvite formation on real digestion residues. The resulting products were also examined as mentioned above.

The cooperation intended to support the scientific exchange between the partner institutions. One Master’s Thesis and one Diploma work were created within the project. A close collaboration was performed by visits from both institutions, enabling an ambilateral exchange of experience.

Funding:
Internationales Büro des Bundesministerium für Bildung und Forschung

Funding Period:
02/2008 - 01/2010

Project partner:
Ortadogu Teknik Üniversitesi (Ankara, Türkei)

Project Manager:
Prof. Dr.-Ing. H. Steinmetz und Prof. Dr. G. Demirer

Contact Person:
D. Antakyali, M.Sc.

Internet:
http://www.iswa.uni-stuttgart.de/awt/en/research_current.html#intenC
Biological hydrogen production from organic substrates in the biological wastewater treatment

The investigations within the scope of this research project demonstrated the following fundamental and process related results:
Continuous pH regulation results in higher hydrogen production yield than sole initial pH adjustment. In the first case, the optimum pH is 6.5.
Complete utilization of the substrate is only possible when the bacterial metabolic pathways are not inhibited by very low pH (lower than 6.0). The composition of a suitable nutrient solution has to be carefully selected, otherwise it may induce an inhibition of the biocenosis which leads to a decrease of the hydrogen production yield.
Sodium, magnesium and iron have been indentified to influence hydrogen production the most.
Under the optimum experimentally derived conditions (continuous pH control, pH = 6.5, substrate concentration 15 g/L, no addition of extra nutrients) the highest yield was found to be 2.48 mol H₂ per mol hexose. Comparatively high yields were also acquired for substrate concentration of 20 g/L under the same experimental conditions. These values correspond to F:M ratios between 2,5 g hexose / g VS and 4,5 g hexose / g VS.
Batch experiments with composite substrates demonstrated the suitability of wastewater originating from sugar industry. As optimum marginal conditions pH equal to 6 and F:M equal to 12:1 g COD / g VS were acquired.
Investigations with primary and secondary sludge exhibited hydrogen production only in trace quantities. Prerequisite in all cases was the substrate pre-treatment by acidification or heating for inhibition of methanogenesis and solubility of the substrate. The usage of brewery wastewater as substrate leads also to hydrogen production in trace quantities. The applied F:M ratios due to substrate nature were too low.
The results of the batch experiments indicate that there is a potential of continuous hydrogen production. Though, for high process performance and hence for the optimization of energy production on wastewater treatment plants further experimental investigations in lab-scale are required.

Funding:
Umweltministerium Baden-Württemberg
Project Manager:
Prof. Dr.-Ing. Heidrun Steinmetz
Project Coordinator:
Dr.-Ing. J. Krampe, AOR
Funding Period:
03/2007 – 03/2009
Contact Person:
Iosif Mariakakis, M.Sc.
Internet:
http://www.iswa.uni-stuttgart.de/awt/en/research_completed.html#hydrogen

Figure: F/M ratios with and without addition of nutrients
A 2-stage concept for fermentative hydrogen and biogas production by means of an innovative gas treatment

Worldwide, the energy demand is still predominantly supplied from fossil fuels. Increasing energy consumption, limited natural resources and global warming, as a result of the excessive CO₂ emissions connected with the burning of fossil fuels, require the development of alternative methods for energy production. Fuel cells that use hydrogen as a fuel are a promising alternative for energy production. However, current methods for hydrogen production are still quite energy-consuming. For this reason, biological production of hydrogen is investigated as a possible alternative.

Aim of the project is the production of bio-hydrogen and biogas by means of an innovative technique for gas separation (IFK). The process should be carried out in a two-stage anaerobic fermentation process. As an alternative, bio-polymers instead of biogas could be produced. At the first stage the substrate originating from biological wastewater treatment processes is transformed by incomplete fermentation to hydrogen. The end-products of the first incomplete fermentation can be further fermented at a second stage to produce biogas or biopolymers. The produced gas of both stages is treated by means of special ion-exchangers, which separate CO₂ from the corresponding gas mixture, at ambient pressure. The upgraded pure hydrogen can be used as fuel in public traffic while the pure biogas can be injected into the biogas network. During the gas-separation process heat is emitted, which can be utilized for the heating of the fermenters and contribute to the self-sufficiency of the whole process.

The production of almost pure CO₂ during the regeneration process of the ion-exchangers is another advantage. This CO₂ can be returned into the reactor of the first stage for the reduction of the partial pressure of hydrogen down to equilibrium concentrations (10⁻³ bar – 10⁻⁴ bar) for the improvement of the hydrogen yield.

Within the scope of lab-scale experiments, various substrates originating from wastewater treatment will be tested for their suitability for bio-hydrogen production and their corresponding end-products for biogas and biopolymer production. Herewith, the influence of the boundary conditions (e.g. pH, partial pressure of hydrogen, required CO₂ quantities for stripping, nutrients, solids retention time, loading of the fermenters, substrate composition) on these biological processes should be investigated. The major aim is the maximisation of the yields of each process.

Funding:
Bundesministerium für Bildung und Forschung (BMBF)
Funding Duration:
03/2009 - 02/2012
Project Partner:
Institut für Feuerungs- und Kraftwerkstechnik (IFK), Universität Stuttgart
EnBW AG
Purolite Deutschland GmbH
RBS wave GmbH
Project Manager:
Prof. Dr.-Ing. H. Steinmetz
Project Coordinator:
Dipl.-Ing. RBM C. Meyer
Contact Person:
Iosif Mariakakis, M.Sc.
Internet:
http://www.iswa.uni-stuttgart.de/awt/en/research_current.html#hydrogen2

Figure: Scheme of process
Development of a mobile treatment plant for the biological purification of black water in camping vehicles and boats as well as the development of an inspection process and analysis of the treatment plant performance

In mobile toilets for camping vehicles and boats, chemical products are mainly used to liquify feces (black water). This provides the possibility of storage and disposal of the produced black water. In addition to the application of chemicals, this concept has some disadvantages: dependency on chemicals, odours, unpleasant handling of the faecal tanks.

The project partner HRZ has developed in the last years a chemical-free liquefying unit ('Aqualizer') which simultaneously acts as a pre-treatment step for the black water storage. This process depends on a bacteria/enzyme mixture. Next, the black water is liquefied in Aqualizer and further pre-treated aerobically. The self-developed biocenosis should be able to endure variations in influencing parameters such as: temperature variations, shock loads and no load periods. The investigation of the necessary boundary conditions and operational settings is the core objective of the University of Stuttgart part in the project. In comparison to conventional treatment plants, blackwater will be treated on its own. Such a process with a low space requirement and a discontinuous operation mode provides a big challenge to be fulfilled. Until today, it is not known how an adapted biocenosis will react to variations in operational parameters and extreme conditions with the maintenance of stable effluent values.

The aim of the project is to achieve the highest cleaning performance of the plant that corresponds to the legal requirements of the wastewater law, where the elimination of carbon compounds is the main priority. In addition, technical expertise of possible methods of nitrogen elimination should be gained.

The achievement of a treatment performance by the mobile treatment plant will allow the potential discharge of the effluent in the grey water tank, water bodies, and soil accordingly.

Funding:
Bundesministerium für Wirtschaft und Technologie

Funding Duration:
08/2008 - 07/2010

Project Partner:
HRZ Reisemobile GmbH

Project Manager:
Prof. Dr.-Ing. H. Steinmetz

Projektkoordinator:
Dipl.-Ing. RBM C. Meyer

Contact Person:
Karen Mouarkech, M.Sc.

Internet:
http://www.iswa.uni-stuttgart.de/awt/en/research_current.html#blackwater

Figure: Test rig with Aqualizer unit
Research for further P-elimination in Stuttgart’s wastewater treatment plants in the Neckar catchment area in the context of implementing the WFD

As part of the EU Water Framework Directive (WFD) implementation in the Neckar catchment area, a study was based and prepared at the Institute for Sanitary Engineering, Water Quality and Solid Waste Management (ISWA), covering the major wastewater treatment plants in the Neckar catchment area and dealing with more stringent requirements for the discharged phosphorus load.

Therefore, on behalf of the Stuttgart city drainage company (SES), it was investigated which total phosphorus (Ptot) monitoring values at the wastewater treatment plants outside Stuttgart can be met without introducing any additional procedural steps for phosphorus removal. For the group of wastewater treatment plants WWTP Ditzingen and WWTP Plieningen detailed studies are conducted, whose results are transferred to the sewage treatment plant Möhringen.

As a first step, the daily operation records of the treatment plant from years 2007 and 2008 were reviewed. It was found that, for both particulate and dissolved organic phosphorus compounds at the outflow of the treatment plants, no additional action was needed because the measured concentrations were in the expected range. Accordingly, the existing scope for action was primarily in a reduction of the o-phosphate concentration in the effluent of the wastewater treatment plants.

For rapid and systematic implementation of the studies, a statistical method was developed at ISWA for the analysis of routinely collected data and, therefore, improvement of the available phosphorus data, which provides reliable and comparable results to evaluate the achievable Ptot concentrations.

Key point of the evaluation is the verifiable statistical independence of the o-phosphate concentrations of the remaining phosphate fractions, i.e. essentially the particulate and dissolved organic phosphate compounds. The coupling of high-resolution data on the o-phosphate concentrations in the effluent of the activated sludge process with a probability distribution of these remaining phosphate fractions, taken from the operation diaries of 2007 and 2008, lead to high-resolution probability values for Ptot concentrations in the effluent. As agreed with SES, the goal was to reach a 90% probability of compliance with the monitoring values in the qualified sample. In the analysis of the data, the proportion of the collected high-resolution data points, which do not meet this requirement, was increased. This parameter is used as a comparison between the various stages of investigation and allows making conclusions on compliance with various assumed surveillance values.

Prerequisite for the application of the developed evaluation method is, firstly, the likelihood of giving accurate high-resolution o-phosphate values. The data will be collected online for the wastewater treatment plants outside Stuttgart at the outflow of the activated sludge tanks. The quality of the data for the group of wastewater treatment plants Ditzingen and WWTP Plieningen has been considered sufficient. In the case of WWTP Ditzingen, however, the o-phosphate concentration values after the secondary sedimentation increased, which was considered with an impact factor. The second prerequisite for the application of the method lies in the comparability of the probability distribution of the remaining phosphate fractions between measurements campaign and the operation diaries 2007-2008. These are the adequate measures taken for the wastewater treatment plants.

With the help of the developed statistical methods, it was shown that, in the case of the group of wastewater treatment plants Ditzingen, compliance with the stringent monitoring values is possible with a very high probability, without any additional procedural steps, only by an appropriate dosage of a precipitation agent. Regarding the WWTP Plieningen, it can be concluded that a significant increase of the phosphorus monitoring value can be accomplished without a problem.

Funding:
Eigenbetrieb Stadtentwässerung Stuttgart

Funding Duration:
01/2009 - 12/2009

Project Manager:
Prof. Dr.-Ing. H. Steinmetz

Project Coordinator:
Dipl.-Ing. RBM C. Meyer

Contact Person:
Dipl.-Ing. Andreas Neft, Dipl.-Ing. Sabine Schmidt
Figure: Proportion of samples in which different $P_{\text{tot}}$-limit values of $x$ mg P/L is not sufficiently likely to be met with 90% probability of compliance (GKW Ditzingen)
**Examinations to improve the hygienic river quality of the Koersch**

The determination of significant anthropogenic pollutions and the evaluation of their effects on the ecological current state of the surface water are an important part of the European Union water framework directive (2000/60/EG). The causes for poor quality (hygienic) of river water are mainly anthropogenic loads, first of all sewage discharges. These degrade the river water hygienic-biologically as well as optically (e.g. by foam formation, sanitary products etc.).

The Koersch is a small river south of the Stuttgart metropolitan area and an important inflow into the Neckar. It is significantly affected by anthropogenic sources, 2 wastewater treatment plants and 52 stormwater overflow tanks (only within the boarders of Stuttgart City). Under the scope of this research project microbiological examinations of the river Koersch, the discharges from certain stormwater overflow tanks and the two wastewater treatment plants Stuttgart-Moehringen and Stuttgart-Plieningen were to be carried out. The main objective of this investigation was to identify the major sources of pathogen entry into the river during both dry and rainy weather conditions. The results were then used to suggest technical measures to reduce the pathogen entry, as well as to simulate the polluting load.

After the examination, the impact of the sewage became obvious during dry weather periods (discharges from the first wastewater treatment plant), as well as by rainy weather periods (discharges from the sewage overflow tanks). The concentrations of the pathogens in the river were higher at rainy weather than that at dry weather by 1 to 2 orders of magnitude.

The results show that in addition to the effluents from wastewater treatment plants and stormwater overflow tanks, diffuse pollution is also a significant source of hygienic pollution of surface water. River sections were heavily burdened even without wastewater entry and did not meet the requirements of the EU Bathing Water Directive (2006/7/EC). Additionally, under dry weather conditions, wastewater treatment plants were responsible for high pathogen concentrations. Effluents from wastewater treatment plants with advanced treatment steps, such as sand filtration, resulted in some dilution of pathogen concentrations in rivers. However, the EU Bathing Water Directive criteria were still not met. During rainy weather conditions, the effluents from stormwater overflow tanks then produced peaks in the hygienic load in the rivers. Hence, the efficiency of advanced wastewater treatment steps is to be critically evaluated when a simultaneous reduction of diffuse pollution cannot be achieved.

![Figure: Escherichia coli concentrations of the Koersch as well as the confluences Steinbach and Ramsbach and the discharges of municipal wastewater at dry and rainy weather conditions](image_url)
Microwave-generated plasma-UV-light for disinfection of wastewater/water

Municipal wastewater contains a large number of microorganisms even after biological treatment, including pathogens (bacteria, viruses, parasites). However, in Germany there are no limit values which are to be kept in the discharge from municipal wastewater plants. Depending on the type and utilisation of treated wastewater and receiving water bodies (e.g. service water, bathing water), a disinfection might be required. The spectrum of the ultraviolet rays accounts for the killing and inactivating of bacteria, viruses and protozoans. The aim of the project was to develop and investigate a source of UV light with radiation emissions within the range of 200 - 300 nm and to figure out whether the disinfection could be considerably improved through the plasma-UV-technology compared to conventional UV-techniques. The feasibility should be tested by ISWA at the effluent of a wastewater treatment plant. The new developed technology should be tested under practical operating conditions with regard to the operating stability. UV-Lamps with compounds of xenon-bromide and xenon-iodide were tested. None of the analysed parameters (typical wastewater parameters and micropollutants) were decreased by the new UV source. The elimination of pathogens was also insufficient with maximum two orders of magnitude. The novel plasma-UV-technology requires further development and investigation before a market-ready technology is available. Some improvements and long-running tests are necessary with measurements of the irradiation intensity. The operational reliability must be inspected as well.

Funding:
Bundesministerium für Bildung und Forschung (BMBF)
Funding Duration:
08/2006 - 07/2009
Project Partner:
Fraunhofer Institute for chemical technology (ICT), Pfinztal;
Institute of Functional Interfaces (IFG), Karlsruhe Institute of Technology;
H. Popp Matlab GmbH, Berg;
Muegge Electronic GmbH, Reichelsheim;
WEDECO AG Water Technology, Herford;
WEDECO AG UV-Light, Essen
Project Manager:
Prof. Dr.-Ing. H. Steinmetz
Project Coordinator:
Dr.-Ing. J. Krampe, AOR, Dipl.-Ing. RBM C. Meyer
Contact Person:
Dr.-Ing. J. Gasse
Internet:
http://www.iswa.uni-stuttgart.de/awt/forschung/forschung_mikrowellenplasma.html
MODULAARE: Integrated Modules for Efficient Wastewater Treatment, Solid Waste Disposal and Regenerative Energy Recovery in Tourist Resorts

Tourism is a rapidly growing sector and sustainability in tourism requires an environmentally conscious management. Particularly in arid provinces, large amounts of water required for the irrigation may constitute a problem. Preferred regions often include naturally vulnerable areas in which hotels or holiday villages are located far from central infrastructure, such as wastewater treatment plants and landfills. The transport of wastes to central systems is a costly process. On one hand’s side, large amounts of wastewater and solid waste are produced due to increased needs on holiday, on the other side wastewater, even though polluted, constitutes an important water resource and can be reused if properly treated.

In this context, an innovative, decentralised and modular concept for wastewater treatment, solid waste disposal and energy production was developed. The concept was applied within the framework of a research project (MODULAARE) and conducted by a consortium including University of Stuttgart. The emphasis of the project was placed on the practical and economical feasibility of the concept. Thus for the implementation of the project a Turkish tourist resort connected to a municipal waste water treatment plant has been selected as pilot hotel. A pilot plant combining wastewater treatment and solid waste processing were installed and operated. A simple laboratory was established in the hotel grounds.

The modular pilot plant combined a membrane bioreactor for wastewater recycling with a digester unit for energy recovery out of organic waste from the kitchen and green areas as well as the excess sludge of the membrane bioreactor.

The wastewater module was constructed in a cargo container in Germany and then transported to the hotel at the beginning of the summer season 2005. The process was based on a low loaded membrane bioreactor consisting of several steps to remove nitrogen and carbonaceous substances and ending with membrane filtration. Wastewater produced in the hotel is collected in a central shaft and only a small part of it is brought to the plant (7 m³/d - 10 m³/d). After being stored in a mass balancing tank, wastewater was pumped into a primary sedimentation unit. This was followed by separate anoxic and aerobic zones, interconnected by a recirculation line. Treated wastewater was then permeated through submerged ultrafiltration membranes placed in the aerobic tank and stored in a separate chamber connected to the irrigation pond.

Separate analyses of different wastewater streams
The membrane bioreactor was operated during 3 summer seasons from 2005 to 2007 in the large tourist. Treatment efficiency was monitored through chemical and microbiological analyses. Data related to water use was collected. Specific user values were calculated. Wastewater was analysed in different production points. Acceptance of guests about environmental applications on holiday was investigated.

According to the results, the water consumption in Iberotel remained in average range compared to other given literature. Kitchen and laundry together constituted the largest potable water use station after the garden. A considerably higher water use per guest was observed in low occupancy. Regarding the water use points in the hotel, the most concentrated pollution loads originated from the kitchen, laundry and the rooms. Figure below presents the pollution loads in wastewater from the kitchen, laundry and rooms comparatively. The wastewater of Iberotel in general represented a very concentrated wastewater, differing from common domestic wastewater also with its extremely high solid matter content. Therefore an extra sieve had to be constructed after the first operation season. An efficient wastewater treatment was achieved in membrane bioreactor. COD removal rates were mostly above 98 % where nitrogen removal varied in a wider range between 90 % and 98 %. Besides operational parameters, the heavy metal content was investigated in some permeate samples. All of the measured values remained far below the critical threshold levels of FAO (1992). During microbiological investigations t. coli and e. coli were analysed in 20 permeate samples. All of the measured values remained far below the limit values of EU-directive for bathing and recreational purposes (76/160/EEC), most were smaller than the recommended values. Also according to the WHO guidelines for the use of treated wastewater in agriculture the treated wastewater from the wastewater module was within the acceptable range. Both chemical and microbiological analyses proved the treated wastewater to be “safe to use” for recreational purposes.

The acceptance study presented surprisingly positive results. A significant majority of the participants gave opinions in favour of decentralised processes in holiday resorts and wastewater reuse.

This modular and decentralised system is expected to be suitable for applications in sensitive regions such as tourism regions, coral reefs, islands, coasts, natural parks etc. as well as remote settlements which experience difficulties to get connected to the central systems. Such applications can also help minimising the environmental pollution in naturally valuable regions that do not have the required infrastructure. Due to the modular concept, an adaptation to various places and climatic zones seems to be easily realisable.

The practical phase of the project has been completed in October 2007. Data evaluation is being conducted. The results will show whether such decentralised plants can be operated optimally in terms of both economical issues and quality of secondary products.

Financing institution:
German Ferderal Ministry of Education and Research (BMBF)

Project partner:
• AT-Verband (Verband zur Förderung angepasster, sozial- und umweltverträglicher Technologien e.V.)
• Universität Stuttgart, Institut für Siedlungswasserbau, Wassergüte- und Abfallwirtschaft, Abteilung Siedlungsabfall
• Memos Membranes Modules Systems GmbH
• Bio-Sytem Selecta GmbH
• Iberotel Sarigerme Park, TUI AG - Umweltmanagement

Duration:
10/2003 – 03/2008

Contact:
Demet Antakyali, M.Sc.
Dr.-Ing. Jörg Krampe

Internet:
www.iswa.uni-stuttgart.de/awt/en/research_current.html#modulaare
Independent Studies, Master- and Diploma Thesis

Die gesplitte Abwassergebühr in der Praxis
Frank Wunderlich (Bauingenieurwesen) (2008)
Betreuer: Dipl.-Ing. RBM C. Meyer,
Prof. Dr.-Ing. U. Rott

Cost Functions for Rapid Gravity Filters applied as Pretreatment Option in SWRO Desalination
Sonja Amend (Umwelttechnik) (2008)
Betreuer: Dipl.-Ing. RBM C. Meyer,
Prof. Dr.-Ing. U. Rott

Verwertung von Klärgas - Einsatz einer Schmelzkarbonat-Brennstoffzelle auf der Kläranlage Stuttgart-Möhringen
Marc Gustain (Umwelttechnik) (2008)
Betreuer: Dipl.-Ing. Chr. Locher,
Prof. Dr.-Ing. H. Steinmetz, Dipl.-Ing. RBM C. Meyer

Anwendung der E-PRTR-Verordnung auf kommunalen Kläranlagen über 100000 EW in Baden-Württemberg
Bastian Dommnik (Umwelttechnik) (2008)
Betreuer: Dr.-Ing. J. Krampe,
Prof. Dr.-Ing. H. Steinmetz

Modelling and Simulation of a Trickling Filter under High Temperatures using Simba
Karen Mouarkech (WASTE) (2008)
Betreuer: Prof. Dr.-Ing. H. Steinmetz

Fermentative Hydrogen Produktion: Analysis of the current state of research and comparison to batch experiments with waste water sludge
Unmut Keles (WASTE) (2008)
Betreuer: Dr.-Ing. J. Krampe,
Prof. Dr.-Ing. H. Steinmetz

Corrosion of Pipes in Water Supply and Waste Water Disposal Systems
Odusami Adepapo (WAREM) (2008)
Betreuer: Dr.-Ing. G. Stotz,
Prof. Dr.-Ing. H. Steinmetz

Phosphorrhückgewinnung aus Klärschlämmen
Diyar Tasdelen (Bauingenieurwesen) (2008)
Betreuer: Dipl.-Ing. A. Weidelener,
Prof. Dr.-Ing. H. Steinmetz

Optimierung und Beurteilung der tertiären Stufe (Ozonbehandlung/Biofilter) der Abwasserreinigungsanlage Fa. Lang Papier GmbH, Ettlingen
Anas Benani (2008)
Betreuer: Dr.-Ing. J. Krampe,
Prof. Dr.-Ing. H. Steinmetz

Fermentative Hydrogen Produktion for use cells: evaluation of the energy potential and technical feasibility compared to biogas
Malinka Bogdanova-Solanka (WASTE) (2008)
Betreuer: Dr.-Ing. J. Krampe,
Prof. Dr.-Ing. H. Steinmetz

Identification and Evaluation of Reuse-oriented Treatment Alternatives of Municipal Wastewater in coastal city. Case study: Xiamen Island, China
Xuan You (WAREM) (2008)
Betreuer: Prof. Dr.-Ing. H. Steinmetz

Natural und natural close systems
Nadja Khawaja (WASTE) (2008)
Betreuer: Prof. Dr.-Ing. H. Steinmetz

Biogaseinpressung bei der anaeroben Schlammbehandlung zur Faulbehälterdurchmischung - ein Verfahrensvergleich
Peng Chen (Umwelttechnik) (2008)
Betreuer: Dr.-Ing. G. Stotz,
Prof. Dr.-Ing. H. Steinmetz

Investigations on the composition of recovered Magnesium Ammonium Phosphate (MAP) regarding different wastewater constituents
Gizem Mutlu (WASTE) (2009)
Betreuer: Demet Antakyali, M.Sc., Dr.-Ing. U. Dittmer,
Prof. Dr.-Ing. H. Steinmetz

Modelling of Struvite Formation by Using PhreeqC
Christa Morgenschweis (Umwelttechnik) (2009)
Betreuer: D. Antakyali, M.Sc.,
Dipl.-Ing. RBM C. Meyer, Prof. Dr.-Ing. H. Steinmetz
Biologische Wasserstoffproduktion durch dunkle Fermentation: hemmende und förderliche Wirkstoffe

Maria Tzivanopoulou (Umweltschutztechnik) (2009)
Betreuer: I. Mariakakis, M.Sc., Dipl.-Ing. RBM C. Meyer, Prof. Dr.-Ing. H. Steinmetz

Determinierung von geeigneten Substraten aus Abfall- und Abwasserbehandlungsprozessen für bio-hydrogenproduktion durch dunkle Fermentation unter verschiedenen Prozessbedingungen

Karen Mourakch (WASTE) (2009)
Betreuer: I. Mariakakis, M.Sc., Prof. Dr.-Ing. H. Steinmetz

Investigation, evaluation and optimization of process parameters for the biological aerobic treatment of wastewater streams from the paper making industry

Dominika Krauza (ERASMUS) (2009)
Betreuer: Dipl.-Ing. S. Tews, Prof. Dr.-Ing. habil. Krystyna Olańczuk-Neyman

Hygienische Aspekte der Wiederverwendbarkeit von Abwasser zur Bewässerung nach anaeroben Reinigung und anschließender Nitratfiltration

Dagmar Untereiner (2009)
Betreuer: Prof. Dr. rer. nat. habil. K.-H. Engesser, Prof. Dr.-Ing. H. Steinmetz

Untersuchungen zum Betrieb und zur Bemessung von flachen Tropfkörpern

Ada Lisa Turner (Umweltschutztechnik) (2009)
Betreuer: F. Chui-Pressinotti, M.Sc., Dipl.-Ing. RBM C. Meyer

Untersuchungen zum Einsatz des CAKIR-Verfahrens auf der Kläranlage Weissach

Lutz Achim Walka (Bauingenieurwesen) (2009)
Betreuer: Dr.-Ing. G. Stotz, Dipl.-Ing. Chr. Locher, Prof. Dr.-Ing. H. Steinmetz

Einflussfaktoren auf das Wachstum und die Abbauleistung von Nitrifikanten in einem MBR-System in der Milchwirtschaft

Tamara Junghans (Umweltschutztechnik) (2009)
Betreuer: Prof. Dr. rer. nat. habil. K.-H. Engesser, Prof. Dr.-Ing. H. Steinmetz
Contact

Dipl.-Ing. C. Meyer, Regierungsbaumeister
Tel.:  ++(0)711 / 685 - 63754
Fax:  ++(0)711 / 685 - 63729
E-Mail:  carsten.meyer@iswa.uni-stuttgart.de

Scientists

Demet Antakyali, M.Sc.
Tel.:  ++(0)711 / 685 - 63895
Fax:  ++(0)711 / 685 - 63729
E-Mail:  demet.antakyali@iswa.uni-stuttgart.de

Dr.-Ing. Juliane Gasse
Tel.:  ++(0)711 / 685 - 65410
Fax:  ++(0)711 / 685 - 63729
E-Mail:  juliane.gasse@iswa.uni-stuttgart.de

Dipl.-Ing. Christian Locher
Tel.:  ++(0)711 / 685 - 65422
Fax:  ++(0)711 / 685 - 63729
E-Mail:  christian.locher@iswa.uni-stuttgart.de

Iosif Mariakakis, M.Sc.
Tel.:  ++(0)711 / 685 - 65405
Fax:  ++(0)711 / 685 - 63729
E-Mail:  iosif.mariakakis@iswa.uni-stuttgart.de

Karen Mouarkech, M.Sc.
Tel.:  ++(0)711 / 685 - 63740
Fax:  ++(0)711 / 685 - 63729
E-Mail:  karen.mouarkech@iswa.uni-stuttgart.de

Dipl.-Ing. Sebastian Tews
Tel.:  ++(0)711 / 685 - 65466
Fax:  ++(0)711 / 685 - 63729
E-Mail:  sebastian.tews@iswa.uni-stuttgart.de

Meanwhile quittet:

Dr.-Ing. Jörg Krampe
Fabio Chui Pressinotti, M.Sc.
Dr.-Ing. Alexander Weidelener

Laboratory

Chief:
Heidi Hüneborg
Tel.:  ++(0)711 / 685 - 63728
E-Mail:  heidi.hueneborg@iswa.uni-stuttgart.de

Chemical technical employee

Harald Duvinage
Bärbel Huber
Harald Müller
Industrial Water and Wastewater Technology

Research topics:

- Process and production integrated environmental protection
- Treatment and reuse of process water e.g. in the automobile industry
- Adsorption processes in industrial water and wastewater technology, e.g. in the textile industry
- Reduction of lipophilic substances in the food and cosmetics industries
- Biological and chemo-physical treatment of industrial wastewater
- Aerobic and anaerobic degradation tests
- Testing Centre of the German Institute for Construction Technology (DIBt)
- International Consulting and export-oriented research for example Middle and South America

It will all come out in the wash

At the department IWT (Industrial Water and Wastewater Technology), we specialize in refining internal plant processes and aim at integrating environmental protection as well as minimizing the industrial emissions by implementing a water circulation and plant-internal treatment processes.

We plan environmental moderations for customers in the industrial process as well as integrated solutions in the manufacturing process. The first step we take in order to make a current assessment of the situation at the plant is an on-site inventory survey. According to the survey we can then localize water consumption, wastewater amount and dirt load accrualment points. In order to determine the dirt loads accumulated during the manufacturing process, partial wastewater flows are sampled and the relevant parameters are then analyzed. After consulting with the respective company, the tap water quality required for the production process can be specified, in order to minimize fresh water consumption. This can be done by implementing a water circuit consisting of treated wastewater. Production related water consumption and wastewater volumes are then determined by precise recording of the productions figures. This subsequent changes in the production figures allow precise projections of the associated parameters. Based on the survey and the formulation of goals a customer-specified procedure for wastewater treatment can then be agreed upon, which normally leads to further in-depth tests, such as e.g. determination of biodegradability. Due to our systematic procedures and many years of experience we are able to represent our customers with new sustainable solution and potentials.
We emphasize mainly in offering our professional advice to clients from the textile finishing industry and paper industry, gastronomy- and food-industry, the cosmetic and pharmaceutical industry, the chemical as well as the metal and automobile industry. Alongside plant internal solutions we also create decentral as well as central solutions by developing extensive purification processes for the treatment of industrial wastewater at communal treatment plant. Therefore a series of aerobic and anaerobic biological degradation tests are carried out in advance.

Further emphasis of ours is the treatment of leachate of landfills using biological and chemical-physical processes. For example we are developing adaptable modular processes for the aftercare operations of landfills at reduced leachate levels and toxic concentrations. Therefore the use of carbon adsorption processes and membrane processes play an essential role in our work. Here at the IWT department we also deal with topics such as water and waste recycling as well as saving resources. Exemplary is our expert’s assessment of industrial residues as alternative fuel in the cement industry as well as the sludge incineration in cement plants.

Our department is an official control center of the “Deutsches Institut für Bautechnik (DIBt)” in Berlin which is responsible for controlling plants for the limitation of hydrocarbons in wastewater including mineral oils.

Our department also offers lectures in the following courses: Civil Engineering, Environmental Engineering, Process Engineering, WAREM (Water Resources Engineering and Management) and WASTE (Air Quality Control, Solid Waste and Wastewater Process Engineering).

Our department also offers its courses at different universities abroad, e.g. to Brazil and cooperates with Latin American facilities. Which enables such programs as the cooperation of the Universidade Federal do Parana (UFPR) and the national environmental protection industry Servicio Nacional de Aprendizagen Industrial (SENAI/PR) in Curitiba/ Brazil to create the new Masters program EDUBRAS-MAUI (communal and industrial environmental protection) under management of the IWT Department and under German standards.

Furthermore our Department offers so called “Summer Schools” in the area of environmental protection in various Brazilian states.
Projects

An example of economically, flexible and sustainable treatments based on the case of hazardous wastewater from landfill

The treatment of leakage from landfill with active charcoal is state of the art technology. The goal of this landfill leakage treatment is to reduce the parameter of chemical oxygen demand (COD) and adsorbable organic halogens (AOX). This goal is easily achieved by using activated charcoal. For this procedure it is common to use granulated activated charcoal.

At the Institute for Sanitary Engineering, Water Quality and Solid Waste Management at the University of Stuttgart there was a project called “development of a process for the separation and reuse of powdered activated charcoal (PAC) in the wastewater treatment”, which was sponsored by the BMBF. During the course of this project an extra research topic came up regarding a process that justifies the use of PAC in the landfill leakage treatment according to the variable needs of the landfill operators.

After a landfill is filled and no new waste is allowed to be added, it is normally covered up in order to minimize additional rainwater from seeping in and creating additional leakage. From this point on the amount of land leakage sinks, but at the same time the structure of the leakage changes. Due to the low cost and short usage time it make sense to implement a flexible process that easily adapts itself to the changing amounts of landfill leakage and to its polluting load.

Since the year 2005 according to the regulations of TA Siedlungsaufall it is only allowed to deposit waste containing dry organic solids less than 3 mass-% and 5 mass-%. This fact makes it indispensable having and fill leakage and to decrease pollution loads.

After considering the latter aspects it has been proven that an adsorption process with PAC and then a following treatment of PAC in the sewage treatment plant is not only an affordable, but also a flexible treatment procedure during the period that the landfill is shut down. This method guarantees the necessary cleaning performance through the adsorption of the pollution load to the PAC. The treatment loaded PAC at a communal sewage treatment plant makes it possible to manage without PAC separation and therefore it isn’t necessary to drain the PAC-sludge, which makes this procedure extremely interesting from an economical point of view.

Before beginning the process of loaded PAC in a communal sewage treatment plant with a biological treatment, at ISWA a number of experiments were carried out on a laboratory scale to ensure that the substance leading to COD and AOX adsorbed in the PAC do not dissolve from the loaded PAC. Despite these results there is still great need for further research in order to ensure such a process that is risk free for the environment and the operator.

The purpose of this research is to find out what the results are of initiating the use of loaded PAC from the landfill leakage treatment in a communal sewage treatment plant. Simultaneously we are also looking into the matter of transporting the PAC-suspension to the sewage treatment plant by means of the communal sewer system, and comparing this with alternative transport methods such as a truck. The latter described adsorption process without separated the loaded PAC should be compared with the more conventional methods of landfill leakage purification by conducting a cost-effectiveness analysis.

The accumulated knowledge from the research related to the influence of loaded PAC in a communal sewage treatment plant can prove to be beneficial in many cases throughout different industrial branches.

**Development of a mechanical-biological treatment process based on the BIOPERCOLAT®-process in order to reduce the waste amount and to create refuse derived fuel**

For most of the developing countries and especially for many newly industrialized countries waste is getting more and more a serious problem for the environment and for the society. So far the most common way of waste disposal is to dump it into landfills. Usually these landfills are simple dumps without any sealing or coverings. Hence, leachate water can not be collected and be treated with treatment plants as we know them from Europe or other developed countries. As a consequence the surrounding environment suffers severe impacts and damages. In a global scale this way of waste disposal heavily contributes to the global warming by emitting the green house gases CO₂ and Methane.

In Europe the usage of landfills for the disposal of
household waste is prohibited by law since 2005. The old landfills still need a long and expensive maintenance up to 50 years. Nowadays waste incineration plants, composting plants, recycling facilities and mechanical-biological waste treatment (MBT) plants are state of the art.

The big advantage of MBT plants is the low energy consumption for the operation, low emissions of greenhouse gases and a high energy recovery. Even the invest costs are relatively low, compared the waste incineration plants. Also the rate of return is very high, as MBT plant can produce valuable refuse derived fuel (RDF) and biogas. The biogas can be used to produce electrical energy and heat by using combined heat and power plant (CHP) or modern gas turbines.

As boundary conditions differs from country to country and especially between developed and developing/newly industrialized countries the in Germany well approved MBT technology can not be used for waste of other countries one-to-one. One of the biggest differences in the waste composition is the higher organic as well as the higher water content. Beside that the climate and the weather can have a big influence on the performance.

The University of Stuttgart, in cooperation with the German company WEHRLE Umwelt GmbH, Emmendingen is working on the development of a new MBT technology. This technology is based on a well approved German technology, which is positively field-tested and successfully in use at the site Kahlenberg, Ringsheim for more then 5 years. The main task of the development is the adaption of the technology to other boundary conditions. Hence, the University of Stuttgart planed and installed a MBT pilot in central Thailand in the province Petchaburi. During the operation the suitability is going to be tested. The local Thai company Cemtech Co. Ltd. and the “King Mongkut’s Institute of Technology Ladkrabang” (KMITL) are supporting the project.

The advantages by using the planed MBT-technology for the waste disposal are:
- Very low impacts on the local and global environment (gobing warming)
- Relatively low investment costs
- High rate of return
- Clean Development Mechanism (CDM) à Selling of carbon credits
- Low tipping fees for the population
- Production of CO₂-neutral and valuable RDF
- Production of CO₂-neutral biogas

<table>
<thead>
<tr>
<th>Financing institution:</th>
<th>Umweltministerium Baden-Württemberg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financing program:</td>
<td>Betriebliche Umwelttechnik</td>
</tr>
<tr>
<td>Project Partner:</td>
<td>WEHRLE Umwelt GmbH, Emmendingen</td>
</tr>
<tr>
<td>Contact Persons:</td>
<td>Prof. Dr.-Ing. Uwe Menzel</td>
</tr>
<tr>
<td></td>
<td>M.Sc. Dipl.-Ing. Sebastian Platz</td>
</tr>
</tbody>
</table>

**Development of a process to produce bioplastic on municipal wastewater treatment plants**

The ambition of this research project is to find an economic, effective process to produce bioplastic out of waste water. The state of the art of the bioplastic production is the basic idea of this project. Wastewater as raw material for the bioplastic production has not been an object of research so far and offers the opportunity to transform the waste water treatment plant into a bioplastic factory. Today, plastic is made out of unlasting crude oil. So it is obvious, that the production of bioplastic includes some benefits and fits to the main idea of sustainability. Bioplastic, for example, enables preservation of resources, is compostable and biodegradable.

<table>
<thead>
<tr>
<th>Financing institution:</th>
<th>Willy Hager Stiftung</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact Persons:</td>
<td>Prof. Dr.-Ing. Uwe Menzel</td>
</tr>
<tr>
<td></td>
<td>Dipl.-Ing. Timo Pittmann</td>
</tr>
</tbody>
</table>

**Assessment of the water treatment facilities of the steel work of the ThyssenKrupp Steel AG in the federal state Rio de Janeiro / Brazil**

ThyssenKrupp belongs to one the biggest enterprises from the technology group worldwide. More then 190,000 employees are working in main sectors steel, industry goods and services. The company had a turnover of more then 51 billion Euro in the business year 2006/2007.

Around 20 percent of the turnover is realised by the ThyssenKrupp Steel AG. The ThyssenKrupp CSA is a sub company of the ThyssenKrupp Steel AG.

The ThyssenKrupp CSA Companhia Siderurgica currently builds one of the biggest steel works worldwide in the Sepetiba bay in the federal state of Rio de Janeiro in Brazil. This will be done in order to increase the worldwide steel production of the ThyssenKrupp Steel AG. The investment of the project is estimated with
costs around 3 billion Euro. From the year 2010 on the steel work will produce 5 million tons steel per year.

One of the main aspects of a modern steel work with integrated smeltery is a secured supply of the media water and energy. The necessary water supply will be taken from the local river. The flow rate will be around 20 m³/s.

The working group Industrial Water and Wastewater Technology (IWT) of the Institute for Sanitary Engineering, Water Quality and Solid Waste Management (ISWA) of the University Stuttgart is assigned to assess the water treatment facilities of the new steel work.

The assessment is split into two parts:

- Part 1: Plausibility check of the water treatment facilities of the steel work of the ThyssenKrupp Steel AG in the federal state Rio de Janeiro / Brazil
- Part 2: As-is analysis of the planning documents and assessment of the “water treatment plant 3” of the steel work of the ThyssenKrupp Steel AG in the federal state Rio de Janeiro / Brazil

Client:
ThyssenKrupp Steel AG
Contact Persons:
Prof. Dr.-Ing. Uwe Menzel
M.Sc. Dipl.-Ing. Sebastian Platz

The development of a process for the treatment of process water from the separation of chlorite-sulfate and bypass-dust from the cement industry.

The Schwenk Zement KG company was found in the year 1847, making it the oldest cement company in the European cement industry. Alongside manufacturing cement Schwenk Zement KG also specializes in dam technology, façade technology as well as the manufacturing of transport concrete. Further more the Schwenk Zement KG is the leading company in the German branch known for renting/leasing concrete-pumps. In the company’s 4 cement plants in Germany partially up to 100% of the used fuels are alternative/recovered fuels.

In each cement plant about one or two tons of bypass-dust accumulates per hour, and therefore creating amounts of 10.000 tons of accumulated bypass-dust a year.

This means that at a total production rate of 1 Mio. tons of cement a year adds up to 40.000 tons of accumulated bypass-dust. This bypass-dust is amongst other things fortified with a high concentration of chloride-sulfate which encourages caking and corrosion.

Therefore, the Schwenk Zement KG company intends to gather the chlorine load from the bypass-dust. In order to achieve this four or five times the amount of heated water is added to the dust. This leads to the dissolving of the salts in the bypass-dust, and therefore enabling the dust to be used in an environmental friendly manner.

The salt from the process water should be gathered in a suitable process-combination. This process should be affordable and efficient and therefore enabling the use of a water circuit of the process water. For this purpose an environmental friendly process or process-combination should be developed, tested and applied on a big scale in the industry. Here is a description of the research process:

- Part 1: Literature and application studies
- Part 2: The research of the conclusion from part 1 through laboratory or technical tests
- Part 3: Suitability test in a pilot-installation
- Part 4: Consultation and monitoring of the technical implementation of the project

Client:
Schwenk Zement KG, Ulm
Contact Persons:
Prof. Dr.-Ing. Uwe Menzel
M.Sc. Dipl.-Ing. Sebastian Platz

Testing and interpretation of a Pilot Jet-Zone Reactor Membran Treatment Plant with Wastewater from the Natural Cosmetics Industry

A jet-zone reactor (JZR) membrane pilot wastewater treatment plant was tested in a 13-week on-site experimental program with the wastewater of WALA Heilmittel GmbH. The JZR plant can be described as a high-rate activated sludge treatment process. The objectives of the trial program were to test the treatment performance with respect to reduction of COD and oil and grease parameters, to assess the effect of heavy metals in the wastewater, and to observe the operational parameters. The experimental set-up comprised a wastewater tank, a pre-treatment flotation unit, wastewater feed tanks, and a JZR-membrane unit, in that order.
The main operational issues faced during the trial program were foaming, low membrane flux, and mechanical disruptions. The COD removal efficiency of the JZR-membrane unit during the ten weeks of efficiency testing was 88 % (± 6 %). The reduction efficiency of the oil and grease parameter was greater than 99 %; the permeate concentration was about 3 mg/l, which was well below the legal discharge limit of 300 mg/l. Zinc and copper concentrations tested during the heavy metal phase were extremely low or not detectable in the permeate. Most of the heavy metals in the flow stream were removed via the flotate from the flotation unit and the excess sludge from the JZR. The pilot plant was found to run effectively at a sludge loading rate of up to 2.0 g COD/(g TSS • d). The average sludge growth rate was 0.14 Δg TSS/(g COD eliminated) for the testing period.

The official inspection office, responsible for carrying out practical tests at different plants to ensure the reduction of hydrocarbon in wastewater containing mineral oil.

As a result of Prof. Menzel being appointed part of the expert-committees

- “Abscheider und Mineralölhaltiges Abwasser -A-(428)”
- “Mineralölhaltiges Abwasser -B 3-(428c)”
- “Mineralölhaltiges -B 4-(428d)”

by the “Deutsches Institut für Bautechnik (DIBt)” in Berlin, the Institute for Sanitary Engineering, Water Quality and Solid Waste Management at the University of Stuttgart (IWT department) was then appointed as the official inspection office. The department is responsible for carrying out practical tests at different plants to ensure the reduction of hydrocarbon in wastewater containing mineral oil.

Client:
WALA Heilmittel GmbH, Bad Boll/Eckwälden

Project Partner:
WEHRLE Umwelt GmbH

Contact Persons:
Prof. Dr.-Ing. Uwe Menzel
Dipl.-Ing. Timo Pittmann
International curriculum exchange

Study course offers from German universities and academies abroad

The initiation of German environmental Master of Science programs at Brazilian universities under German supervision and at German standards – EDUBRAS

At the pace of the current booming industrialization, environmental pollution causes serious problems in emerging and developing countries. In Brazil, which is the most populous country in South America, this is particularly visible in densely populated areas.

Due to the successful years at experience that the lectures from the University of Stuttgart have had in creating new environmental study courses such as “Umweltschutztechnik” and the English Master of Science program WAREM and WASTE, this experience should now be transported to Brazil through the EDUBRAS program which takes place in the Brazilian state Paraná. EDUBRAS is meant to be an exemplary program, which can then later be implemented at other universities abroad.

The basic concept behind the planned study program were established based on the environmental inventory of Prof. Menzel during the research project “Export oriented research on the field of water supply and water disposal, part 2: wastewater treatment and water reuse” funded by the German “Federal Ministry for Education and Research (BMBF)”.

This revealed the desperate need to import new and modern environmental technologies to Brazil. It also revealed the need and the interest in educating local skilled specialists in order to operate the imported technologies and thereby creating a sustainable environmental-protection system.

After the success of the “Summer-School-courses” from 2002-2005 dealing with the topics of wastewater/industrial wastewater and waste/industrial waste, not only showed a great interest for environmental topics, but the need for such courses or similar ones to be given on a permanent basis as local study courses at Brazilian universities as well. This is crucial in order to train local specialized staff in order to ensure the sustainability and success of all environmental procedures. With the help of the program “Course offers from German universities in foreign countries” offered by the DAAD, it will be possible for Brazilian universities to offer additional study courses in Brazil.

In July 2007 the master program environmental engineering was inducted at the national university “Universidade Federal do Paraná – UFPR” in Curitiba, Brazil.

The goal is to create a “Master of science” program which is accepted in Brazil or alternatively in German and Brazil, and to achieve an accreditation of that program. The study program will be financed by tuition fees.

It is intended to first link the university lectures and research through close cooperation with the University of Stuttgart and later on by building an infrastructure at the UFPR. The lectures will be held in German as well as in Portuguese. Alongside the lectures German language courses will be offered in order to strengthen the relationship with Germany. German will take part in creating the courses’ curriculum as well as being responsible for the quality control of the courses. The German side will be in charge of administrating and coordinating the overall project. The structure of the study program offers a wide range of courses in the field of environmental engineering, and the positions will be occupied by Germans and Brazilians.

The coordination with the project-partner UFPR is regulated by a cooperation treaty. The UFPR is responsible for providing the infrastructure and the lecturers as well as for the fee and coordination on the Brazilian side. Due to the public relations and the contact to the industry, and the partnership in the industrial alliance SENAI it is therefore possible to guarantee practical-oriented programs as well.

<table>
<thead>
<tr>
<th>Financing institution:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Deutscher Akademischer Austauschdienst DAAD</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project Partner:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Universidade Federal do Paraná (UFPR)</td>
<td></td>
</tr>
<tr>
<td>Serviço Nacional de Aprendizagem Industrial (SENAI)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contact Persons:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof. Dr.-Ing. U. Menzel (IWT)</td>
<td></td>
</tr>
<tr>
<td>Dr.-Ing. D. Neuffer (IWT)</td>
<td></td>
</tr>
<tr>
<td>Dr.-Ing. K. Fischer (SIA)</td>
<td></td>
</tr>
<tr>
<td>Prof. Dr. rer. nat. J. Metzger (CH)</td>
<td></td>
</tr>
</tbody>
</table>
Evaluation of the Masters programme EDUBRAS-MAUI

DAAD: Degree in Environmental Studies in Brazil with excellent Know-How from Stuttgart

The University of Stuttgart has a significant interest in training Brazilian environmental experts in accordance with German standards. In winter, 2007, scientists from the Institute for Sanitary Engineering, Water Quality and Solid Waste Management (ISWA) from the Uni Stuttgart, created a Masters Degree for Community and Industrial Environmental Studies within the framework of the project, EDUBRAS (Induction of German Technological Environmental Studies in Brazil) in conjunction with partners in Curitiba. This course of study has recently been evaluated and has been given the commendation ‘excellent’, by the DAAD (German Academic Exchange Service). The DAAD announced, “Since its recent introduction, this course of study has already become a showcase of exemplary character” and recommended that the establishment of sustainable German courses of study be implemented in a similar way. Based on the Uni Stuttgart’s extensive knowledge in environmental technology and its experience in numerous environmental projects in various countries, “Brazilian students undertaking this degree will receive an exacting course of study of the highest scientific quality.” The project director and representative of the Uni Stuttgart for the EDUBRAS-program, Prof. Uwe Menzel, was attested to in the assessors’ evaluation report citing, “professional project management, conducted with extraordinary commitment.”

Figure:
With know-how from the Uni Stuttgart environmental experts will be trained in Brazil. This will contribute to less pollutants reaching and harming Iguazu falls.

Prof. Menzel from ISWA, who developed this course of study together with his colleagues, Dr. Klaus Fischer und Dr. Daniela Neuffer, and who also often teaches onsite, regards this praise to be a big success. In particular he is pleased that the DAAD considers this course of study, which was implemented in cooperation with the Universidade Federal do Paraná and the industry association Senai, “as an exemplary model of engineering and further education.” Menzel is convinced that there is still much to be done in the area of environment protection in Brazil. Menzel views it to be particularly advantageous that, students will receive practical experience, which will then directly be put into practice on the job. The future environmental experts will be prepared to graduate in Brazil after two years of study and to attain their German Master degree after completing three years of study. The curriculum is specially designed so that primarily Brazilian lecturers will be teaching compulsory subjects and then, alongside lecturers from Stuttgart, they will be offering emphasis subjects such as industrial water technologies, water supply and treatment technology, hydro chemistry and biology, air pollution control and under the headword prevention, the avoidance of pollution. The Master thesis will be completed within the industry. Tuition fees, when converted, amount to 2,400 Euros per semester.

"In light of the excellence of the expertise being offered in the EDUBRAS-Project and the positive resonance Brazil-wide, the DAAD should have the intention of continuing to support this project, even after the expiration of the initial grant". This was the final recommendation to the DAAD by the evaluation team.

Prof. Menzel has already set this course in motion and is currently planning a research program to accompany the Masters degree. He will also be exploring ways to expand upon corresponding promotional opportunities at the Universidade Federal do Paraná the Uni Stuttgart.

Homepage:
http://www.edubras-maui.uni-stuttgart.de

Contact Persons:
Prof. Dr.-Ing. Uwe Menzel
Dr.-Ing. Daniela Neuffer
Extensive treatment processes for water and wastewater. Post-graduation-specializing course at the "FACULDADE DE TECNOLOGIA SENAI BLUMENAU", the national environmental protection center of the industry (SENAI-SC) in Blumenau/Santa Catarina Brazil.

The national environmental protection center of the industry (SENAI-SC) in Blumenau/Santa Catarina offers a post-graduate-specializing course "Gerenciamento de Aguas e Efluentes".

As part of these courses Prof. Menzel gives a series of lectures called "Advanced Treatment Technologies for Process-Water and Wastewater".

Financing institution:
Nationales Umweltschutzzentrum der Industrie (SENAI) in Blumenau
Contact Persons:
Prof. Dr.-Ing. Uwe Menzel

Environmental management in the industry” post-graduate-specializing course at the Universidade Federal do Parana (UFPR) in cooperation with the national environmental protection center of the industry (SENAI)

Over the past few years the Universidade Federal do Parana (UFPR) has lead the post-graduate-specializing course "Environmental Management in Industries" in cooperation with SENAI.

As part of this course Prof. Menzel gives a series of lectures called "Management of Industrial Wastewater".

Financing institution:
Universidade Federal do Parana (UFPR) in Curitiba
Nationales Umweltschutzzentrum der Industrie (SENAI) in Curitiba
Project Partner:
Universidade Federal do Parana (UFPR) in Curitiba
Nationales Umweltschutzzentrum der Industrie (SENAI) in Curitiba
Contact Persons:
Prof. Dr.-Ing. Uwe Menzel

Environmental engineering study offers in Brazilian Summer School at Fundacentro (Fundao Jorge Duprat Figueiredo de Seguranc e Medicina do Trabalho) in Sao Paulo and CEFET (Centro Federal de Educacao Tecnologica do Parana) in Curitiba, Brazil.

Alongside political and legal conditions it is also crucial to obtain the know-how and qualified personal in order to create a sustainable environmental protection program and solve environmental problems.

As part of the model-project “Umweltschutztechnische Studienangebote in Brasilien – Summer School” lecturers of the University of Stuttgart will hold a three week learning event in Brazil in which the field of waste-economy, waste technology and industrial water and wastewater technology will be taught.

The participants in the Summer School should be able to apply their acquired knowledge in order to contribute to the environmental protection in Brazil. The Participants include professors, students from higher semesters and colleges, as well as professionals from industrial and communal branches.

The Summer Schools are executed due to strong cooperation between the IWT department at the University of Stuttgart and Brazilian universities and academic institutions in Brazil.

The experiences and contacts made during this model-project should contribute to the development of new study events and programs in Brazil as well as create a bond to the University of Stuttgart.

As far as the participating partners are concerned this project is an opportunity to cooperate in the fields of science, research, joined projects as well as student exchange programs etc. with the University of Stuttgart.

Teaching topics of the Summer Schools:

„Industrial Waste Water Treatment“
- Intro waste water treatment technology
- Volume, types and contents of waste water
- Fundamentals of industrial watermanagement
- Abstract of process technologies
- Preparing measures
- Mechanical-physical treatment
- Biological treatment
- Conditioning of sludge and sludge disposal
- Physicochemical treatment
- Case study: combined processes
Expert’s Reports

Plausibilitätsprüfung der Wasseraufbereitungsanlage des Stahlwerks der ThyssenKrupp CSA im Bundesstaat Rio de Janeiro / Brasilien
Auftraggeber:
TheissenKrupp Steel AG

Ist-Analyse der Planunterlagen und Überprüfung der Einrichtungen des „Water Treatment Plant 3“ des Stahlwerks der ThyssenKrupp CSA im Bundesstaat Rio de Janeiro / Brasilien
Auftraggeber:
TheissenKrupp Steel AG

Literaturrecherche und Machbarkeitsstudie - Entwicklung einer Verfahrenskombination zur Aufbereitung des bei der Entfernung von Kaliumsalzen aus Bypass-Stäuben der Zementindustrie anfallenden Prozesswassers
Auftraggeber:
Schwenk Zement KG

Expert’s Reports

Example of practical applications
Exercises in groups
Excursion

„Solid Waste Management and Treatment“
- Environmental aspects of solid waste
- Source, composition, quantities of solid waste
- Waste management systems
- Collection and transport of solid waste
- Sorting and recycling
- Waste disposal – landfill, incineration
- Composting and anaerobic digestion of separate collected biowaste
- Air purification
- Analysis of solid waste

Financing institution:
Deutscher Akademischer Austauschdienst DAAD

Project Partner:
Fundacentro (Fundacao Jorge Duprat Figueiredo de Segurança e Medicina do Trabalho (Forschungsinstitut am Arbeitsministerium) in Sao Paulo; CEFET (Centro Federal de Educacao Tecnologica do Parana) in Curitiba

Contact Persons:
Prof. Dr.-Ing. U. Menzel
Dr.-Ing. D. Neuffer
Dr.-Ing. K. Fischer (SIA)
Dipl.-Geol. D. Clauß (SIA)

Expert’s Reports

Plausibilitätsprüfung der Wasseraufbereitungsanlage des Stahlwerks der ThyssenKrupp CSA im Bundesstaat Rio de Janeiro / Brasilien
Auftraggeber:
TheissenKrupp Steel AG

Ist-Analyse der Planunterlagen und Überprüfung der Einrichtungen des „Water Treatment Plant 3“ des Stahlwerks der ThyssenKrupp CSA im Bundesstaat Rio de Janeiro / Brasilien
Auftraggeber:
TheissenKrupp Steel AG

Literaturrecherche und Machbarkeitsstudie - Entwicklung einer Verfahrenskombination zur Aufbereitung des bei der Entfernung von Kaliumsalzen aus Bypass-Stäuben der Zementindustrie anfallenden Prozesswassers
Auftraggeber:
Schwenk Zement KG

Expert’s Reports

Example of practical applications
Exercises in groups
Excursion

„Solid Waste Management and Treatment“
- Environmental aspects of solid waste
- Source, composition, quantities of solid waste
- Waste management systems
- Collection and transport of solid waste
- Sorting and recycling
- Waste disposal – landfill, incineration
- Composting and anaerobic digestion of separate collected biowaste
- Air purification
- Analysis of solid waste

Financing institution:
Deutscher Akademischer Austauschdienst DAAD

Project Partner:
Fundacentro (Fundacao Jorge Duprat Figueiredo de Segurança e Medicina do Trabalho (Forschungsinstitut am Arbeitsministerium) in Sao Paulo; CEFET (Centro Federal de Educacao Tecnologica do Parana) in Curitiba

Contact Persons:
Prof. Dr.-Ing. U. Menzel
Dr.-Ing. D. Neuffer
Dr.-Ing. K. Fischer (SIA)
Dipl.-Geol. D. Clauß (SIA)
Diploma- und Master Theses

**Erforschung und Entwicklung von neuen Methoden zur Bestimmung der Toxizität anhand der Respirationsmessung**

Natalia Neumann (Umweltschutztechnik) (2008)
Betreuer: Prof. Dr.-Ing. Uwe Menzel

**Untersuchung zur Biomassenabtrennung an einem Strahlzonenschlaufenreaktor und weitergehende Behandlung mittels Nanofiltration bei einem Abwasser der Textilindustrie**

Ridong Huang (Bauingenieurwesen) (2008)
Betreuer: Prof. Dr.-Ing. Uwe Menzel

**Abwasserbehandlungsstrategie in der Industriezone Zekou Stadt Qianjiang (Hubei, China)**

Chenjie Jiang (Umweltschutztechnik) (2008)
Betreuer: Prof. Dr.-Ing. Uwe Menzel
Betreuer: D.Sc. Karen Amaral

**Zentrale oder dezentrale in Ze Kou – Industriezone Qian Jiang, Hu Bei, China**

Kun Zhang (Umweltschutztechnik) (2008)
Betreuer: Prof. Dr.-Ing. Uwe Menzel
Betreuer: D.Sc. Karen Amaral

**Untersuchung eines Waschprozesses zum Entfernen von Kaliumsalzen aus Bypass-Stäuben der Zementindustrie**

Jan Althammer (Verfahrenstechnik) (2009)
Betreuer: Prof. Dr.-Ing. Uwe Menzel
Betreuer: M.Sc. Dipl.-Ing. Sebastian Platz

**Ermittlung einer kreislaufgeführten Prozesswaseraufbereitung zur Entfernung von Kaliumsalzen aus Bypass-Stäuben der Zementindustrie**

Katharina Beicht (Umweltschutztechnik) (2009)
Betreuer: Prof. Dr.-Ing. Uwe Menzel
Betreuer: M.Sc. Dipl.-Ing. Sebastian Platz

**Behandlung von biologisch vorgereinigtem Deponiesickerwasser mit Pulveraktivkohle und deren Nachweis im kommunalen Abwasser**

Thi Thi Vu (Umweltschutztechnik) (2009)
Betreuer: Prof. Dr.-Ing. Uwe Menzel
Betreuer: Stefan Schöpple

**Testing of a Pilot Jet-Zone Reactor Membrane Treatment Plant with Wastewater from the Natural Cosmetics Industry**

Nadira Khawaja (WASTE) (2009)
Betreuer: Prof. Dr.-Ing. Uwe Menzel
Betreuer: Dipl.-Ing. Timo Pittmann

**Planung und Inbetriebnahme einer Pilotanlage zur mechanisch-biologischen Behandlung von häuslichem Restmüll aus Schwellenländern (Arbeitsort: Thailand)**

David Vu (Umweltschutztechnik) (2009)
Betreuer: Prof. Dr.-Ing. Uwe Menzel
Betreuer: M.Sc. Dipl.-Ing. Sebastian Platz

**Ermittlung und Vergleich mehrere Varianten der Abwasserreinigung der Gemeinde Bergtheim-Opferbaum hinsichtlich Durchführbarkeit und Kosten.**

Sebastian Ludwig (Umweltschutztechnik) (2009)
Betreuer: Prof. Dr.-Ing. Uwe Menzel
Betreuer: Dipl.-Ing. Timo Pittmann

**Wirtschaftlichkeitsbetrachtung für Prozess- und Abwasserbehandlungsverfahren in China**

Yongquan Yan (Umweltschutztechnik) (2009)
Betreuer: Prof. Dr.-Ing. Uwe Menzel

**Verbesserung der Bioverfügbarkeit von schwerabbaubaren Abwasserinhaltsstoffen durch eine oxidative Vorbehandlung**

Guangwen He (Umweltschutztechnik) (2009)
Betreuer: Prof. Dr.-Ing. Uwe Menzel

**Possibilities and consequences of using MBR technology in waste water treatment of surfactant containing waste waters**

Rui Fang (Umweltschutztechnik) (2009)
Betreuer: Prof. Dr.-Ing. Uwe Menzel

**Optimização da Flotação na ETE Atuba Sul**

(Gisele Elisabete Kovaltchuk (Professioneller Masterkurs MAUI - Kommunaler und Industrieller Umweltschutz, Brasilien) (2009)
Betreuer: Prof. Dr.-Ing. Uwe Menzel)
Contact

Head of Department

Prof. Dr.-Ing. Uwe Menzel
Professor colaborador (Universidade Blumenau)

Tel:  ++49 (0)711/685-65417
Fax:  ++49 (0)711/685-63729
Mobil:  ++49 (0)172/7303330
Email:  uwe.menzel@iswa.uni-stuttgart.de

Scientists

Dr.-Ing. Daniela Neuffer

Tel:  ++49 (0)711/685-65419
Fax:  ++49 (0)711/685-63729
Email:  daniela.neuffer@iswa.uni-stuttgart.de

Dipl.-Ing. MSc. Sebastian Platz

Tel:  ++49 (0)711/685-65470
Fax:  ++49 (0)711/685-63729
Email:  sebastian.platz@iswa.uni-stuttgart.de

Dipl.-Ing. Timo Pittmann

Tel:  ++49 (0)711/685-65852
Fax:  ++49 (0)711/685-63729
Email:  timo.pittmann@iswa.uni-stuttgart.de

Dipl.-Ing. Karen Amaral

Email:  karen.amaral@iswa.uni-stuttgart.de

M.Sc. Angkhana Klongkarn

Tel.  ++49 (0)711/685-65477;  ++49 (0)7641/585-261
Fax:  ++49 (0)711/685-63729
Email:  a.klongkarn@iswa.uni-stuttgart.de

Meanwhile quittet:

Dipl.-Ing. Stefan Schölpple

Laboratory

CTA Silvia Brechtel

Tel:  ++49 (0)711/685-63731
Fax:  ++49 (0)711/685-63729
Email:  silvia.brechtel@iswa.uni-stuttgart.de

Discussão dos aspectos ambientais no Brasil e na Alemanha referentes à outorga para lançamento de efluentes em corpos hídricos - Estudo de caso: Estado do Paraná, Brasil

(Vergleichende Diskussion der Umweltaspekte Brasiliens und Deutschlands hinsichtlich der wasserrechtlichen Einleiterlaubnis am Beispiel des Bundesstaates Paraná)

Cristiane Schappo (Professioneller Masterkurs MAUI - Kommunaler und Industrieller Umweltschutz, Brasilien) (2009)
Betreuer: Dr.-Ing. Daniela Neuffer

Estudo do reuso de efluentes tratado e recuperação de água utilizada em indústria de bebidas

(Studie zur Verwendung von behandelter Abwasser und zum Wiedereinsatz von Betriebswasser in der Getränkeindustrie)

Michel Ribas Galvão (Professioneller Masterkurs MAUI - Kommunaler und Industrieller Umweltschutz, Brasilien) (2009)
Betreuer: Dr.-Ing. Daniela Neuffer

Análise da Viabilidade técnica, ambiental e legal da utilização de efluentes de esgotos domésticos tratados no conceito de reuso indireto potável e o seu potencial para outros tipos de reuso - Estudo de caso: ETE Atuba Sul, Curitiba

(Untersuchungen zur Durchführbarkeit eines indirekten Wiedereinsatzes von behandeltem häuslichem Abwasser und dessen Potenzial für andere Nutzungen am Beispiel der Kläranlage Atuba Sul, Curitiba)

Betreuer: Dr.-Ing. Daniela Neuffer

Utilização de bioreator a membrana para o tratamento de efluente de aterro industrial no Brasil

(Anwendung eines Biomembranreaktors zur Abwasserbehandlung eine Industriedeponie in Brasilien)

Betreuer: Prof. Dr.-Ing. Uwe Menzel
Urban Drainage

Research topics:

- Sustainable urban drainage systems (SUDS)
- Treatment of wet-weather flows in combined and separate sewer systems
- Real-time control based on quantity and quality parameters
- Treatment of highway runoff
- Infiltration water management
- Monitoring of sewer systems

Our department covers all aspects related to discharge and treatment of stormwater and wastewater in urban areas.

The implementation of novel drainage concepts over the last decades and new technical possibilities facilitate an increasingly sophisticated management of urban wet-weather flows. Prominent examples are the use of semi-natural devices in stormwater management (generally known as SUDS or BMPs), quality-based separation of different types of stormwater and real-time control of entire sewer networks. Due to these developments urban drainage systems play a more important role for the management of water and pollutant fluxes. Another aspect is the risk of urban flooding that receives higher attention as climate change is expected to result in a higher frequency of extreme events.

To address these themes adequately in research and education the department of urban drainage was founded in 2009.
Karl-Imhoff-Prize

In 2009, Ulrich Dittmer from the Chair for Sanitary Engineering and Water Recycling was awarded the Karl-Imhoff-Prize of the DWA (German Water Association). After Professor Krauth (1971) and Professor Thomanetz (1984) he is the third scientist from ISWA to receive this renowned award.

The Karl-Imhoff-Prize was established in 1965 in recognition of the outstanding merits of Karl Imhoff. The prize has been handed over at the national DWA-convention in Augsburg on the 27th and 28th of October 2009.

Ulrich Dittmer was awarded the prize for his PhD-thesis on "Retention and Transformation Processes of Carbon and Nitrogen Compounds in Retention Soil Filters for CSO Treatment". Retention Soil Filters (RSF) are applied if the condition of the receiving water requires an enhanced treatment of discharges from CSO structures. In previous field studies, RSF had shown a generally high purification capacity. However, reliable prediction of the performance of RSF as well as further optimization of design and operation required a deeper knowledge of the internal processes. The PhD-thesis addressed open questions on these processes, focussing on retention and transformation of organic carbonates and nitrogen compounds.

The results showed that the elimination of ammonia is based on a two-step process: during infiltration ammonia is absorbed by biofilms within the filter layer. Concentrations are reduced to a background level. Nitrification of the retained nitrogen takes place during the following dry period. Nitrification activity is highest immediately after the draining of the filter layer. Long term loading and high ammonia loads can lead to a breakthrough of the inflow concentration. In a mathematical model ammonia elimination can be represented by a storage unit that is filled during infiltration due to absorption and emptied in the dry periods by nitrification.

Organic carbonates – represented by COD – show a different behaviour. The particulate fraction is retained at the surface of the filter layer and oxidized during dry periods. For soluble COD compounds the filter shows an almost constant removal rate. Oxygen consumption during infiltration indicates immediate degradation. Ammonification during dry periods shows that there is also delayed degradation of organic substances that have previously been retained by absorption.

The Karl-Imhoff-Prize is handed over by DWA-president Otto Schaaf (left)
Monitoring of pollutant loads in the stormwater sewer of the industrial area Haid (Freiburg, Germany)

The city of Freiburg is planning a treatment facility for the stormwater runoff from the industrial area "Haid". With the objective to analyze performance and efficiency of different treatment options, detailed CFD-simulations should be carried out. As a basis for these simulations information on the rainfall-runoff process and on the particulate transport in the systems was needed.

The quantity and quality of stormwater runoff was monitored over six months. Discharge flow was measured using a cross-correlation ultrasonic device. A submersible UV/Vis spectrometric probe was employed for the measurement of concentrations of suspended solids (SS) and chemical oxygen demand (COD). Additionally, an automatic sampler was used to collect reference samples during selected events. Samples were analyzed for SS, COD and PAH.

The correlation between SS reference values and the online measurement are satisfactory for all rain events. A strong correlation was also found between online-measured SS and PAH in the reference samples (see Fig 2). In future monitoring projects, costs of chemical analysis would be minimized by using online-measurements as a surrogate. Sampling will still be needed, but the amount of samples can be reduced drastically without losses in accuracy of the results.

The second part of the project was dedicated to the analysis of the physical properties of particles in the stormwater flow. Samples of 1 m³ were collected during each of two storm events. The settleable solids obtained from these samples were analyzed for their grain size distribution. Concentration of PAH was measured in the individual grain size fractions. Subsequently settling velocity distribution of each fraction was determined.

Highest loading of PAH was not found in the finest fraction but in the particles with diameters between 0.2 mm and 0.3 mm. This can be explained by the higher organic percentage.

Projects

Fig 1:
Hydrograph (blue) and pollutograph (grey) of a rain event (01.09. 2009)

Fig. 2:
Correlation of concentrations of SS and PAH for one rain event (02.06.2009)

Financing institution:
Abwasser Freiburg GmbH

Duration:
12/2008 - 09/2009

Contact Person:
Dr.-Ing. Ulrich Dittmer
Modification of a software for the simulation of the wastewater temperature to local conditions on Baden-Württemberg

Heat recovery from wastewater is a topic of rising importance in Germany. Heat exchangers could be used to extract thermal energy from the sewer systems. On the other hand the temperature has an important influence on the efficiency of the treatment plant. A reliable prediction of the temperature is therefore vital if implementation of such systems is planned in a large scale.

The temperature regime of wastewater in sewers is complex. Quantities and temperature of raw sewage and infiltration water, soil temperature and interaction between water and air in partly filled pipes have to be considered. A software for the simulation of these processes has been developed by EAWAG (Dübendorf, Switzerland). It has not yet been widely used in practice because essential model parameters have to be monitored in practice.

Within the project, extensive monitoring of flow rate, wastewater temperature and soil temperature is planned. Based on these results basic parameters of the model will be fitted (e.g. heat-transfer coefficients).

Financing institution:
Umweltministerium Baden-Württemberg
Project Partner:
Klinger und Partner, Stuttgart
Duration:
12/2009 - 06/2011
Contact Person:
Dr.-Ing. Ulrich Dittmer
Internet:
http://www.iswa.uni-stuttgart.de/sew/forschung/abwaermetauscher.en.html

Master- and Diploma Thesis

Solids in Storm Sewers and Stormwater Sedimentation Tanks - The Role of Physicochemical Characteristics on their Transport and Settling Behaviour
Jiajia Zhang (WAREM) (2008)
Betreuer: Dr.-Ing. G. Stotz,
Prof. Dr.-Ing. H. Steinmetz

Bewertung von zentralen und dezentralen Entwässerungslösungen im ländlichen Raum in Hinblick auf den demographischen Wandel
Johannes Hawlik (Bauingenieurwesen) (2008)
Betreuer: Prof. Dr.-Ing. H. Steinmetz,
Prof. Dr.-Ing. S. Siedentop

Vergleich der Entlastungstätigkeit statisch betriebener Entwässerungsnetze mit gesteuerten Systemen in Hinblick auf eine Minimierung des Schmutztstoffeintrags bei Ungleichberegnung - Untersuchung am Beispiel eines realistisch entworfenen Versuchsgebietes
Katrin Schopf (Umweltschuttechnik) (2009)
Betreuer: Dr.-Ing. Ulrich Dittmer,
Prof. Dr.-Ing. H. Steinmetz

Contact

Dr.-Ing. Ulrich Dittmer (Akad. Rat)
Tel.: 0711 / 685 - 69350
Fax: 0711 / 685 - 63729
E-Mail: ulrich.dittmer@iswa.uni-stuttgart.de

Scientists

Dr.-Ing. Gebhard Stotz
Tel.: 0711 / 685 - 65439
Fax.: 0711 / 685 - 63729
E-Mail: gebhard.stotz@iswa.uni-stuttgart.de

Dipl.-Hyd. Isabelle Fechner
Tel.: 0711 / 685 - 63739
Fax: 0711 / 685 - 63729
E-Mail: isabelle.fechner@iswa.uni-stuttgart.de

Dipl.-Ing. Marie Launay
Tel.: 0711 / 685 - 65445
Fax: 0711 / 685 - 63729
E-Mail: marie.launay@iswa.uni-stuttgart.de
Water Quality Management and Water Supply

With us, effluent is just water under the bridge

Our field of work consists of all aspects of extraction and provision of water from surface and groundwater sources. Most notably, this involves subterranean groundwater treatment, and all questions relating to the transport, storage and distribution of water. The technical, economical and hygienic aspects play the primary role in this.

In the field of water supply, we deal with the problems shown in the margin, whereby the technology of groundwater treatment is increasingly applied to contaminated site remediation. For the treatment of water for industrial use, we employ membranes, oxidation, UV disinfection and anaerobic biological processes. The transport and distribution of drinking water, and the associated hygienic problems, are also subjects of our investigations.

We have also listed the focal points of our work in water quality management. Generally, this involves anthropogenic influences on water quality and the protection of drinking water resources. One important example of our research is the investigation of the interaction between wastewater pretreatment in industry and the operation of municipal wastewater treatment plants, and their influence on water quality. The final aim is the optimum disposal of sewage from both a business management and an economical point of view. The development, optimization and implementation of sustainable, cost effective and ecologically sensible water treatment technologies on the one hand and technologically advanced procedures on the other, remains a central task in view of the global drinking water supply crisis. One of the main research areas for the future will therefore be the analysis and defeat of transfer and implementation restraints. In addition, it is also necessary, due to the limited global water resources, to increase research in the fields of water resource control and management in terms of safeguarding drinking water supplies.

Research topics:

- Water collection and water treatment
- Removal of iron, manganese and arsenic by subterranean groundwater treatment
- In-situ bioreactors for decentralized groundwater treatment and supply
- Ecosystem research of rivers and groundwater
- Stormwater run-off management, rainwater harvesting and water conservation
- Protection of drinking water resources
- Investigation of anaerobic treatability of wastewater and concentrates
- Water quality management and its interaction with indirect dischargers and operation of the wastewater treatment plant
Projects

Development of a low cost technology for in-situ treatment of groundwater for potable and irrigation purposes

In many regions of the world arsenic contaminated water represents a huge problem for the health and the environment. One of those affected regions is for example eastern India (West Bengal). In the course of the project "Development of a low cost technology for in-situ treatment of groundwater for potable and irrigation purposes" several activities concerning this topic took place.

In order to remove arsenic from groundwater and to improve groundwater quality a low cost technology for in-situ (subterranean) treatment of groundwater was established in eastern India and a field trial was carried out in order to investigate the practical implementation of this technology on location. Beside the establishment of a low cost technology for subterranean removal of arsenic amongst others workings concerning the improvement of agriculture and farming practices to reduce arsenic contamination in the food chain and public relations were conducted.

Financing institution:
European Union (EU)

Project partner:
1. Queen’s University Belfast - School of Chemical Engineering and Queen’s University Environmental Science and Technology Research Centre (Questor Centre), Großbritannien
2. University of Stuttgart, Germany
3. Miguel Hernandez University, Spain
4. Leiden University, Netherlands
5. National Metallurgical Laboratory, Indien
6. Institute of Environmental Management and Studies, Indien

Contact:
Prof. Dr.-Ing. U. Rott
Dipl.-Ing. Ralf Minke, AOR
Dipl.-Ing. H. Kauffmann

Co-funded by the European Union under:
"Asia Pro Eco Programme - a programme dedicated to promote sustainable solutions to environmental problems in Asia".
„The contents of this publication is the sole responsibility of ISWA - WGW and can in no way be taken to reflect the views of the European Union".
Subterranean Arsenic Removal: From Experiment to Delivery

Together with the Indian applicant organisation Ramakrishna Vivekananda Mission – Institute of Advanced studies (RKVM-IAS) the Institute for Sanitary Engineering, Water Quality and Solid Waste Management (ISWA) of the University of Stuttgart is implementing the project "Subterranean Arsenic Removal: From Experiment to Delivery". The objective of this project is to reduce in an affordable and sustainable manner the health consequences of arsenic contaminated water in rural communities of West Bengal, India by in-situ treatment of groundwater. Within the project six in-situ treatment plants shall be established. The in-situ treatment plants shall be manufactured and distributed/serviced by local entrepreneurs. Further on they shall be managed by self-sustained community groups with the support of classroom and hands-on training.

Development of strategies for water circuit closure for selected industries with split flow concept

Most industries used to treat or pre-treat the cumulative waste waters of a factory, targeting in some cases for a partial recycling. Some factories collect waste waters according to their origin and treat these waste waters independently. Nonetheless, often waste waters are thereby blended from individual sources, differing greatly in quantity and quality.

These blend waste waters are often difficult to be purified, since the waste water constituents may vary greatly. The treatment steps needed for a purification of such waste waters will become complex and demanding, mastering all eventualities. Thus, a recycling of waste waters is not considered for economical reasons.

Paper industry

Main focus was given to the application of membrane processes, mainly ultrafiltration and nanofiltration. Ultrafiltration is much less costly than nanofiltration, but only with nanofiltration and reverse osmosis solute salts can be removed. Therewith, an effective sink is created for the removal of salts, accumulating in the circuits otherwise. Thus, with nanofiltration or reverse osmosis applied, water circuits can be concentrated or even closed, without deteriorating product quality. Research is conducted both with waste waters from paper mills producing white paper and mills producing brown paper.

The corresponding water circuits differ significantly in respect to organic and inorganic waste water constituents. The COD-levels in the water circuits for instance are usually more than 10 times higher in mills producing brown paper as they are in mills producing white paper. The same applies to the concentration of soluble salts, expressed in terms of conductivity, with a factor of at least 5.

Besides the research on finding suitable membranes and membrane combinations, focus is also given on where to apply membrane processes. Biologically treated water is usually easier to treat with membranes, yet resulting in large amounts of concentrates to be disposed. A membrane step close to the production, i.e. the direct filtration of waste waters from the water circuits, can result in a more cost-effective configuration of subsequent biological treatment steps for the resulting concentrates, since smaller streams with higher concentration levels can be applied to for example...
anaerobic treatment. Thus, waste waters from different places of origin are considered in the research project.

**Milk industry**

For the milk industry, waste waters from different cleaning steps were treated with different membranes. The concentration of constituents in these rinsing waters varies greatly over flushing time. With a separate collection of variable contaminated parts of these flushing waters into streams that either can be reused without treatment, can be fed to membranes directly or need a more complex treatment scheme, including e.g. biological reactors in combination with membranes, the necessary treatment schemes can be applied most cost-effective and purposeful.

Apart from this research close to the production processes, experiments were conducted with the effluent of the waste water treatment plant of a milk processing company, whether there are opportunities to recycle the effluent as boiler feed water with reverse osmosis. The quality requirements for boiler feed water are demanding, an almost complete removal of inorganic and organic constituents is required.

<table>
<thead>
<tr>
<th>Financing institution:</th>
<th>Willy-Hager-Stiftung</th>
</tr>
</thead>
</table>
| Contact:               | Dipl.-Ing. Ralf Minke, AOR  
                        | Dipl.-Ing. A. Neft |

Membrane pilot-plant to treat wastewater from milk processing by ultrafiltration and nanofiltration
Assessment Of River Water Quality In A Watershed Affected By Large-scale Rubber Plantations

Change in land use can directly and indirectly affect local and regional water quality. The aim of this study is to investigate the environmental impact of large-scale rubber cultivation in an area which is classified as nature reserve. Within the course of the assessment in the dry and wet seasons, the impact of rubber cultivation will be evaluated, in particular in terms of pesticides, by comparing river water quality data obtained from an affected river with data from a river not being subject to adverse effects from rubber cultivation.

The Yunnan province in southwest China possesses a very unique landscape. However, the introduction of rubber in the 1950s and the fast development of rubber plantation in the 1980s have changed the landscape tremendously. Due to progresses in cultural techniques, more suitable growing conditions and high economic profits, the size of rubber plantations grew rapidly. Rubber cultivation has expanded even into protected areas such as the Naban River Watershed National Nature Reserve, which leads to destruction of the nature reserve and a loss of biodiversity.

In order to increase production, the use of pesticides and fertilizers has dramatically increased in rubber plantations in Yunnan. It is a known fact that certain pesticides/fertilizers can damage aquatic ecosystems and human health because of their acute or chronic toxicity. The pathway, which is considered to be the most important diffuse source of chemical contamination, is the transport of pesticides in water runoff from agricultural fields. The pollutants can also be transported through the soil by infiltrating water.

This study will focus on the impact of land use change on water quality in the Naban River Watershed National Nature Reserve. This nature reserve is located in Jinghong County, Xishuangbanna Autonomous Prefecture of Yunnan Province. The nature reserve covers about 26,600 ha of land. The introduction of rubber took place in the 1980s and has become the main source of income for many farming households in the region. Rubber planting area covered nearly one quarter of the nature reserve in 2004.

Herbicides, fungicides and insecticides are used in high quantity in the plantations. However, it is unknown what kind of pesticides is applied in which quantity to the plantations. It is also unknown to which extent the pesticides and their metabolites have a negative impact on river water quality.

Two river segments in Naban River Watershed National Nature Reserve will be selected for a first impact assessment of large-scale rubber plantation on river water quality. The river segments have their spring in the same pristine area. Whilst one of the river segments is flowing through the plantations and is thus subject to pollution caused by the plantations, the second river segment is not adversely affected by the plantations and can thus provide a reference state.

The study area is characterized by significant variations in rainfall with a distinctive dry season lasting from November to March and a distinctive wet season from April to August, respectively. As it can be assumed that the seasonal variations in rainfall have an intensive effect on runoff losses, the impact assessment will be carried out in both seasons. The main parameters considered in the impact assessment are:

1. Physical parameters: pH-value, dissolved oxygen, electric conductivity etc.
2. Chemical parameters: COD, phosphate, nitrate, nitrite, ammonium etc.
3. Pesticides and fertilizers in surface water
4. Microbiological parameters: Coliform bacteria and E. Coli.

During the fieldworks, both grab samples and composite samples will be taken in order to evaluate the impact of the rubber plantations on river quality adequately.

The results of the impact assessment of rubber cultivation for the both season will be obtained. Conclusions will be drawn on how adverse effects of rubber cultivation on river quality could be reduced. The reference state of water quality, being concluded from the river segment not adversely affected by the rubber plantations, will be intensively discussed, as it may significantly facilitate the assessment of environmental impacts of land use in other cases - being it rubber or not - where no reference state is available.
A novel and cost-effective approach on preventive water pollution control

An improvement of water pollution control in the municipal waste water practice is either achieved long term by process integrated in-plant measures in order to reduce the waste water quantity respectively improve the waste water quality or near-term by cost-intensive advanced treatment (end-of-pipe). The generally fluctuating water quality and quantity results in extremely varying dirt load peaks the treatment plant has to cope with, i.e. the waste water treatment plants rarely work in their optimal range. Temporarily either the compulsory limit values are exceeded resulting in potential water pollution or the waste water treatment plants capacity is not efficiently used. A solution to this problem can be integrated approach to the entire waste water system. Often free storage or treatment capacity is not detected or used.

The objective of a case study of the University of Stuttgart, Institute of Sanitary Engineering, Water Quality and Solid Waste Management, is to achieve a preventive water pollution control by setting up a sophisticated interaction of industrial indirect dischargers, municipal waste water treatment plant, sewage network and storm water treatment. The main idea is to establish a load controlled concept based both on online measurement and data from an integrated dynamic simulation model embracing the complete sewage system. A major task of the project is to design this simulation model.
The sewage system consisting of a trickling filter treatment plant (ca. 130,000 PT), the sewage draining system, i.e. sewage transport network and storm water treatment facilities, is fed with municipal and industrial waste water (the latter mainly indirectly discharged by a paper mill). To meet the challenges of project the following steps have to be accomplished:

- collection and analysis of data and samples from the waste water treatment plant, especially evaluation of the operational journals and the continuous online-measurement data of the biological treatment stage (trickling filter)
- collection of meteorological data
- set-up of the online measurement (e.g. COD, NH\textsubscript{4}\textsuperscript{+}, NO\textsubscript{3}\textsuperscript{-})
- extensive collection and analysis of data and samples from the indirect discharger (paper mill), e.g. basic waste water flows and waste water quality dependent on various conditions like paper grade or internal process impacts
- analysis of the existing sewage network, e.g. surveying hydraulic conditions of the sewers and respective facilities
- calculation of relevant sewage network flow times, utilisation ratios of sewers, hydrostatic water levels and flows under dry weather and storm weather conditions
- design, calibration and verification of an integrated dynamic simulation model
- installation of structural measures concerning the control facilities of the storm water treatment, the indirect discharger and the sewage network
- application of the simulation model and coupling with the online measurement and control facilities

With the help of these measures the municipal waste water treatment plant is likely to continuous operation in optimal range. The risk of concentration and dirt load peaks polluting receiving waters is avoided or minimised. By a sophisticated discharge control of the industrial waste water point sources and the control of the sewage system facilities based on the continuous model and online measurement information on the free storage capacity of the sewage network and storm water treatment facilities in dependence on the present hydraulic situation (dry weather flow, storm weather flow) as well as on the current state of the municipal waste water treatment plant, an optimal quantitative and qualitative (head parameter = chemical oxygen demand (COD)) feed to the treatment plant is achieved. Thus, long-term an improvement of the water quality without the necessity of expensive new investments in advanced treatment stages can be expected.

Financing Institution:
Ministry for the environment Baden-Württemberg
Project Partner:
University of Stuttgart, Germany
City of Heidenheim
Voith Paper Technology Center (Heidenheim)
Contact:
Dipl.-Ing. Ralf Minke, AOR
Dipl.-Ing. C. Meyer
Dipl.-Ing. S. Schmidt

NASSY: laboratories and holiday camps for female pupils

The project „Nassy: laboratories and holiday camps for female pupils“, has been put out for tender as a part of the project “researching pupils – insights into sciences and engineering” by the ministry for sciences, research and arts and has been benefitted for 18 months. The research centre for water in Stuttgart (wfz) under the aegis of the organization VEGAS has applied for the project which is run by three chairs of the institutes for water engineering (IWS and ISWA).

The aim of Nassy is to acquaint female pupils from primary and secondary school with physical issues, sciences and engineering by the medium water. The variety of topics based on water is large and has the advantage, that the pupils can associate their own everyday experiences.

The Nassy-courses shall inspire the pupils to get interested in a scientific or engineering occupation. This can be realized through the inductive practices of working out the scientific laws on the basis of exciting experiments and excursions as well as through the exemplary function of experienced female engineers.

The project includes the three components:
1. experimental afternoons
2. holiday camps
3. information about study and employment

The three technical contents of the components 1 and 2 were developed by the three chairs of the two institutes and are offered in three thematic modules:

Module I:
- drinking water production and groundwater,
Module II:
- wastewater treatment and drinking water purification,
Module III:
- surface water and hydropower.
The experimental afternoons take place in the laboratories of the institutes. The pupils can experimentalise and carry out research for the subject “water and environment”.

The department ISWA takes on module II. After a short introduction to the subject wastewater treatment and drinking water preparation, the pupils have the possibility to follow the way of the wastewater from the sewer until the stream Bandtälesbach on a guided tour on the grounds of the wastewater treatment plant for research and education (LFKW). Then the pupils can simulate and analyze some of the purification processes which are used in the wastewater treatment plant e.g. coagulation/flocculation, sedimentation and flotation. There are thematised experiments about the drinking water purification and its connection to the daily contact with drinking water. Experiments about calcium, softening and gas exchange are run as well. The aim of the holiday camps is to provide the opportunity to experience sciences and engineering at first hand. Those five days shall show the pupils that plenty of every day life issues are related to engineering, especially the environmental area, that a lot of tasks and measuring are not just run in the laboratories but also afield and that the engineering occupation provides diverse and interesting tasks for women. The holiday camps contain all three thematic modules of the Nassy – experimental afternoons (modules I-III).

The holiday camp starts in the institute of hydraulic engineering (IWS) in Stuttgart to relate it with the university as the place of study. At first an introduction to the subject and viewing of the research facilities VEGAS and the hydraulic laboratory at IWS take place. The camp is closing with the viewing of the wastewater treatment plant for research and education (LFKW) as well as the modern laboratories at ISWA.

Beside interesting experiences and backgrounds social integration is another important part of the camp.

The third component (information about study and employment) which is in charge of VEGAS, LWW, ISWA, the student counselling centre and the agency for employment in Stuttgart, offers the pupils their parents and teachers a variety of possibilities for employment guidance. The events are organized similar to fairs and contain short lectures, viewings of technical facilities, active experimentation and information stands.

| Financing Institution:                          |
| Ministry of science, research and art of the federal state of Baden-Württemberg |
| Regional Federal Employment Agency Baden-Württemberg |

| Project Partner:                           |
| Institute of Hydraulic Engineering (IWS), VEGAS and LWW, Student Counselling Centre (ZSB) at the University of Stuttgart |

| Project Manager:                       |
| Prof. Dr.-Ing. Heidrun Steinmetz |

| Project Coordinator:                  |
| Dipl.-Ing. Ralf Minke, AOR |

| Contact:                        |
| Dipl.-Ing. S. Schmidt |

Fig.: Participants of the NASSY holiday camp
Diploma- and Master Thesis

Die gesplittete Abwassergebühr in der Praxis
Frank Wunderlich (Bauingenieurwesen) (2008)
Betreuer: Dipl.-Ing. C. Meyer; Prof. Dr.-Ing. U. Rott

Cost Functions for Rapid Gravity Filters applied as Pretreatment Option in SWRO Desalination
Sonja Amend (Umweltschutztechnik) (2008)
Betreuer: Dipl.-Ing. C. Meyer; Prof. Dr.-Ing. U. Rott

Untersuchungen zur Ermöglichung des biologischen Abbaus organischer Inhaltsstoffe aus der Papierproduktion mittels anaeroben Verfahren
Daniel Löffler (Bauingenieurwesen) (2008)
Betreuer: Dipl.-Ing. R. Minke, AOR; Prof. Ulrich Rott

Rahadi Evaluation of Driving Forces for the use of Membrane Technology in the Pulp and Paper Sector in Indonesia
Karen Damayanti (WASTE) (2008)
Betreuer: Dipl.-Ing. R. Minke, AOR; Prof. Ulrich Rott
Independent Study

Efficiency Assessment of Urban Water Utilities using Data Envelopment Analysis - a Case Study of National Water and Sewerage Corporation Uganda
Fredrick Tumusiime (Infrastructure Planning) (2008)
Betreuer: Dipl.-Ing. R. Minke, AOR; Prof. Dr.-Ing. U. Rott
Master Thesis

Untersuchungen zur Adsorbierbarkeit von organischen Stoffen an Aktivkohle mit einem vereinfachten Labor-Schnelltest
Sabine Mertineit (Umweltschutztechnik) (2009)
Betreuer: Dipl.-Ing. R. Minke, AOR; Prof. Ulrich Rott

Pilotierung einer Nanofiltrations- bzw. Niederdruckumkehrosmoseanlage zur zentralen Trinkwasseraufbereitung - Ermittlung von Betriebsparametern für eine künftige großtechnische Membrananlage unter Berücksichtigung wasserchemischer Effekte
Steffen Greger (Umweltschutztechnik) (2009)
Betreuer: Dipl.-Ing. R. Minke, AOR; Prof. Dr.-Ing. H. Steinmetz

Quantitative und qualitative Beschreibung der Phosphorelimination am Beispiel der Kläranlage LFKW unter Berücksichtigung der Fraktionen
Alexandra Wagner (Umweltschutztechnik) (2009)
Betreuer: Dipl.-Ing. R. Minke, AOR; Prof. Heidrun Steinmetz

Untersuchung der Einflussfaktoren zur Wasserabscheidung an Filtermedien
Qingfan Zhang (Umweltschutztechnik) (2009)
Betreuer: Dipl.-Ing. R. Minke, AOR; Prof. Dr.-Ing. H. Steinmetz
Contact

Dipl.-Ing. Ralf Minke, Akad. Oberrat
Tel.: ++49 (0)711/685-65423
Fax: ++49 (0)711/685-63729
E-Mail: ralf.minke@iswa.uni-stuttgart.de

Secretary´s office

Gabriele Glaßmann
Tel.: ++49 (0)711/685-63711
Fax: ++49 (0)711/685-63729
E-Mail: gabriele.glassmann@iswa.uni-stuttgart.de

Scientists

M. Sc. Kenan Güney
Tel.: ++49 (0)711/685-65425
Fax: ++49 (0)711/685-63729
E-Mail: kenan.gueney@iswa.uni-stuttgart.de

Dipl.-Ing. Manuel Krauß
Tel.: 0711 / 685 - 63700
Fax: 0711 / 685 - 63729
E-Mail: manuel.krauss@iswa.uni-stuttgart.de

Dipl.-Ing. Andreas Neft
Tel.: ++49 (0)711/685-65425
Fax: ++49 (0)711/685-63729
E-Mail: andreas.neft@iswa.uni-stuttgart.de

Dipl.-Ing. Sabine Schmidt
Tel.: ++49 (0)711/685-63738
Fax: ++49 (0)711/685-63729
E-Mail: sabine.schmidt@iswa.uni-stuttgart.de

Dipl.-Ing. Quingfan Zhang
Tel.: 0711 / 685 - 60497
Fax: 0711 / 685 - 63729
E-Mail: quingfan.zhang@iswa.uni-stuttgart.de

Meanwhile quittet:

Dipl.-Ing. Christine Dobslaw
Dr.-Ing. Holger Kauffmann
Dipl.-Ing. Christof Zinßer

Laboratory

CTA Ellen Raith-Bausch
Tel.: ++49 (0)711/685-65400
Fax: ++49 (0)711/685-63729
E-Mail: wgw.labor@iswa.uni-stuttgart.de
Chair of Waste Management and Emissions

o. Prof. Dr. -Ing. Martin Kranert

Solid Waste Management | SIA
Dr. -Ing. K. Fischer

Hazardous Waste and Contaminated Sites | SOA
Prof. Dr. -Ing. E. Thomanetz

Measuring in Air Pollution Control | TAL
Dr. -Ing. M. Reiser

Biological Air Purification | ALR
Prof. Dr. rer. nat. K.-H. Engesser
Chair of Waste Management and Emissions

The aim of research and education at the Chair of Waste Management and Emissions is to assure resource conservation and climate protection in a sustainable manner. Within this context, material flows that become waste as result of the use of resources, their treatment processes, along with the emissions from waste treatment plants, are considered. The topic of biological waste air purification is dealt in a special department within the chair. Considering that sustainable waste management gives priority to actions that counteract the generation of waste, fundamental waste management processes, which serve as cornerstones for sustainable resource management, span from the generation of waste and its avoidance, over the recovery of materials and energy from waste, up to the environmentally sound disposal of wastes and the control of the associated emissions.

Education and research encompass a holistic approach to waste management, from waste avoidance, to the valorisation of wastes, up to the environmentally sound disposal of residual waste. Beside the lectures offered for Civil Engineering students, courses are specially tailored for the German taught Environmental Engineering program, and the international Master of Science program „Air Quality Control, Solid Waste and Waste Water Process Engineering – WASTE“.

Because of the retirement of Prof. Dr. -Ing. Dipl.-Chem. Erwin Thomanetz in June 2008 and new additional topics, the work areas in our department have been newly arranged and newly renamed.

Dr.-Ing. Dipl.-Chem. Klaus Fischer is in charge of solid waste working group; Dipl.-Ing. Gerold Hafner leads the working group for resource management and industrial recycling and Dr.-Ing. Dipl.-Chem. Martin Reiser is responsible for the emissions working group. The research team for IGNIS project is led by Mr MSc Nicolas Escalante and Dipl.-Geogr. Agata Rymkiewicz.

Research is focused on the following fields:
- Modelling, simulation and evaluation of waste management systems and concepts taking into consideration resource conservation and climate protection.
- Biotechnological waste treatment processes (composting, anaerobic digestion), concentrating specially on process modelling and simulation of anaerobic systems, and regenerative energy recovery from organic waste and renewable resources.
- Examination and evaluation of decentralized disposal systems for the joint treatment of solid waste and wastewater, as well as energy recovery (zero waste and wastewater processes e.g. tourist areas, islands).
- Infrastructure development for future megacities, particularly in developing and emerging economies. Scientific accompaniment of the implementation of sustainable material management systems and waste treatment technologies.
- Analysis of wastes and emissions
- Laser based method of measuring methane emissions from area sources
- Stabilization of landfills by in-situ aeration

The Chair of Waste Management and Emissions is a member of several competence networks e.g. Competence Centre Environmental Engineering (Kompetenzzentrum für Umweltschutz Region Stuttgart (KURS e.V.)) and several standardization committees and scientific advisory boards, and as a result has established numerous contacts and cooperation agreements with several research institutions, public waste management authorities and private enterprises. Cooperation with foreign universities and research institutions have been established through international research projects.

Activities in Education

The Chair’s staff, including lecturers, researchers and external readers, holds lectures covering several study courses, and supervises students from different academic programmes:

German taught Diploma "Civil Engineering" and "Environmental Engineering":
- From winter semester 08/09 the diploma courses Environmental Engineering will be converted to Bachelor-/Master Courses and the form of modular teaching will be provided.

- Core course “Sanitary Engineering (and Waste Disposal)”, Subarea: Solid Waste Management
- Specialization field “Solid Waste Management” (including 13 specialized lectures, laboratory work, seminars)

International Master Programme „Infrastructure Planning“:
- Solid waste Management
- Ecology III

International Master Programme „WAREM“:
- Solid waste Management
International Master Programme „WASTE“ (Established in 2002):
- Sanitary Engineering, course Solid Waste Management
- Mechanical and Biological Waste Treatment
- Design of Solid Waste Treatment Plants
- Industrial waste and contaminated sites
- Independent Study
- Biological Waste air purification and adsorption
- International Waste Management
- Sanitary Engineering: Practical class
- Ressourcenmanagement
- Environmental relevance
- Biogas
- Waste management systems

Seminars, laboratory work, design exercises, and excursions supplement the lectures.

International

Cooperation agreements in research and education have established with the Institute of Environmental Engineering and Biotechnology at the Tampere University of Technology (Finland) as well as the Dokuz Eylül University at Izmir (Turkey), the University of Salerno (Italy), the University of Thessaloniki (Greece), the Technical University of Temesvar (Romania), the Universiti Saints Malaysia (Malaysia), the Guangxi University (China), the Universidad Católica Boliviana „San Pablo“ /Bolivia, the Universidad Costa Rica (Costa Rica), the Universidade Federal do Parana (Brazil), and the Universidade Federal do Santa Catarina (Brazil).

Furthermore, several staff members of the Chair are active as associated lecturers at other institutions worldwide.

Conferences

Beyond research and academic activities, the Chair is involved in the continuing education and advanced training of professionals. Conferences organized by the Chair include the “Baden-Wuerttembergischen Waste Days“, hosted together with the Environmental Ministry of the federal state of Baden-Wuerttemberg; the waste management colloquia; the landfill seminars, in association with the Environmental Protection Agency of the federal state of Baden-Wuerttemberg; continuing education courses in cooperation with the Society of Engineers for Water Management, Waste Management and Agricultural Infrastructure (Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau (BWK)); as well as lectures in the field of waste management within the scope of the distance education programme ”Water and Environment“ offered by the Bauhaus-Universität Weimar. Finally, in collaboration with the Turkish Environmental Ministry, the tradition of the German-Turkish Conferences has been revived.

Committees

Staff members are also involved in several committees, including academic councils, professional associations and advisory boards. Since the 1st, April 2009 Prof. Kranert has been Chairman of the Joint Commission of Environmental Engineering, and manager of this master program is Dipl.-Biol. Andreas Sihler. These include the German Institute of Standardization (DIN), the Association of German Engineers (VDI e.V.), the Society of Engineers for Water Management, Waste Management and Agricultural Infrastructure (Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau (BWK)), Working Group for the Valorization of Municipal Solid Waste (Arbeitskreis zur Nutzbarmachung von Siedlungsabfällen (ANS e.V.)), German Association for Water, Wastewater and Waste (DWA e.V.), Association for Quality Control of Compost derived from Sewage Sludge , Association for Quality Assurance of Fertilization and Substrates (VQSD eV), the ORBIT Association, the European Compost Network (ECN), and the Federal Compost Quality Association (Bundesgütegemeinschaft Kompost (BGK)). Prof. Kranert is a member of the Quality Committee of the BGK, the Chair of the Trustees of the Professors of Waste Disposal Community for the German waste disposal industry, spokesman for the Group of Professors in Solid Waste Management in RETech under the initiative of the Federal Environment Ministry and a member of the Sustainability Advisory Board of the State of Baden-Wuerttemberg.

Additionally, the chairholder serves as referee for several research funding institutions, scholarship foundations and accreditation agencies. Furthermore, several staff members play a leading role in the Competence Centre ”Environmental Engineering“ (Kompetenzzentrum für Umweltschutz Region Stuttgart (KURS e.V.)).
Innovation stress and short product life cycles in the industrial sector of biomass processing ask for clear methodical procedures during the design process. Currently, there is a lack of systematic approaches to the development process of technical systems in this sector. Therefore, in this work the design method proposed by The Association of German Engineers (VDI) was tested and adapted to the context of biomass process engineering. The development of a mixing and transporting robot for solar biomass dryers exemplifies the potential of that systematic and scientific approach.

First, the requirements on the robot were determined to set up in ‘requirements lists’. A ‘conflict matrix’ supported identification and elimination of conflicts of aims. The requirements on the functions of the robot were abstracted and arranged in several ‘function structure plans’. For each function, various potential ‘working principles’ were identified and organised in several ‘morphological matrices’. In order to select exclusive reliable and cost-efficient components each of the 155 identified working principles was benchmarked in a ‘pre-evaluation matrix’. The best-marked components were chosen and combined to two promising preliminary concepts for the robot.

Next, the modules of the robot were refined and worked out to two preliminary embodiment designs, solution (1) and (2). Before releasing for production, both designs were technically and economically evaluated. As result, the economically and technically weak points were identified. The product strength s of the solutions for the robot was computed as $s_1 = 0.79$ and $s_2 = 0.70$. Solution (1) was therefore selected for being designed in detail. For detail design phase, an approach is presented to combine novel Digital Mock-Up (DMU) techniques with the VDI design method. As result, especially FEM structure analysis, collision and assembly analyses were integrated into the VDI procedure. Prior to building the first physical prototype design problems were identified and solved on the digital prototype ranging from geometrical errors to impossible assembly sequences. In addition, this work shows a strategy for Product Data Management (DMU). Data information loss was therefore reduced and data safety was increased since the suppliers got exclusively the manufacturing information they needed actually. Finally, a physical prototype was manufactured and tested before market release. For this testing phase, an optimisation approach was integrated into the VDI design process. That approach was exemplified by optimising the mixing and transporting module of the biomass processing robot. During testing
phase, both useful and harmful interactions between the components were diagnosed and set up in a Reverse Functional Model. That model was visualised by the Interaction Matrix. Based on the Reverse Functional Model, several optimisation strategies such as problem elimination, cost reduction or value increasing were discussed. The optimisation was done according to the value increasing strategy. Embedding computer-aided ergonomic design (CAED) allowed avoiding ergonomic failures, which were identified during the testing of the robot.

The performance of a biomass processing greenhouse robot for autonomous handling of biomass in solar dryers was investigated. Power consumption and specific energy demand were registered during various field tests. Applying 3D laser scanning, the effects of the rotary tiller type tool on the transportation capacity were investigated. An empirical model describing these effects was developed. For efficient motion control, six motion strategies for the robot were developed. Each of the corresponding trajectories consists of more than 1,300 three-dimensional coordinate points. The motion strategies were evaluated due to their efficiency to select the most promising one for being embedded into the control system of the robot. For evaluation, an algorithm was developed calculating different evaluation parameters such as total cycle time, covered distance and no-load time. The best strategy was recommended for being embedded into the control system of the robot.

In conclusion, the adapted and extended VDI design procedure, which was presented in this work, supported rapid development of an innovative and cost-efficient robot. In addition, it delivered a consistent documentation that allows tracing all decisions made during the product development. For the testing phase, which is up to now not a part of the classical VDI design method, the presented optimisation approach proved to be uncomplicated, clear and compatible to the VDI design procedure. In combination with CAED it could contribute to develop highvalue and user-friendly products. Regarding the control design of the robot, 3D laser scanning helped to identify rapidly optimum parameter settings for maximum transportation capacity of the robot. Finally, 3D path planning led to optimised motion paths and therefore to reduction of cycle time of the whole process of drying biomass.

In general, the development of the mixing and transporting robot contributed to increased automation level of solar and solar assisted drying systems. From now the solar drying technology possesses a fully automated processing robot and the competitiveness to conventional systems will be enhanced significantly. Furthermore, by now a technology is provided, which is suitable for application in industrial scale such as processing of biowaste or residues from biogas plants.

Doctoral candidate: Nikica Starčević
Principal examiner: Prof. Dr.-Ing. Martin Kranert
Secondary examiner: Prof. Dr. Joachim Müller

Nikica Starčević

"International Kitzbühler Water Prize" for Mr. Nikica Starcevic

Mr. Nikica Starcevic was granted the degree of doctor with his excellent dissertation, which on 14th October, 2009 won him the first place (3000€) in "International Kitzbühler Water Prize" under the program Kitzbühler Water Price 2009.

Mr. Starcevic’s Phd. dissertation is entitled „Systematic design and process optimization of a robot for treatment of biomass in solar dryers”, which is under the cooperation project between the Institute for Sanitary Engineering, Water and Waste Management at the University of Stuttgart (Prof. Kranert) and the Institute of Agricultural Engineering at the University of Hohenheim (Prof. Müller). Mr. Starcevic graduated with distinction in the spring of 2009 at the Faculty of Civil and Environmental Engineering, University of Stuttgart. Since the summer of 2009 Dr. Starcevic has been working as the project leader in a consulting firm for environmental technologies.
Simulation and nonlinear control of anaerobic digestion

Anaerobic digestion represents a valid option in the treatment of organic waste, providing a solution for its disposal and the simultaneous production of green energy. However, the process is considered problematic and tends to instability due to acidification. Process control can improve the stability of the system by keeping the acid concentration within safety limits, while permitting a regular and sustained production of methane. The scope of this work is the development and test of a nonlinear control strategy for anaerobic digestion using reliable virtual laboratories or simulators. The work proceeded through two major steps:

1. the implementation and calibration of a nonlinear anaerobic digestion model to test the capability of reproducing the dynamical behaviour of a real system; the model chosen is the detailed ADM1 [13], implemented in the software Matlab® and calibrated for the simulation of three real cases: a biowaste reactor, a cofermentation reactor for sludge and kitchen waste and a surplus sludge fermentation process. In the latter case a detailed parameter estimation procedure is implemented.

2. the design, implementation and tuning of a nonlinear adaptive control algorithm, using the feedback linearisation method; the control system is tested on simulated plants, a co-fermentation reactor for corn silage and cow manure and the biowaste reactor simulated in the previous section.

The results of the work are very encouraging: the control system is able to reject the disturbances acting on the feed of the process while maintaining a sustained biogas production. The tests on the simulated systems are a valid alternative to costly and time-consuming experimental work, and can be considered reliable, if the model has been properly calibrated to the real system.

Doctoral candidate: Carla Cimatoribus
Principal examiner: Prof. Dr.-Ing. Martin Kranert
Secondary examiners: Prof. Dr.-Ing. Eckhard Kraft
Prof. Dr.-Ing. Renatus Widmann

Carla Cimatoribus
Simulation and nonlinear control of anaerobic digestion (2009), Forschungs- und Entwicklungssinstitut für Industrie- und Siedlungswasserwirtschaft sowie Abfallwirtschaft e.V. Stuttgart (FEI). München: Oldenbourg

The bacterial degradation of halogenated and methylsubstituted aromatic mixtures and its application in biological waste air treatment

Methyl- and halogen substituted aromatics are widely used in industrial processes as educt for the production of o-cresol, agro-chemicals, flame retardants, dyes, varnish and pigments, textile additives, adhesives, polymers and resins, air fresheners, drain cleaners and optical brighteners. Furthermore, it is used as solvent for agro-chemicals, in heavy metal industry, paint thinners, heat conductable oils as well as condenser liquids and is used as additive for fuels. Depending on the specific aromatic compound about 5–15 % of the world production per year is set free into the air or water. Especially in case of the waste air high volumetric flows with low carbon freight occur. Thus, biological treatment techniques are the first choice as treatment procedure.
However, the simultaneous degradation of mixtures of methyl substituted or halogene substituted aromatics is sophisticated because of incompatible induced pathways and the production of toxic intermediates as a result of this (so called suicide inactivation). Furthermore, based on regulatory effects only one specific pathway for degradation of single compounds is induced leading to non simultaneous degradation of the other waste air compounds.

In context of this work two bacterial strains Burkholderia fungorum FLU 100 and Rhodococcus wratislaviensis OCT 10 were analysed in detail. Next to a interesting spectrum of degradable aromatic substrates, both bacteria show novel, non described pathways. FLU 100 is capable to mineralise toluene using a modified ortho-pathway and OCT 10 is able to degrade the persistent compound 2-chlorotoluene using a so called meta-pathway. Studies of feasibility of simultaneous degradation of toluene and 2-chlorotoluene were extended by further aromatic compounds like fluorobenzene, chlorobenzene, benzene and o-xylene. The studies were operated in laboratory and half-technical scale. The latter were realised in a biotrickling filter system where the effect of highly fluctuating waste air...
compositions, waste air concentration as well as starvation periods, effect of toxic peak concentrations, alternating carbon freight time profiles and the adsorption behaviour of the chosen aromatics on different package materials were examined.

Daniel Doblaw
Principal examiner: Prof. Dr. K.-H. Engesser
Secondary examiners: Prof. Dr. T. Hirth

Co-Supervision of Dissertations and Habilitations

Entwässerung und solare Trocknung von flüssigem Klärschlamm
Rainer Baumann
Supervisor: PD Dr. M. Bux, Universität Hohenheim (2009)
Dissertation

Entwicklung eines Emissionsprognoseverfahrens zur Erstellung der Geruchsprognosen für Kompostierungsanlagen verschiedener Bauweisen und Verfahrenstechniken
Kaukab Harba
Supervisor: Prof. Dr.-Ing. habil. W. Bidlingmaier, Bauhaus Universität Weimar (2009)
Dissertation

Environmental Assessment of Garden Waste Management
Alessio Boldrin
Supervisor: Prof. Dr. T. H. Christensen, Technical University of Denmark, Kgs Lyngby (2009)
Dissertation

Stickstoffhaushalt bei der Kompostierung: Bilanzen, Gehalte, Umsetzungs- und Austragsprozesse
Dr.-Ing. Ina Körner
Supervisor: Prof. Dr.-Ing. R. Stegmann, Technische Universität Hamburg-Harburg (2008)
Habilitation

Publications


Chair of Waste Management and Emissions


In den Jahren 2008 und 2009 wurden in der Schriftenreihe Stuttgarter Berichte zur Abfallwirtschaft folgende Bücher herausgegeben:

Band 92: Zeitgemäße Deponietechnik 2008

Band 93: Abfalltage 2008

Band 94: Zeitgemäße Deponietechnik 2009


Band 97: Der bakterielle Abbau von halogen- und methylishustuitierten Aromaten gemischen und dessen technische Anwendung in der biologischen Abluftreinigung
Autor: Daniel Dobslaw (2009)
295 S., 134 Abb., 51 Tab., ISBN 978-3-8356-3192-2 (38,50 €)

Band 98: 87. Abfallwirtschaftliches Kolloquium

Dr. Sigrid Kusch, Prof. Martin Kranert and Dr.-Ing. Martin Reiser are guest editors for the International Journal of Environmental Engineering Special Issue „Progress in Landfill Management and Landfill Emission Reduction“.
Contact

**o. Prof. Dr.-Ing. Martin Kranert**
Tel.: ++49 (0)711/685-65500 oder 65495
Fax: ++49 (0)711/685-65460
E-Mail: kranert@iswa.uni-stuttgart.de

**Secretary´s office**

Gudrun Heinl
Tel.: ++49 (0)711/685-65495
Fax: ++49 (0)711/685-65460
E-Mail: gudrun.heinl@iswa.uni-stuttgart.de

**Central functions of teaching and research**

Dipl.-Geol. Detlef Clauß
Tel.: ++49 (0)711/685-65502
Fax: ++49 (0)711/685-65460
E-Mail: detlef.clauss@iswa.uni-stuttgart.de

Dr. sc. agr. Cornelius Jantschke
Tel.: ++49 (0)711/685-65407
Fax: ++49 (0)711/685-65460
E-Mail: cornelius.jantschke@iswa.uni-stuttgart.de

Dr. sc. agr. Dipl.-Ing. Sigrid Kusch
Tel.: ++49 (0)711/685-65409
Fax: ++49 (0)711/685-65460
E-Mail: sigrid.kusch@iswa.uni-stuttgart.de

Solid Waste

Dr.-Ing. Klaus Fischer
Tel.: ++49 (0)711/685-65427
Fax: ++49 (0)711/685-65460
E-Mail: klaus.fischer@iswa.uni-stuttgart.de

Resource management and industrial recycling

Dipl.-Ing. Gerold Hafner
Tel: ++49 (0)711/685-65438
Fax: ++49 (0)711/685-65460
E-Mail: gerold.hafner@iswa.uni-stuttgart.de

**Emissions**

Dr.-Ing. Martin Reiser
Tel.: ++49 (0)711/685-65416
Fax: ++49 (0)711/685-63729
E-Mail: martin.reiser@iswa.uni-stuttgart.de

**Biological Air Purification**

Prof. Dr. rer. nat. habil. Karl-Heinrich Engesser
Tel: ++49 (0)711/685-63734
Fax: ++49 (0)711/685-63785
E-Mail: karl-h.engesser@iswa.uni-stuttgart.de

**Environmental Engineering study course**

Study course manager
Dipl.-Biol. Andreas Sihler
Tel.: ++49 (0)711/685-65498
Fax: ++49 (0)711/685-65460
E-Mail: andreas.sihler@iswa.uni-stuttgart.de

Constanze Sanwald M.A.
Tel.: ++49 (0)711/685-65413
Fax: ++49 (0)711/685-63729
E-Mail: constanze.sanwald@iswa.uni-stuttgart.de
Solid Waste Management

In our job, we’re on top of the pile

Waste is a potentially valuable material in the wrong place. This statement is the central principle of many activities of our municipal solid waste section. Focal points are avoidance, utilisation and environmentally friendly treatment of municipal and commercial waste.

Both ecological and economical aspects are dealt with. It has been shown, e.g., that avoidance of waste in commercial operations can be financially interesting for the companies concerned. We are intensively busy with the question of how waste management of the future may look. Some questions here are: which waste types should continue to be collected separately? Which mixtures of substances can be separated using new technical methods? Can part of the waste be economically transported by rail? Several research projects are occupied with the treatment of biological waste, among others with the questions: do pollutants exist in organic wastes? Are these pollutants reduced during composting? What energy potential is concealed in organic waste, if they are used in fermentation plants to generate biogas or employed in biomass power stations? For the creation of waste management concepts for communities or counties, the simulation and modelling of waste streams and utilisation techniques play a major role. Because even humans can become a waste problem from an ecological point of view, we have carried out investigations on the ecological effects of burials and cremations. For a number of communities, our investigations on decentral concepts for waste treatment in tourist regions are of particular interest. These island solutions allow processes for waste and sewage treatment to be combined with the generation of service water and power. Decentral and adapted technology is of prime importance for the sustainable development of third-world and fast-developing countries. This is why we have established cooperation and joint projects with institutions in Brazil, Costa Rica, Egypt, Turkey, China and other countries.
Projects

City with Energy Efficiency - SEE Stuttgart

The project LAKE traced to the following objectives:
1. Development of a macroscopic balance model
2. Development of a microscopic model strategy
3. Identification of optimization potential
4. Creating a Road Map „energy“ by 2050
5. Implementation of identified actions
6. Evaluation of operations and performance review

Prerequisite for a sustainable society is in addition to economic prosperity and social well-being also a healthy environment. It is necessary to reduce emissions of pollutants - in particular climate-relevant pollutants - and to increase significantly the efficiency of resource use. As undisputed the need for energy and resource efficiency in society and politics is, so difficult is the setting of concrete goals and the understanding on the „right“ strategies and actions. Reasons for this include the difficulties of assessing impact of measures in the framework of formulation of policy / planning strategies (overall effectiveness, as well as the contribution of well targeted measures to achieve the objectives) and the uncertainty about the nature and scope of opportunity costs in the case of scope achievement as well as the potential distributional effects of social costs. A suitable tool for municipal planning strategy may be models that allow assessing the effects of various measures in terms of their individual as well as cumulative effect. In this framework, with the project SEE it is meant to develop a macro and a microscopic balance and strategy model to support the development of the local strategies and action planning.

The project SEE has the following objectives:
1. Development of a macroscopic balance model
2. Development of a microscopic strategy model
3. Identification of optimization potential
4. Creating a Road Map „energy“ up to 2050
5. Implementation of identified measures
6. Evaluation of measures and performance review

Key activities of the Chair of Solid Waste Management and Exhausted Air:
- Macroscopic balance model for the energy consumption of consumer goods in Stuttgart
- Microscopic balance and strategic model for energy consumption of households in Stuttgart caused by the consumption of goods
- Development and evaluation of measures in the waste and consumption area

### Financing institution:
Bundesministerium für Bildung und Forschung BMBF
- Förderinitiative „Wettbewerb Energieeffiziente Stadt“

### Project partner:
- Regional Capital City of Stuttgart
- EnBW Energie Baden-Württemberg AG
- Fraunhofer-Institute for Construction Physics
- University of Stuttgart
- Institute of Railway and Transport Sciences (IEV)
- Institute for Regional and Development Planning (IREUS)
- Institute for Sanitary Engineering, Water Quality and Waste Management, Chair of Solid Waste Management and Exhausted Air (ISWA, AFW)
- Institute of Social Sciences, International Center for Cultural and Technological Research (IZKT); Interdisciplinary Research Risk and Sustainable Technology Development (ZIRN)
- Institute of Road and Transportation, Department of Transport Planning and Traffic Control Systems (VUV)

### Duration:
April 2009 - March 2010

### Contact:
Prof. Dr.-Ing. Martin Kranert
Dipl.-Ing., M.Sc. Mihaela Berechet
Dipl.-Geol. Detlef Clauß
Development of new technologies for production and application of plastics from renewable resources.

The annual output of petrochemical plastics of the global production from crude oil is more than 300 million tonnes. Plastics are used in numerous applications for our daily life. But after their useful life as plastics materials they will be disposed in landfills, dumpsites, or delivered to composting plants or to incinerators. The degradability in general is very slow, in the case of landfills we are expecting to last hundreds of years. In incinerators they are used for producing energy, but with this oxidising process plastics from crude oils are contributing to increasing amounts of the greenhouse gas carbon dioxide (CO₂).

Degradability of plastics is known as a non-biotic process with the influence of UV, light and oxygen. A second way for degradation is the biological influence of microorganisms. Also some of the petrochemical plastics can be biologically degraded, e.g. polyesters. But also in this case we will have increasing amounts of the greenhouse gas CO₂.

Therefore during the last years new plastics were developed, plastics from renewable resources and biologically degradable by microorganisms.

Our own project research was done with a very new degradable plastic from lignin, a by-product in the cellulose pulping process for papermaking. The degradability of this new product based on lignin was tested in aerobic conditions with respirometric tests and also in a composting process. The velocity of the degradation process is depending on the composition of the plastics. In the respirometric tests we found for the different products a degradation rate of about 30% up to 80% in a time of 80 days, using longer testing time, the degradation rate was increasing up to 50% up to 100% in 120 days.

Plastics have an important impact on the environment. Bioplastics can be produced from renewable raw material and are partially biologically degradable. Currently the production of bioplastics is relatively low. In the case of bigger amounts this material should be integrated in the waste management. The new bioplastics based on lignin that we have analyzed could be considered as well degradable in the respirometric tests.

The usability for many applications seems to be really good. As it is a material from renewable resources, the degradation process will not give any influence to the greenhouse effect.

Sponsorship:
AIF

Projekt partner:
• Fa. Tecnaro GmbH
• Fa. Bauer Kunststofftechnik
• Institut für Siedlungswasserbau, Wassergüte- und Abfallwirtschaft; Lehrstuhl für Abfallwirtschaft und Abluft (ISWA, AFW)

Duration:
April 2008 - March 2010

Contact:
Dr.-Ing. Klaus Fischer
Dipl.-Ing. Jingjing Huang
IGNIS – Income Generation und Klimaschutz durch die nachhaltige Inwertsetzung von Siedlungsabfällen in Megacities (IGNIS)

Increasing urbanization in rapidly growing urban centres in developing countries has lead to the increase environmental pressure on natural resources, but at the same time it opens an opportunity window for the exploration of new approaches in order to help these countries direct their efforts towards sustainable development. The research project “IGNIS - Income Generation and Climate Protection through the Sustainable Valorisation of! Municipal Solid Wastes in Emerging Megacities” strives to develop a new concept for the improvement of waste management and the local environment while generating new workplaces, increasing general welfare, considering occupational safety and health and reducing greenhouse gas emissions. Funded by the German Ministry of Education and Research (BMBF) through it Future Megacities programme, the IGNIS project takes on a systemic research approach to resource recovery from wastes in large urban centres in developing countries by implementing the project in the Ethiopian capital, Addis Ababa. The project consortium, composed by the AT-Association, the Universitaet Stuttgart, the Institute for Future Energy Systems and the Federal Institute for Occupational Safety and Health, from Germany, and the Environmental Development Agency for the Third World, Faculty of Technology and the Centre for Regional and Local Development Studies of the Addis Ababa University and the Environmental Protection Agency of Addis Ababa, from Ethiopia, will holistically assess constraints of the existing waste management system, introduce decentralized pilot projects and evaluate their environmental, economic and social impacts, develop a decision support system and carry out extensive training of the local authorities and personnel. At the end of the project, the extent to which the results and insights gained from research are transferable to other emerging megacities will be evaluated.

Within the scope of the IGNIS Project understanding the material and energy flows that move through the urban metabolism is of great importance in order to establish their environmental, economic and social relevance. Materials consumed by households, commercial and public institutions are converted into wastes and enter the municipal waste management system. A large part of these materials are landfilled without treatment or recovery, while only part of the secondary resources with market value are recovered and reintroduced in the economic cycle.
In most megacities in developing countries, the fate of postconsumer materials, organic waste and other residuals are not well known. This is a result of the lack of a system of data collection along the waste management chain. In many cases there is no systematic recording and assessment of the amount of waste collected and transported by the municipal or private enterprises. Additionally, some of the final disposal sites lack of a weighing bridge to register the amount of residues landfilled and little or no information is available about the streams of valuable materials recovered and recycled. The previous situation is compounded by the fact that large amounts of recyclables are recovered by an army of informal waste pickers, which is practically invisible to the waste management authorities, that scavenge for materials on the streets and at the final disposal sites.

Based on the case study of the Ethiopian capital, the IGNIS project strives to structure the waste management system by identifying the actors that determine the dynamics of the system and by quantifying the material flows. For this purpose the project consortium is currently developing a methodology to characterize in detail how the different subsectors of the waste management chain function. This involves eliciting which factors influence the performance of the collection, transportation and street sweeping sector, which interactions determine how much material is recovered and recycled by both the formal and informal recovery sectors, and what are the reasons for the amount of waste currently being disposed.

In order to guarantee that the project findings are well founded, a reliable data basis must be collected. This data basis includes relevant information of spatial, socioeconomic, and waste management structures, which in many cases is missing or incomplete. The quantification and characterization of the resource potential in the municipal wastes being generated actually and in the future is a key step towards completing this data pool. Especially for planning purposes, it is not enough to know the composition of the waste, but also the per capita waste generation. For this purpose, standard

GIS Map, Socio-Economic Interview of Households in Addis Abeba, November 2009
methodologies used in industrialized countries for the characterization and quantification of municipal solid wastes have been taken as a basis, and have been adapted and synthesized into a solid waste analysis procedure appropriate for considering the restrictions and local conditions.

Since working conditions during waste collection and sorting were not comparable with the European situation, occupational safety and health standards for the respective activities had to be adapted as well by using the locally procurable means. Efficient and inexpensive solutions on a low technical level were developed and integrated into the solid waste analysis procedure.

As a result of the methodological development and validation, an applicable waste sorting analysis procedure was achieved, while finding a compromise between data quality, workers safety and health and available resources. Furthermore, since standard sample survey techniques have been taken into consideration, sampling errors and uncertainty levels have been accounted for, thus guaranteeing the collection of statistically representative data.

---

**Financing institution:**
Bundesministerium für Bildung und Forschung - BMBF

**Project partner:**
Universität Stuttgart, Lehrstuhl für Abfallwirtschaft und Abluft; Verband zur Förderung angepasster, sozial- und umweltverträglicher Technologien e.V. (AT-Verband); Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAUA); Institut für Zukunftsenergiesysteme (IZES); Environmental Development Action in the Third World (ENDA); Addis Abeba Universität, Faculty of Technology; Addis Abeba Universität, Institute of Regional and Local Development Studies; Addis Abeba Environmental Protection Agency (EPA)

**Duration:**
June 2008 - June 2013; Project evaluation autumn 2010

**Contact:**
Prof. Dr.-Ing. Martin Kranert
Dipl.-Geogr. Agata Rymkiewicz
M.Sc. Nicolas Escalante

**Internet:**
www.p-42.de/ignis

---

**Economic and environmental evaluation of the separate collection of recyclable waste from households.**

According to the currently discussed collection systems in Germany, different scenarios were modelled for the ecological assessment. The priority was to optimize the collection rate and the common collection of non-packaging materials. Alternatively, a scenario was modelled for the common collection of residual household waste and lightweight packaging materials with and without recycling of the lightweight packaging. As reference, scenarios are shown for urban, for densely rural districts and for sparsely populated rural districts. For urban and densely rural districts a collection system for light packaging has been modelled; for rural areas a bring-system to recycling-centres was modelled among others. Thermal waste treatment in waste incineration plants and the pre-treatment in mechanical-biological treatment plants (MBT) were considered for residual household waste and residues from optional treatments. For the MBT, the utilization of refuse-derivate fuel (RDF) in cement plants was modelled. Relevant process steps for collection, processing and recycling of lightweight packaging and non-packaging were modelled for the ecological assessment. The assessment of the waste management scenarios was based on the method of LCA according to the ISO 14040 ff. The impact categories evaluated primarily the impact of greenhouse gases (CO$_2$-equivalents). In order to take into account shifts in other environmental compartments, the analysis considered the impact categories acidification (SO$_2$-equivalents) and eutrophication (PO$_4$-equivalents).

The separate collection and recycling of lightweight packaging has environmental benefits, such as savings of climate-related CO$_2$-equivalents, and the minimization of the acidification and eutrophication potential. Therefore a common collection and the recovery of lightweight packaging and non-packaging must be sought for. For the common collection of light packaging together with residual waste, the separation in a anaerobic mechanical-biological treatment plant with biogas recovery and utilization of the energy-rich fraction in cement kilns, with substitution of coal provides advantages in terms of CO$_2$-balancing in comparison to the direct thermal treatment in waste incineration plants, considering the current approach of the average efficiencies of these plants in Germany. The MBA scenarios with cement kiln show in comparison to waste incineration plants worse results in terms of the acidification and eutrophication potential. If the energy efficiency

---
Chair of Waste Management and Emissions

In incineration plants is increased, the CO₂-balancing advantages of the separate collection with material recovery are reduced significantly, without having the need to derive a change regarding the separate collection. An optimization potential in the status quo is especially given by improving the energy efficiency in incineration plants. Thus, the treatment in waste incineration plants is in terms of CO₂ emissions more favourable than in MBT. No significant differences in the LCA can be observed between urban, densely rural districts and sparsely populated rural districts, since the CO₂-balance only changes marginally with an increased collection effort.

Consequently, it is imperative to adjust, under environmental and cost related aspects, the collection and recycling of packaging waste and residual waste to the local situation. In this sense, the division of packaging and similar non-packaging materials in different collection systems is neither useful nor necessary. Instead, it is necessary to enable a flexible design framework for collection and recovery systems, in order to reach an optimum by involving the local waste disposal situation.

MODULAARE – Integrated modules for high efficient wastewater purification, waste treatment and regenerative energy recovery in tourism resorts

Modules for wastewater purification with membranes and for fermentation of sewage sludge and organic wastes: an integrated concept for recovery of process water, production of hygiene fertiliser and regenerative energy and for waste minimisation.

Introduction:
Background Information:
Germany, as one of the large travel nations, has a special responsibility for a sustainable and environmentally aware tourism. Therefore, one of the main targets of this investigation project is to verify the operation of an innovative, decentralized and modular system for waste water purification, waste treatment and production of energy from biogas in a large Tourists Resort located in Turkey. This modular system combines a membrane system for the purification of wastewater with a fermentation/biogas system for the recovery of relevant quantities of organic wastes.

The advantages of both treatment procedures strengthen themselves and remove disadvantages of the respective procedures, so that the two systems can be operated with a high efficiency regarding economic and environmental aspects.

In the context of this research and demonstration project, a low loaded membrane facility has been installed in a representative Tourists Resort (approx. 900 beds). Efficiency and possible applications for the purified wastewater are determined and examined. Remaining excess sludge is fed directly into the biogas facility where it is co-fermented with organic solid waste (waste from kitchen, restaurant and garden).

The analysis program of the fermentation module covers both the technical adjustment to the input material and the optimisation and simplification of the handling.

Substrates, processing, fermenter, residues and biogas are investigated regarding optimisation. Wastewater resulting from the fermentation process can be supplied to the membrane module. An additional important aspect is the option to realize an energy concept for the optimal use of the biogas and the combination with other regenerative sources of energy (e.g. solar, wind).
This modular, decentralised system is especially suitable for the application in sensitive areas, e.g. tourism regions, corral reefs, islands, coasts, nature parks, etc. The demonstration project MODULAARE should assess whether this modular concept can be operated economically and routinely. Therefore the tests in the practical use and the integration into the processes within the tourists resort are of special interest.

**Innovative Character:**
The innovative character of the MODULAARE concept can be outlined by the following key points:
- Combination of waste recycling + wastewater treatment + energy concept
- Modular units can be adapted to extensions of the hotel
- Decentralised use is possible (bays, little villages without regular wastewater treatment and waste disposal)
- Development of a sustainable, recycling management resulting in an nearly waste- and wastewater-free tourists resort.
- By modifying the solid content and switching on/off individual membrane modules the membrane facility can be adapted very easily to seasonal fluctuations (guest numbers)
- Advanced development to self-sufficient systems (e.g. by including other regenerative energy sources)
- Membrane and sanitation stage (fermentation) enable short cycles (no germs, exciter, etc.)
- Altogether, the membrane system will demand low attention during operation because the settling of the activated sludge plays a role no more
- Difficulties with wastewater in fermentation facilities are solved by means of the membrane facility
- Excess sludge problems are solved by fermentation system

**Advantages:**
MODULAARE promotes substantially the sustainable management of both the hotel system and the environment. The largest advantage which can be expected is the use of the benefits (high-efficient cleaning, recycling of waste, regenerative energy) of both systems. Simultaneous the problems determined by the system (power requirement of the membrane, excess sludge, fermentation wastewater) will be neutralised. Further advantages are:
- Avoidance of pollution of high-sensitive ecological systems (e.g. corral reefs, mud flats, etc.) by insufficiently treated wastewater
- Discharge to dumps which often indicate insufficient standards in tourism regions (methane production leachate, setting, hygiene aspects) will be minimised
- Regenerative energy can be used to save fossil sources of energy
- The modular system makes extensions simple and economically possible (construction, integration into existing modules etc.)
- Direct water utilisation as process water or for irrigation (substitution of drinking water and water for domestic use)
- Depending upon the respective local situation, fermentation residues can be used directly in agriculture or be made applicable in hotel gardens by drainage and maturing to compost
- Water retention capacity of soils and content of humic substances will be increased by application of compost
- Preservation of resources (water, artificial fertiliser, etc.)
- Production of valuable soil-conditioner; saving of artificial fertiliser (costs), compost contributes to improve humus generation and to increase CO₂ fixation in the soils (Kyoto Protocol)
- No problems with organically highly loaded fermentation residues
- Enrichment of ground-water by spray irrigation of green belts and infiltration of the purified waste
- Reduction of environmental pollution as chlorinated water will not be utilised any more
- Cost saving within the area of water supply and wastewater disposal

**Description of the demonstration plant:**
The demonstration plant, located in Iberotel Sarigerme Park (Sarigerme, Turkey), consists of the waste water treatment module (container on the right) and the biogas module. This article describes the anaerobic digestion module.

In this module, organic waste and sludge from the membrane wastewater purification are digested under anaerobic conditions, while producing biogas and anaerobic digestion residues. The digestate can be used as an organic fertilizer if tested suitable.

**The biogas module comprises the following technical components:**
- Delivery storage tank
- Digester
- Gas storage
- Gas flare
- Storage tank for the fermentation output
- Digester input
- Digester Output
- Fermentation residues
Results and conclusions:
The demonstration plant, located at a large tourism resort in Turkey shows the feasibility of the MODULAARE-concept under technical and economical aspects. Results from scientific analyses and measurements show a high efficiency of both components - the waste water treatment module and the biogas module. The two components complement each other. Excess sludge from waste water treatment is utilized within the fermentation process. Biogas of high quality substitutes primary energy resources. The digestate can be used (and sold) as fertilizer or – if more suitable – can be treated within the wastewater treatment module.

Financing institution:
Bundesministerium für Bildung und Forschung
BMBF

Project partner:
- AT-Verband (Verband zur Förderung angepasster, sozial- und umweltverträglicher Technologien e.V.)
- Universität Stuttgart, Institut für Siedlungswasserbau, Wassergüte- und Abfallwirtschaft, Abteilung Abwassertechnik
- Memos Membranes Modules Systems GmbH
- Bio-Sytem Selecta GmbH
- Iberotel Sarigerme Park, TUI AG - Umweltmanagement

Duration:
10/2003 - 01/2007

Contact:
Prof. Dr.-Ing. Martin Kranert
Dipl.-Geogr. Dieter Steinbach
Dipl.-Geogr. Andrea Schultheis
Dr.-Ing. Klaus Fischer
Dipl.-Ing. Gerold Hafner

WasteNet – A new international network for research activities in the area of sustainable solid waste management

WasteNet brings together 12 partners from 3 continents committed to action for conflict transformation through sharing of skills, knowledge, experiences and resources in the area of sustainable solid waste management. WasteNet members from universities and institutions participating in the programme are as follows.

Latin America: Costa Rica, Bolivia, Columbia, Brazil, Chile

Asia: China, Malaysia und Thailand
Europe: Finland, Turkey und Germany.

Aim of WasteNet?
Developing countries have sometimes restricted access to information sources concerning solid and hazardous waste management which has led to a generalised lack of knowledge about the problem, resulting in nonexistent, inappropriate or incomplete technical, political and operational measures. On the other hand, countries with advanced know-how about waste management and treatment technologies are unaware of the research and policy needs in developing countries, being unable to access these potential markets.

Through the establishment of an international knowledge network for the advancement of sustainable and appropriate waste management both issues can be addressed. In this sense, WasteNet strengthens the international research in sustainable and appropriate waste management strategies and technologies.

WasteNet can thereby act as a platform for communication with its highly qualified scientists from Latin America, Asia and Europe to intensify multilateral exchange of experiences and knowledge in the field of waste management.

The first meeting of Latin America Partner took place in October 2007 in Bogota, Columbia. Despite some differences between individual partner countries, the
evaluation of solid waste management in urban and rural areas has shown a surprisingly high compliance. One important insight gained through this meeting is:

Whereas almost all big cities in each partner country can ensure a relatively good collection and treatment of waste, the situation in the rural areas is yet completely unsatisfying. In many cases only a minor part of the waste collected, the disposal happens in illegal dump sites, in rivers or anywhere in the landscape.

Even that the situation in the partner countries is not entirely comparable, our estimations still show that more than 50% of waste appearance occurs in rural areas and therefore is treated inadequately. The environmental impact on soil, ground and surface water and on the atmosphere is without any doubts profound.

A further critical point has been elaborated: Waste from hospitals and hazardous waste (industrial as well as household waste, e.g. batteries or fluorescent tubes). As one of the first Latin-American countries, Colombia compiles a cadastral register of hazardous waste. The next step will be the development of waste treatment and disposal facility plants.

Results, examples and other useful information including dictionary for solid waste management in German, English, Spanish can be found in our website www.wastenet.de.

<table>
<thead>
<tr>
<th>Financing institution:</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU, DG International Cooperation INCO</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project partner:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Costa Rica; Universidad de Costa Rica San Pedro de Montes de Oca, San Jose</td>
</tr>
<tr>
<td>• Brazil; Centro Integrado de Tecnologia e Educação Profissional da Cidade Industrial de Curitiba</td>
</tr>
<tr>
<td>• Bolivia; Catholic Bolivian University „San Pablo“, La Paz</td>
</tr>
<tr>
<td>• Chile; Technical University Federico Santa María, Valparaíso</td>
</tr>
<tr>
<td>• Colombia; Los Andes University, Bogota</td>
</tr>
<tr>
<td>• Thailand; King Mongkut's Institute of Technology North Bangkok</td>
</tr>
<tr>
<td>• Malaysia; University Sains Malaysia, Penang</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Duration:</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007 - 2008</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contact:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr.-Ing. Klaus Fischer</td>
</tr>
<tr>
<td>M.Sc. Anghana Klongkarn</td>
</tr>
<tr>
<td>M.Sc. Maria Espinoza</td>
</tr>
</tbody>
</table>

Photo of Participants - WasteNet Meeting at Los Andes University in Bogota /Columbia
Composition of Municipal Solid Waste from selected Urban Structures in Romania

In the framework of the increasing concern about the environmental protection in Romania in year 2007 was initiated a cooperation between the environmental ministries Umwelt Ministerium Baden Württemberg and Ministerul Mediului Romania. This cooperation was meant to support Romania in finding the appropriate solutions for the treatment of municipal solid waste. The first step was to define the composition of the municipal solid waste from Romania. In this scope, at the request of Umwelt Ministerium Baden Württemberg, the Institute for Sanitary Engineering, Water Quality and Solid Waste Management carried on the research project in collaboration with "Politehnica" Timisoara University, as well as Retim (Timisoara) and Goscom (Vaslui).

In agreement with National Environmental Protection Agency from Romania there were selected two locations with different economic development levels, Timisoara a city with a dynamic development and low unemployment rates and Vaslui, a city with a precarious economical situation and high unemployment rates. Due to financial reasons Vaslui could not continue participating in the project. Therefore the sorting campaigns were organized only in Timisoara, in two different seasons (summer and autumn).

In Timisoara were analyzed the content of the container from the conventional collection system as well as the "wet container" from a new introduced collection system, in which the "wet container" is meant for the residual waste while the "dried container" for the recyclable materials. The samples were collected from residential areas with well determined features and analyzed on the basis of the methods described by the Guidelines Brandenburg.

Comparison Between 1-Container and 2-Containers Systems [Mass.-%-%-MS]

Comparison between 1-container-system and 2-containers-system from Timisoara and the data from Baden-Württemberg
The results indicated the presence of the biological waste in a high percentage, as well as a high quantity of plastics, paper and glass, therefore a considerable potential for material and energy recovery.

The model will be applied to historical time series of resource inflows into the economy, and calibrated to known quantities of waste generation, the core question being to estimate coefficients for stocks life time for the different materials (sand/gravel, wood, metals, paper, etc.) and interpret dynamically the causes of the variation of stocks (accumulation versus waste generation or dispersive losses).

The policy relevance of the project will be strengthened by the definition of 25 years horizon scenarios of waste generation combined with technological options for waste prevention and recycling. The waste with the higher stakes to reduce environmental pressures will be assessed through simulations.

It is expected that the FORWAST project will bring a new insight into Life Cycle Thinking, and above all, more confidence in the use of environmental indicators in natural resources and waste management policies.

Project objective(s):
The FORWAST project intends to provide comprehensive and validated data on the material flows, stocks and environmental pressures coming from the different sectors of the life cycle of resources to waste. In the wider context of sustainable development and environment protection, the connections between the use of natural resources, their accumulation in economy and waste generation and management need to be more clearly understood. Waste management policies may affect potentially all sectors. Their influence on the use of natural resources must also account for the potential recovery of these resources from stocks, the technical and economical constraints of recycling, the side effects on the by-products associated with natural resources, and at the end, the global balance of the environmental costs and benefits.

The current uncertainties on the environmental stakes of waste policies are pre-dominantly due to a lack of real physical data on the quantities and qualities of flows of resources, either natural or coming from waste recovery. Particularly important for the latter is to account for the actual stocks of these resources that will end-up in the waste flows in the future.

The objectives of the proposed FORWAST project are therefore to:

- Provide an inventory of the historically cumulated physical stock of materials in EU-27 (EU-25 plus Romania and Bulgaria), and to forecast the expected amounts of waste generated, per resource category, in the next 25 years.
- Provide an assessment of the life-cycle wide environmental impacts from different scenarios of waste prevention and recycling.

FORWAST: Project full title: Overall mapping of physical flows and stocks of resources to forecast waste quantities in Europe and identify life-cycle environmental stakes of waste prevention and recycling.

Project summary:
The FORWAST project intends to provide:

- an inventory of the historically cumulated physical stock of materials in EU-27 (EU-25 plus Romania and Bulgaria), and to forecast the expected amounts of waste generated, per resource category, in the next 25 years.
- an assessment of the life-cycle wide environmental impacts from different scenarios of waste prevention, recycling and waste treatment in the EU-27.

The work programme is designed to favour the synergy between these objectives, by applying a generic model for material flows, stocks and emissions. The proposed model is an environmentally extended, physical, quasi-dynamic input-output model. This model combined with a robust method of Material Flow Analysis will guide the mining of new data, which is the main focus of the project. It will take place as a combination of "in-depth" studies in selected countries where high-quality statistics are available, and an EU-wide effort consolidating and calibrating different statistical and technical data sources.
waste prevention, recycling and waste treatment in the EU-27.

With this STREP proposal, sound experiences on resources and waste management are combined in order to give direct decision and policy support. The partnership experience is mainly characterised by:

- European and National experience in policy support;
- The access to data from various countries (particularly East and South);
- Availability of a successfully applied assessment tool (NAMEA, MFA), along with more insight in processes for various waste streams (AWAST simulator);
- An extensive network in resources and waste management.

The project aims at accounting for all sectors in the economy (the figure below shows a possible conceptual organisation of the system) the flows, stocks and linked environmental pressures to increase the reliability of source data used in “Life Cycle Approaches” to waste management issues.

Waste policies influence the „primary production“ due to recycling and prevention, the „manufacturing and consumption“ stages due to recycling, reuse and prevention and the „waste management“ sector. The input/output (I/O) balance of each stage is (dynamically) linked to the others.

As an example, the following figure shows the situation of sand and gravels in Austria. The net balance between the consumption and the stock (104-10 Tg/year) represent the net balance of the primary sector (105-9 Tg/year), which means that the evolution of this stock (age) is of primary importance for a policy aiming at resources saving.

The difficulties of establishing that type of figure for resources saving in Europe are at two levels:

- Data quality: considering the disparity of I/O country data quality in the EU, it is anticipated to set out a global mapping of materials cycles in three steps: 1) elaboration of a global model for matter balance applicable in all countries, 2) calculation of the so-called “transfer coefficients” with “reliable and complete” country data (four countries), and 3) extension to EU-27 macro-economic data.
- Completeness: considering the variety of resources, and eventually associated secondary resources (as in ores), and their mixed occurrence in the products, it will be necessary to combine the “materials flows and stocks setting” approach with a more global Input/output modelling for individual countries and for EU.

Conceptual system description
Further, the objective is to forecast the waste generation in the next 25 years. The need is to establish a relation between stocks quantities and qualities and waste generation, the core question being to estimate stocks life time for the different materials (sand/gravel, wood, metals, paper, etc.), products and waste types, and interpret dynamically the causes of the variation of stocks (accumulation versus waste generation or dispersive losses).

As a result, the following support can be given directly to policy and decision makers:

- Estimation of the material stock of the EU-27.
- Overall mapping of environmental pressures of waste, enabling an understanding of the environmental issues of waste;
- As a result of scenarios simulations, links between the stocks and waste generation in terms of quantities and quality/composition in the next 25 years.
- The identification of the costs and benefits associated with:
  - Prevention of the wastes has the highest potential to reduce the environmental pressures on the use of resources;
  - Recovery or recycling of the waste has the highest potential to reduce the environmental pressures on the use of resources; and
  - Treatment of the wastes is the most polluting.

Additionally, the “leaks” of materials in the system above mentioned as “uncontrolled waste disposal” point out the difficulties in making reliable balances on materials life-cycle. These quantified data anyhow allow the drawing of tracks of interpretation. These will be explored providing the knowledge gaps to be filled for assessing the environmental impacts over the entire life cycle including dispersive losses of the physical stocks to the environment (e.g. corrosion and weathering) and losses of materials as a result of materials management (e.g. transport and processing), including energy use of recycling.

### Materials balance for sand and Gravel in Austria 2001

![Diagram of Materials balance for sand and Gravel in Austria 2001](image-url)
Comparison of the energy recovery and usage of compost from green waste: What is the impact on primary resources?

Introduction:
According to §2 and §3 of the Biomass Regulation (2001), the use of green waste (from yards and parks) for power generation is allowed. The generated electricity is subject to the regulations of EEG (regulation for renewable energy), which means a monetary support of 4 – 7 € Cent/kWh.

The aim of the governmental promotion is to substitute primary resources by using renewable primary products - particularly to generate a positive effect on the greenhouse gas situation with regard to power generation.

Unlike energy recovery, material recovery of green waste is currently not supported in Germany.

Humic material in compost, though, assures a partial storage of carbon, achievable even more efficiently when compost substitutes turf (garden earths and substrate). Turf is in fact a primary resource connected to greenhouse gas emissions through the excavation from moors (moors are sinks of carbon dioxide).

More arguments for the employ of turf substitutes result from economic considerations and partially from business management considerations in earth industries as well. In this context we have to consider the annual need of turf: ca. 10 Mio m³ p.a., generating an actual annual import up to ca. 3 Mio. m³ p.a. (2003). The German turf reserves will last another 20 years.

Currently ca. 300.000 m³ compost from green waste are used as turf substitutes. The medium term potential capacity is ca. 1,2-1,8 Mio. m³ p.a., the long term potential capacity is ca. 2,5-3 Mio. m³ p.a.

Although there is a want for data regarding energy recovery, it is estimated that ca. 0,5-2 Mio. t/a of green waste are treated to recover energy.

Evaluations of the two competing alternatives (energy or material use of green waste) are not possible due to the lack of basic data. Although existing studies and reports do not give a clear preference to one of the two alternatives, no governmental support of material usage is available, whereas the energy use of green waste is promoted (ca. 85-160 €/t green waste).

This current practice needs revision, especially considering the relevance of these benefits.

Objectives of the research project:
Objectives of the Investigation Project:

a) Verifying relative preferences of the two mentioned recovery scenarios for green waste, esp. regarding primary resources and CO₂-balances and to develop
b) Instructions / Recommendations for stakeholders in waste management and legislation.

Working Packages:

a) Data mining and analyses concerning calorific values of green waste (different types of materials, different seasons, different types of output from plants).
b) Data mining concerning power requirement of technical systems and substitution of primary resources through both recovery scenarios (energy and material recovery).

c) Calculation of greenhouse gas emissions, including secondary effects.

d) Comparison of the results from c) with other woody energy sources (esp. old timber, wood chip etc.).

e) Valuation of the investigated systems in c) and d), esp. in relation to primary resources and greenhouse gases.

f) Estimation of potential masses/quantities and elaboration of recommendations for future waste management concerning recovery systems for green waste.

Data mining for green waste:
Samples of different types of green waste and secondary fuel are analyzed in the Laboratory of the University of Stuttgart to create a database with chemical-physical characterization (Calorific value, water content etc.), for different seasons and different types of plants.

Balances:
Process balances will be arranged for the following process units:

Bio-/Green Waste, old timber, wood chips:
Collection, Transport 1, Treatment 1, Composting, Treatment 2, Transport 2, Utilisation

Peat:
Coverage, excavation, supply, raw material transport, treatment including packaging, transport of products (wholesale), transport of products (consumer).

Evaluation criteria and borders of balances:
The evaluation criteria of the investigated processes are mass flows, energy- and CO\textsubscript{2}-balances. The respective borders of the balances result from the concept of „completed recovery“.

The first Figure shows the main processes which have to be considered related to the recovery of green waste. A part of the material is more suitable for an energy recovery whereas another part should be used for composting. A third fraction of green waste is suitable for both recovery scenarios.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{Garden_flow_network.png}
\caption{Garden waste composting: material flows}
\end{figure}
First results:
The following figures show examples of results from CO₂-calculations related to different scenarios of green waste recovery. Two time frames are considered: 2 years and 50 years. After 50 years the biomass used for the recovery is renewed (growing of plants). It is illustrated a positive balance for the energy recovery of raw green waste from spring. The energy recovery for conditioned green waste (screening) is much more efficient and has a similar dimension as the CO₂-balance for the substitution of german peat by substrates from green waste compost.

Conclusion:
Both scenarios for the recovery of green waste lead to a reduction of greenhouse gas emissions, although with varying efficiency. Significant savings result from energy recovery as well as from material recovery (similar dimension). Therefore a similar or even equal political treatment – e.g. basing on saved greenhouse gases - is reasonable. The investigation project will also deliver a database and the parameters to provide a basis for future political decisions.

International Exports of Teaching Staff and Cooperation with Universities

Cooperation with the Universidad Católica Boliviana « San Pablo », in La Paz, Bolivia

In collaboration between the Department of Civil Engineering of the Universidad Católica Boliviana and the Institute of Sanitary Engineering, Water Quality and Waste Management of the University of Stuttgart, an exchange of know-how and information is taking place in all the fields of environmental technology and environmental analysis with a focus on waste management. This cooperation developed on the basis of the EU project WasteNet, which is going to be continued in other fields, including student exchange to carry out Bachelor and Master Thesis. In addition to this, block courses will be offered in La Paz for several degree courses in the fields of environmental engineering and environmental analysis. An intensive know-how exchange is taking place with regards to biological waste treatment with emphasis on digestion plants. Other priorities include the recycling of waste tires, mining waste, hazardous household waste and the recovery and treatment of electrical and electronic wastes.
Cooperation with the Guangxi University in Nanning, Guangxi, China

The Guangxi University is one of the largest and most important universities in southern China. The Institute of Environmental Engineering concentrates on many issues, which include the treatment of municipal and industrial waste, landfill technology and thermal waste treatment. A particular focus lies on the anaerobic treatment of organic household waste, which is carried out in cooperation with the Ministry of Forestry. Guangxi is the Chinese Centre for the Development of anaerobic technologies. The program for the construction and dissemination of decentralized biogas digesters is supervised from here. In the meanwhile, there are operating about 25 million of such small biogas plants in China.

The collaboration between the Institute of Environmental Engineering of the Guangxi University and the Institute of Sanitary Engineering, Water Quality and Waste Management of the University of Stuttgart is mainly based on the field of digestion plants. The experiences gained during the long running time of these small decentralized plants in China and the large central plants in Europe may lead to new fruitful approaches for this technology.

<table>
<thead>
<tr>
<th>Project partner:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Institut für Siedlungswasserbau, Wassergüte- und Abfallwirtschaft - Lehrstuhl für Abfallwirtschaft und Abluft</td>
</tr>
<tr>
<td>• Guangxi University in Nanning, Guangxi, China</td>
</tr>
<tr>
<td>• Ministerium für Forstwirtschaft</td>
</tr>
</tbody>
</table>

Contact:
Dr.-Ing. Klaus Fischer
Dipl. Ing. Jingjing Huang

Decentral biogas plant with a toilet in a village near Nanning, Guangxi, China
Independent Studies, Master- and Diploma Thesis

Abfallwirtschaftliche Maßnahmen zur Minderung von Treibhausgasemissionen in Schwellenländern
Yonggang Xue (UMW) (2008)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. M. Kranert

Aerobic in –situ stabilization of landfills
Lidia Glastkowa (WASTE) (2008)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. M. Kranert

Assessment of Solid Waste and its impact on environment in Kathmandu Valley, Nepal
Pradhan Bishan (WAREM) (2008)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. G. Kaule

Baustoffrecycling
Bo Qiu (UMW) (2008)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. M. Kranert

Carbon Emission Reduction Certificates recovery from Leachate Treatment
Daniela Prado (WASTE) (2008)
Betreuung: Dr.-Ing. K. Fischer, Dr. W.R. Müller

Co-fermentation of residuals of kitchen, garden and waste water treatment
Terra Prima Sari (WAREM) (2008)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. E. Thomanetz

Entwicklung und Erprobung zur Überwachung von Biofiltern
Daniel Schaupp (UMW) (2008)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. F. Sabo

Implementation of an integrated environmental management system in motorway operation. Case study: ATTIKI ODOS
Natalia Tziveni (WASTE) (2008)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. E. Thomanetz

Integrated Solid Waste Management: A sustainable to reduce load on landfill site in Pokhara city, Nepal
Purna Prasad Bhandari (Infrastructure Planning) (2008)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. G. Kaule

Leitfaden zur Einführung nationaler und internationaler Schadstoffverbote in Unternehmen
Yuan Li (UMW) (2008)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. E. Thomanetz

Management system and feasibility study for an integrated treatment of organic wastes and wastewater in a Tourism Centre
Tatiana Medon (WASTE) (2008)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. E. Thomanetz

Optimierung des anaeroben Abbaus von Bioabfällen durch Zuschlagstoffe
Melanie Benter (UMW) (2008)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. M. Kranert

Systemanalyse kleintechnischer Verfahren zur Erzeugung und Nutzung von Biogas
Katharina Raab (UMW) (2008)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. M. Kranert

Utilization of agriculture waste: cultivation of oilpalms
Luis Eduardo Castillo Meza (WASTE) (2008)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. M. Kranert

Verfahrensentwicklung zur Aufarbeitung von Gärresten
Lorena Piles Tortajada (UMW) (2008)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. Dr. J. Jungbluth

Untersuchung der Materialbeständigkeit und des Alterungsverhaltens von Filtermedien in Kfz vor dem Hintergrund des Materialrecycling
Peng Bai (UMW) (2008)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. M. Kranert

Stoffstromanalyse ausgewählten Abfallrelevanten Rohstoff für die Bundesrepublik Deutschland
Nataliya Kurz (UMW) (2008)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. M. Kranert
Vergleich der Umweltrechtlichen Anforderungen an Betriebe der Automobilherstellung in USA, Brasilien, Südafrika und Deutschland
Kristy Pena Munoz (WASTE) (2008)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. E. Thomanetz

Recyclingverfahren für Farbstoffsolargzellen
Jingjing Huang (UMW) (2008)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. M. Kranert

Abfallwirtschaftliche Varianten für Curitiba/Brasilien
Werner Kessler (EDUBRAS) (Beginn 07/2009)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. J. Metzger

Comparative analysis of household waste management in the cities of Bogota and Sofia
Natalia Alejandra Ruiz (WASTE) (2009)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. E. Thomanetz

Die kommunale Abfallwirtschaft im Wettbewerb mit der Privatwirtschaft und der Trend zur Rekommunalisierung in Deutschland
Angele Gudefin (VWL) (2009)
Betreuung: Dr.-Ing. K. Fischer, Dr. S. Becker

Emissionen von klimarelevanten Gasen aus Abfallbehandlungsanlagen
Yi Gao (UMW) (2009)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. M. Kranert

Experimental validation and calibration of an anaerobic digester model
Pavel Leonardo Lopez Gonzalez (WASTE) (2009)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. M. Kranert

Limited resources and their recycling aspects
Chinedu Augustine Ngoka (WASTE) (2009)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. M. Kranert

Mechanical Biological treatment: a study of the current state of MBT in the United Kingdom
Oahimire Ejakhegbe (WASTE) (2009)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. M. Kranert

Laboratory studies on long term stability of different process variants the manure free fermentation of corn silage
Luis Eduardo Castillo Meza (WASTE) (2009)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. E. Thomanetz

PET - Recycling
Asrar Ahmad Sheik (WASTE) (2009)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. E. Thomanetz

Possibilities of incineration in solid waste management in Cameroon
Leslie Njume (WASTE) (Beginn 07/2009)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. E. Thomanetz

Untersuchung der Lagerfähigkeit von Gasproben in Nalophan-Beuteln
Erik Schweiker (UMW) (2009)
Betreuung: Dr.-Ing. K. Fischer, Dr.-Ing. M. Reiser

Vergleich der gesetzlichen Regelungen für Krankenhausabfälle in Brasilien und Deutschland
Matilde Soares (EDUBRAS) (Beginn 07/2009)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. J. Metzger

Verwertung und Entsorgung von Baggergut aus Flüssen
Alessandra Heinrich (EDUBRAS) (Beginn 07/2009)
Betreuung: Dr.-Ing. K. Fischer, Prof. Dr. J. Metzger
### Contact

**Dr.-Ing. Klaus Fischer**
Tel.: ++49 (0)711/685-65427  
Fax: ++49 (0)711/685-67634  
E-Mail: klaus.fischer@iswa.uni-stuttgart.de

**Secretary’s office**

**Gudrun Heinl**
Tel.: ++49 (0)711/685-65495  
Fax: ++49 (0)711/685-65460  
E-Mail: gudrun.heinl@iswa.uni-stuttgart.de

**Research Assistants**

**Dipl.-Ing., M.Sc. Mihaela Berechet**
Tel.: ++49 (0)711/685-62567  
Fax: ++49 (0)711/685-65460  
E-Mail: mihaela.berechet@iswa.uni-stuttgart.de

**M.Sc. Nicolas Escalante**
Tel.: ++49 (0)711/685-65456  
Fax: ++49 (0)711/685-65460  
E-Mail: nicolas.escalante@iswa.uni-stuttgart.de

**M.Sc. Maria Alejandra Espinoza**
Tel.: ++49 (0)711/685-65477  
Fax: ++49 (0)711/685-65460  
E-Mail: maria.espinoza@iswa.uni-stuttgart.de

**Dipl.-Ing. Jingjing Huang**
Tel.: ++49 (0)711/685-65477  
Fax: ++49 (0)711/685-67634  
E-Mail: huang_jingjing@hotmail.com

**Dipl.-Ing. Daniel Löffler**
Tel.: ++49 (0)711/685-62567  
Fax: ++49 (0)711/685-65460  
E-Mail: daniel.loeffler@iswa.uni-stuttgart.de

**Dipl.-Geogr. Agata Rymkiewicz**
Tel.: ++49 (0)711/685-65456  
Fax: ++49 (0)711/685-65460  
E-Mail: agata.rymkiewicz@iswa.uni-stuttgart.de

### Laboratory

**CTA Catharina Le Huray-Horel**
Tel.: ++49 (0)711/685-65436  
Fax: ++49 (0)711/685-67634  
E-Mail: r.catharina.horel@iswa.uni-stuttgart.de

**CTA Axel Goschnick**
Tel.: ++49 (0)711/685-63712  
Fax: ++49 (0)711/685-63729  
E-Mail: axel.goschnick@iswa.uni-stuttgart.de

**CTA Jürgen Wolf (till 2009)**
E-Mail: juergen.wolf@iswa.uni-stuttgart.de

### Doctoral Candidates

**Dipl.-Ing. Carla Cimatoribus**
Tel.: ++49 (0)711/685-62567  
Fax: ++49 (0)711/685-65460  
E-Mail: carla.cimatoribus@iswa.uni-stuttgart.de

**M.Sc. Sebnem Bastan Yilman**
Tel.: ++49 (0)711/685-62567  
Fax: ++49 (0)711/685-65460  
E-Mail: sebnem.bastan-yilman@iswa.uni-stuttgart.de

**Dipl.-Ing. Marie-Emilie Mollaret**
Tel.: ++49 (0)711/685-67635  
Fax: ++49 (0)711/685-65460  
E-Mail: m-emilie.mollaret@cemagref.fr

**M.Sc. Carlos Pacheco**
Tel.: ++49 (0)711/685-63709  
Fax: ++49 (0)711/685-67634  
E-Mail: carlos.pacheco@iswa.uni-stuttgart.de

**M.Sc. Ke Bi**
Tel.: ++49 (0)711/685-60356  
Fax: ++49 (0)711/685-67634  
E-Mail: ke.b@daad-alumni.de
Hazardous Waste and Contaminated Sites

Research topics:

• UV wet oxidation of liquid hazardous waste and industrial wastewater
• Development of microsensors for rapid investigation of contaminated sites using the cone penetration test
• Development of adequate waste sampling methods
• Development of adequate (large scale) waste analysis methods
• Pyrolysis of hazardous waste
• Fire inquest investigations of hazardous waste for rock filling and underground storage
• Long term waste investigations within large lysimeter units
• Determination of the spontaneous combustion properties of hazardous waste

Nothing is too dangerous for us

Special procedures for the treatment of hazardous industrial waste as well as investigation and remediation methods for contaminated sites form the focal point of the teaching and research activities within our work area "Hazardous waste and contaminated sites". We are also widely experienced in sampling and analysis of solid, liquid and paste-like waste.

Our research covers the following subjects, e.g.: • Backfilling of mines (stowing): we have developed and introduced methods to industrial routine to quantify the generation of hydrogen in industrial waste and thus to enable avoidance of the hazards presented by hydrogen in the subsurface. Of particular importance for underground waste sites are the methods developed for a new waste parameter: TOCbio – that is the microbially reducible TOC. This parameter has already found its way into the new edition of the Ordinance on Underground Waste Storage. • Intermediate storage of special spontaneous-ignition industrial waste: here, procedures were developed that help to understand the spontaneous combustion mechanism and thus to avoid this hazard. • Development of practical UV wet oxidation reactors for industrial sewage or hazardous liquid waste: not only are UV treatment reactors in disposal scale available for this purpose (the largest has a capacity of 1 cubic metre and 40 kilowatts), but also laboratory reactors of 10 litres capacity for initial investigations. Further activities in brief: The development of “chemical noses” for rapid investigation of waste spoil tips and contaminated sites by means of CPT technology; development of methods for returning reverse osmosis leachate concentrate to the body of the landfill; testing of suitable indicator parameters for determination of the influence of a landfill on its surroundings (tritium, boron and others); development of bespoke industrial solutions with regard to waste and wastewater.
Projects

Solar Photocatalytic Hygienisation and Detoxification of Water

The Advanced Oxidation Process (AOP) used for water purification in this project, is based on the semiconductor properties of Titanium Dioxide when irradiated with ultraviolet light.

Experiments are carried out in laboratory scale to investigate how specially modified and immobilised Titanium Dioxide can act as photocatalyst even in diffuse daylight, and thus generate oxidative radicals.

The University of Hohenheim Institute of Environmental and Animal Hygiene is our partner concerning the microbiological aspects.

Hazardous Waste Management in Turkey

In this Pre-Study a group of German and Turkish experts in hazardous waste management and technique aim to present and evaluate different possibilities to rearrange hazardous waste disposal in Turkey.

<table>
<thead>
<tr>
<th>Client:</th>
<th>KfW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project partner:</td>
<td>ip Institut für Projektplanung, Stuttgart</td>
</tr>
<tr>
<td>Duration:</td>
<td>04/2009 - 06/2009</td>
</tr>
<tr>
<td>Contact:</td>
<td>Prof. Dr.-Ing. Erwin Thomanetz</td>
</tr>
<tr>
<td></td>
<td>Dipl.-Ing. Matthias Rapf</td>
</tr>
</tbody>
</table>

Elimination of hardly degradable Substances from Effluents with a Biologically Regenerating Adsorptive Rotary Disc Reactor

In receiving water courses of biological purifying plants damage on aquatic organisms due to traces of hard to degrade organic industrial chemicals and pharmaceutical products can be observed. The Baden-Württemberg Ministry of Environment considered the removal of these substances currently one of the vital topics in environmental research.

<table>
<thead>
<tr>
<th>Financing institution:</th>
<th>AiF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project partner:</td>
<td>Firma Stengelin-Specker Kläranlagen GmbH, Dürbheim</td>
</tr>
<tr>
<td>Duration:</td>
<td>01/2007 - 03/2009</td>
</tr>
<tr>
<td>Project leader:</td>
<td>Prof. Dr.-Ing. Erwin Thomanetz</td>
</tr>
<tr>
<td>Contact:</td>
<td>Dipl.-Ing. Matthias Rapf</td>
</tr>
<tr>
<td></td>
<td>CTA Brigitte Bergfort</td>
</tr>
</tbody>
</table>
The project firstly, by means of experiments with an appropriate laboratory scale setup, aims at proving that microorganisms settling on activated carbon can degrade the endocrine substances primarily adsorbed hereon. Based on the thus gained data, the design of a technical process is to be investigated with which an industrial scale pilot plant can be erected.

The project will be carried out in cooperation with the Department of Chemistry (CH) of our institute and with the company Stengelin-Specker Kläranlagen GmbH, who invented the Rotating Disc Reactor for the Biological Purification of Waste Water in the 1950es. Furthermore, the departments Biology (BIO), Waste Water Technology (AWT) and Industrial Water and Waste Technology (IWT) of our institute can provide their comprehensive experience on the field.

### Expertises

**Laboratory and industrial scale experiments for the treatment of hazardous foundry waste waters by means of wet chemical oxidation processes**

- **Client:** Reinluft Umwelttechnik Ing. GmbH, Stuttgart
- **Duration:** 12/2007 - 12/2008
- **Contact:** Dipl.-Ing. Matthias Rapf
  CTA Brigitte Bergfort

**Determination of the biodegradable part of the TOC (TOC<sub>bio</sub>) of solid industrial wastes for underground storage**

- **Client:** UEV GmbH / SWS AG, Heilbronn
- **Duration:** seit 2004 ständig
- **Contact:** Dipl.-Ing. Matthias Rapf
  CTA Brigitte Bergfort

### Financing institution:

- Willy-Hager-Stiftung
- **Duration:** 10/2007 - 10/2010
- **Project leader:** Prof. Dr.-Ing. Erwin Thomanetz
- **Contact:** Dipl.-Ing. Matthias Rapf
  CTA Brigitte Bergfort

---

*Industrial scale experiment for the photo-oxidation of industrial waste water*

*Equipment for the determination of the biological part of the TOC (TOC<sub>bio</sub>)*
Study: „Future biowaste treatment in the Zollernalb district“. Evaluation of the economical and ecological feasibility of different options.

<table>
<thead>
<tr>
<th>Client:</th>
<th>Landkreis Zollernalbkreis, Balingen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project partner:</td>
<td>Björnsen Beratende Ingenieure, Koblenz</td>
</tr>
<tr>
<td>Duration:</td>
<td>11/2008 - 05/2009</td>
</tr>
<tr>
<td>Contact:</td>
<td>Dipl.-Ing. Matthias Rapf</td>
</tr>
</tbody>
</table>

Can biowaste be adequately utilised in biomass power stations?

---

### Independent Studies, Master- and Diploma Thesis

#### Acceleration of the BET-Surface Measurement for Activated Carbon by Variation of Pressure and Temperature

Yaoyao Yuan (WASTE) (2008)
Supervisor: Prof. Dr.-Ing. E. Thomanetz, Prof. Dr.-Ing. M. Kranert
Master Thesis

#### Aftercare of Landfill Sites to Accelerate the Microbiological Processes Using Hydrogen Peroxide

Piyathida Baingern (WASTE) (2008)
Supervisor: Prof. Dr.-Ing. E. Thomanetz, Prof. Dr.-Ing. M. Kranert
Master Thesis

#### Suitability of the Zipaquirá salt mine as an underground storage facility for hazardous solid waste

Carlos A. Pacheco Bustos (WASTE) (2009)
Supervisor: Prof. Dr.-Ing. E. Thomanetz, Prof. Dr.-Ing. M. Kranert
Master Thesis

#### Pyrolysis of Plant Material with Special Consideration of Flower Waste

Parik Sabungan Sirumapea (WASTE) (2008)
Supervisor: Prof. Dr.-Ing. E. Thomanetz, Prof. Dr.-Ing. M. Kranert
Master Thesis

---

#### Conditioning of Hazardous Waste

Gloria Patricia Galindo Vanegás (WASTE) (2008)
Supervisor: Prof. Dr.-Ing. E. Thomanetz, Prof. Dr.-Ing. M. Kranert
Independent Study
Dissertations in process

**Advanced Oxidation Processes (AOP) in Waste Water Treatment**

M.Sc. Ibrahim Abdel Fattah (since 02/2007)  
Supervisor: Prof. Dr.-Ing. M. Kranert,  
Prof. Dr.-Ing. E. Thomanetz  
Doctoral Thesis

**Entropy Production as Measure for the Environmental Impact of Technical Processes with Examples from Waste Management**

Dipl.-Ing. Matthias Rapf (since 09/2007)  
Supervisor: Prof. Dr.-Ing. M. Kranert,  
Prof. Dr.-Ing. B. Weigand,  
Prof. Dr.-Ing. E. Thomanetz  
Doctoral Thesis

*Entropy mnemonic S = Q/T, unfortunately not applicable in English*

Laboratory scale photo-oxidation plant for the treatment of industrial waste waters and contaminated ground waters: **Cascade of three 1,7 kW UV Free-Surface Reactors**
Contact

**Prof. Dr.-Ing. Erwin Thomanetz**
Tel: ++49 (0)711/685-63709
Fax: ++49 (0)711/685-65460
E-Mail: erwin.thomanetz@iswa.uni-stuttgart.de

**Research Assistants**

**Dipl.-Ing. Matthias Rapf**
Tel.: ++49 (0)711/685-63709
Fax: ++49 (0)711/685-67634
E-Mail: matthias.rapf@iswa.uni-stuttgart.de

**Laboratory**

**CTA Brigitte Bergfort**
Tel: ++49 (0)711/685-63709
Fax: ++49 (0)711/685-67634

**Doctoral Candidate**

**M.Sc. Ibrahim Abdel Fattah**
Tel.: ++49 (0)711/685-63709
Fax: ++49 (0)711/685-67634
E-Mail: Iabdelhafiz@yahoo.com
And sometimes, the job just stinks

*If it stinks, the people in this section are in their element. To find out what, when and why it stinks, exactly where and how strongly it stinks, is part of the research focus of this group.*

Exhaust gases of all kinds are investigated with the modern gas analysis equipments. The mostly used equipments consist of gas chromatography with mass spectrometers and flame ionisation detectors; as well as of olfactometry and "sniffing port". But the analysis goes further. Our research can be applied as practical solutions for the construction and operation of emission reduction facilities from both municipal authorities and industries. It is possible, for example, to improve the biological exhaust air purification system of a slaughter house, or to determine the sources of strong odours emitted from a cardboard plant, which causes nuisance to local residents.

In practice, however, the purification of odour intensive exhaust gases presents a number of difficulties: the odorous components often remain unrecognized. Therefore, current measures aim at simply reducing the main components of the exhaust gases, which are determined by using standard analysis methods, while the odorous trace substances remain unrecognized. However, by means of a combination of the analytical methods, specific odour relevant components of exhaust gases can be determined. It is therefore possible to optimise exhaust gas purification systems (for odour emissions these are often biological methods). Our work is considered in both technical and economical aspects. Currently, national and international research projects are being conducted, the aim of which is to develop technically and economically effective exhaust gas purification methods using a combination of different processes. Our experience can be taken as reference by both national and international regulations.
Projects

Pilot project of reducing the after-care period for a municipal solid waste landfill – accelerated degradation of the organic waste by extensive interval aeration on BA IV, Landfill Dorfweiherr

The district of Konstanz, in cooperation with ISWA, carried out a research project to reduce the after-care period of the Landfill Konstanz-Dorfweiherr. In this project, with the acronym “TANIA” (Totale Aerobisierung zur Nachsorgeverkürzung durch extensive Intervalbelüftung von Abfalldeponien), the commonly used methods for landfill stabilization will be combined and further developed. Due to the pilot-character, a technical and scientific monitoring with a complex measurement is held.

The project is carried out on a segment of the Landfill Konstanz-Dorfweiherr. The project is advanced by the Ministry of Environment Baden-Württemberg. Duration of the whole project is 5 years, consists of a 3-year-aeration phase and a 2-year-monitoring phase.

Objective of the pilot project is to stabilize the landfill body in an aerobic way, so that the after-care period can be finished in a foreseeable period of time. With the help of the planned procedure, the conversion and degradation of the organic constituents in the waste body should be accelerated. Therefore settlement could take place anticipated and harmful landfill gas emissions could get enormously reduced. Besides, the leachate quality could be greatly enhanced.

In the framework of scientific monitoring in the pilot project, further knowledge will be developed. Measuring data will be collected in closely divided grid and in a short period of time. For instance information is available not only of aeration rates and pressures, but also of gas-, leachate-, temperature- and settling-developments. Moreover, of how effective the biofilter for landfill gas treatment works and how much leachate should be recycled, so that the biological process could run optimally. This leads to a better understanding of the procedure during the aerobic stabilization; and makes it possible to describe the physical, chemical and biological processes in the project. With the available data and information, the objective of an “environmental friendly landfill” can be better described. Modelling of the target values to reduce the after-care period can be carried out as well.

The technical setup for the process, as well as measuring and controlling technology will be constructed in a way of modular design. After the stabilization period, the technical setup is available for other procedures. With the characteristics gathered in this research project, the technology can be applied to other sites or landfill sections.

Project promoter:
Landkreis Konstanz / Umweltministerium Baden-Württemberg

Project partner:
Lhotzky + Partner Ing. Gesellschaft mbH, Braunschweig

Duration:
12/2009 - 12/2014

Contact:
Dr.-Ing. Martin Reiser
Dipl.-Ing. M. Rapf
Dipl.-Ing. M. Kieninger

Development of a simple procedure to evaluate the emission rates of greenhouse gases from area sources

Objective of the project is to develop a practical software, to estimate the emission rates of greenhouse gases from diffusive area sources, by means of tuneable diode laser absorption spectrometer (TDLAS).

A requirement for emission rates of small area sources always exists, where, due to mandatory reporting...
or actions for climate protection, precise values are needed by theoretical estimations or qualitative measurements.

As propagation model, a lagrangian partial model is used and the concentration measurements were performed as open-path-measurements in distances up to over 500 m. According to the measuring results, the emitted gas will be evaluated by an adapted dispersion model.

The cooperation of ISWA in this project was mainly related to the development of the measuring technique, in order to evaluate the emissions of different forming auxiliary agents in odour technical aspects. The analytical procedure for odorous substance detection is described in detail as follows:

- With variation of adsorption- and desorption-conditions in thermal desorption procedure, even odorous substances with lower mass numbers could be recorded by the analysis.
- Extension of the detector system: with an additional flame ionization detector, a precise quantification of odorous relevant compounds could be achievable. The GC/MS/FID-System, in conjunction with the Olfactory-Detection-Port (ODP), which is also called Sniffing-Detector, proved itself useful on this problem as well as other applications.

Minimization of odour emission in foundry sections – Part II

In a research project which was completed in 2008, the basics of olfactory (odour technical) evaluation of the forming auxiliary agents in foundries was accomplished.

These kinds of forming auxiliary agents, such as adhesives, feeder heads, refractory dressings and sand additives, make a great contribution to the odour balance of moulding in sand form. Quantity and importance of the odour contribution was defined and evaluated. Hence the supplying industries and foundries are motivated, to solve the upcoming odour problems with the help of forming auxiliary agents; and to approach an optimization and a sustainable improvement of wide scope.
Expertises

**Determination of the organic carbon and ammonia concentrations with quantification of odorous components in exhaust gas of a sewage sludge drying system**

In many operating conditions, emissions of a belt dryer were quantified in drying procedure of mechanically dewatered sewage sludge, and purification capacity of the connected exhaust gas treatment system (scrubber/biofilter combination) was quantified as well. Two portable FIDs and a quasi-continuous measuring NDIR gas photometer were applied for it. Besides, gas samples were adsorbed on Tenax, and analysed for relevant, odorous exhaust gas constituents by means of a GC/MS/FID-System in conjunction with an Olfactory-Detection-Port (ODP).

Client: Ingenieurbüro Lohmeyer, Karlsruhe

**Evaluation of an exhaust gas purification system in a metal-milling plant to examine the cleaning capacity with VOC emission measurements and odour concentration determination**

Client: Andreas Stihl AG, Waiblingen

**FTIR measurements for different exhaust gas purification systems in a semiconductor production or a solar cell industry**

Client: Centrotherm AG, Blaubeuren

**Analysis of biofilter material with different physical parameters (nutrient salt content, pH value, etc.) and biological respiration activity from different plants (animal body disposal, food industry, coating technology, electrical industry, ARA)**

Client: Various

**Determination of emission potential of oil separator-waste water by total stripping with GC/MS-GC/FID analysis**

The determination of emission potential of waste water was performed according to ATV-Merkblatt A 204 in the way of total stripping. All volatile organic compounds are converted into gas phase by injecting an inert gas at high temperature. The components are then enriched by adsorption on Tenax®; and gas chromatographically determined after thermal desorption and sampling.

Client: Reinluft Umwelttechnik GmbH, Stuttgart
Gas chromatographic analysis (GC/MS) of gas samples from different facilities (waste disposal facilities, waste water treatment plants, et al.)

Client: Reinluft Umwelttechnik GmbH, Stuttgart

GC/MS and GC/FID measurements to determine VOC components in drying ovens and downstream exhaust gas purification systems during the manufacturing of clutch linings

Client: Schaeffler Friction GmbH, Morbach

Hydrogen sulphide measurements on different locations of ARA in a slaughterhouse and regular sampling of raw- and clean-gas in the connected biological exhaust gas purification system

Client: Ulmer Fleisch GmbH, Ulm

NDIR gas photometer were applied for it. Besides, gas samples were adsorbed on Tenax, and analysed for relevant, odorous exhaust gas constituents by means of a GC/MS/FID-System in conjunction with an Olfactory-Detection-Port (ODP).

Client: Ingenieurbüro Lohmeyer, Karlsruhe

Olfactory analysis of emission samples from a wood heating system to determine odour concentration

Client: Ingenieurbüro Dr.-Ing Dröscher, Tübingen

Olfactory evaluation of odours in a study on odour absorption and masking for hygiene products

Client: Hysalma GmbH, Oberhausen

Thermal desorption and gas chromatographic analysis (GC/MS) of gas samples from different facilities (waste disposal facilities, wastewater treatment plants, et al.)

Client: Reinluft Umwelttechnik GmbH, Stuttgart

Independent Studies and Diploma Thesis

Measurements of Methane Emissions by Gasfinder®

Emine Gökçe İyicil (ERASMUS) (2008)
Supervisor: Dr.-Ing. M. Reiser, Prof. Dr.-Ing. M. Kranert
Seminar paper, Individual practical work

Investigation of the storage suitability of gas samples in Nalophan® bags

Erik Schweiker (Environmental Engineering) (2009)
Supervisor: Dr.-Ing. M. Reiser, Prof. Dr.-Ing. M. Kranert
Diploma thesis

Exhaust gas purification in a shredder industry with bio-trickling bed technology

Ulrich Rottensteiner (Umweltschutztechnik) (2009)
Supervisor: Dr.-Ing. M. Reiser, Prof. Dr.-Ing. M. Kranert
Diploma thesis

Exhaust gas purification in a shredder industry with bio-trickling bed technology

Ulrich Rottensteiner (Umweltschutztechnik) (2009)
Supervisor: Dr.-Ing. M. Reiser, Prof. Dr.-Ing. M. Kranert
Diploma thesis
Contact

Dr.-Ing. Martin Reiser
Tel.: ++49 (0) 711/685-65416
Fax: ++49 (0) 711/685-63729
E-Mail: martin.reiser@iswa.uni-stuttgart.de

Research Assistants

Dipl.-Ing. Martin Kieninger
Tel.: ++49 (0) 711/685-63733
Fax: ++49 (0) 711/685-63729
E-Mail: martin.kieninger@iswa.uni-stuttgart.de

M.Sc. Han Zhu
Tel.: ++49 (0) 711/685-65409
Fax: ++49 (0) 711/685-63729
E-Mail: han.zhu@iswa.uni-stuttgart.de

Laboratory

Hans-Jürgen Heiden (CTA)
Tel.: ++49 (0) 711/685-63712
Fax: ++49 (0) 711/685-63729
E-Mail: hans-juergen.heiden@iswa.uni-stuttgart.de

Axel Goschnick (CTA)
Tel.: ++49 (0) 711/685-63712
Fax: ++49 (0) 711/685-63729
E-Mail: axel.goschnick@iswa.uni-stuttgart.de

Doctoral Candidate

M.Sc. Gülsen Öncü
Tel.: ++49 (0) 711/685-65409
Fax: ++49 (0) 711/685-63729
E-Mail: guelsen.oencue@iswa.uni-stuttgart.de
Biological Air Purification

Research topics:

- Detection of degradative potentials
- Isolation of xenobiotics degrading bacteria and fungi
- Elucidation of bacterial degradative pathways by use of genetic, chemical and biochemical techniques
- Development of new waste air purification concepts
- Design, dimensioning and operation of Biological Waste Air Purification (BWAP) plants
- Biosynthesis of fine chemicals with high value

It’s not just hot air to us

The biological cleaning of exhaust air and the biodegradation of xenobiotics (i.e. non-biodegradable substances) by bacteria represent the focal point of our work.

In addition, the department provides assistance in the planning and dimensioning of biofiltration apparatus of various types (biofilter, biotrickling filter and biowasher). Moreover, it is possible to provide scientific supervision of these apparatus and equipment during normal operations and in case of faults. This is in the interest of research in a real practical context, because the weaknesses revealed in any of the functions can be drawn upon to develop new or optimised concepts.

A further field of research is the degradation of xenobiotics: exposing degradation potential, isolating xenobiotic degrading bacteria strains and fungi, investigating bacterial degradation paths and, as a spinoff, the biosynthesis of materials.
Projects

System biology in *Pseudomonas*

In this project, the production of low molecular organic compounds by bacteria is researched. Therefore metabolic networks and genes are examined. Due to a confidentiality obligation, no further information of this project could be shared.

<table>
<thead>
<tr>
<th>Financing institution:</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMBF und BASF</td>
</tr>
<tr>
<td>Duration:</td>
</tr>
<tr>
<td>2009-2011</td>
</tr>
<tr>
<td>Contact:</td>
</tr>
<tr>
<td>Dr.-Ing. Niko Strunk</td>
</tr>
<tr>
<td>M.Sc. Diego Salamanca</td>
</tr>
</tbody>
</table>

Expertise and assignments

Biodegradation of benzoate under hypersaline conditions

Common bacteria normally used in the degradation of natural and xenobiotic compounds tolerate sodium chloride concentrations of up to 3.5 w%. This concentration is similar to saline concentrations in maritime habitats. Habitats with saline concentrations beyond 3.5 w% like salters, industrial solar salt refineries, brines out of the olive oil production or special industrial waste waters can only be populated by specialised bacteria and archaea. In most cases industrial waste waters as well as waste waters of the olive oil production include high COD freights. The biodegradability of benzoate as main compound in these industrial waste waters under technical aspects is the core aspect of this third-party funded project.

Advisor: Dr.-Ing. D. Dobslaw

Optimisation of an existing industrial scale biological waste air treatment system in a hazardous waste recycling company to fulfill limit values of the TA-Luft 2002

In the Technical Instruction on Air Quality of the year 2002 „TA-Luft 2002“ a limit value of 20 mg C/m³ is defined for the treated air of a hazardous waste recycling plant. However, the limit value during design and construction of this plant was 100 mg C/m³. To fulfill the new limit values the existing system consisting of preconditioning and bioscrubber units was modernised and complemented in cooperation with the partner of the project. In analytical campaigns on-site as well as in semi-technical scale in the rooms of the Institute the total waste air compounds were identified and carbon freight, related compound concentrations as well as specific degradation rates in both plants were measured. Since the summer of the year 2008 the industrial scale plant is capable to fulfill the limit values of the TA-Luft 2002.

In a second phase of the project proceeding up to now the feasibility of additional waste water treatment is evaluated.

Advisor: Dr.-Ing. D. Dobslaw

Industrial plant for combined waste air and waste water treatment in a hazardous waste recycling company. The waste air (inlet on the right side) passes through an activated carbon filter (top right side) and two serial connected bioscrubbers afterwards (top left side). In three tanks the circulation liquid (bottom left side) and the aqueous waste fractions (bottom right) are stored.
Analytical benchmark of two optimised industrial scale waste air treatment plants for treatment of sewage sludge emissions during sludge dehydration

In cooperation with the responsible engineers of the industrial project partner an industrial scale procedure for treatment of emissions out of the drying of sewage sludges as well as wood residues was developed and realized. Analytical evaluation of the waste air situation in the inlet and outlet of each treatment step was one of the main topics of the department in this assignment. The results worked out were the base for further development and optimisation procedures.

Advisor: Dr.-Ing. D. Dobslaw

Optimisation of belt dryers’ drying procedures under aspects of minimization of emissions and fulfillment of TA-Luft 2002 limit values

Related to German laws the deposition of municipal and industrial sewage sludges in landfills is no longer and deposition on agricultural fields is only possible under strict conditions. Furthermore, the deposition of saw dust, residues of pressboard and paper production or similar wastes is hardly restricted. Because of their high heating value, in most cases these waste compounds are thermal used in waste incineration plants, cement plants or biomass power plants. However, the sludges’ high water content shows negative effects in production efficiency and product quality, especially in case of clinker brick production. Therefore, these waste compounds have to be pretreated in belt dryers, fluidized bed dryers or drum dryers to reduce water content to a maximum of 10 %. Afterwards, a thermal use is possible. Similar to a water extraction procedure highly volatile organic compounds as well as well soluble and well water extractable compounds are transferred into the air flow for drying. These air streams posses total carbon concentrations of 200 – 300 mg C/m³, but efficient treatment to fulfill limit values of the TA-Luft is not possible.

In cooperation with the industrial partner the main topic to deal with was an optimization of the drying procedure in dependency of the material to be dried to achieve a minimization of waste gas concentrations and carbon freights in the waste air flow.

Advisor: Dr.-Ing. D. Dobslaw

Study of feasibility for chemical cleavage of organic peroxides

Caused by a non efficient biological degradation of the described peroxides, experiments for chemical and physical mineralisation of organic peroxides focusing on DTBP (di-tert-butylperoxide) and DTAP (di-tert-amylperoxide) were proceeded. In a second approach the focus lied on an efficient chemical or physical cleavage of these peroxides combined with a biological stage for treatment of the resulting intermediates afterwards. In these tests both peroxides showed high stability towards UV irradiation and katalytical cleavage at ambient temperature, poor adsorption characteristics, stability against absorption and oxidation by oxidising or reducing agents using aqueous and organic solvents as absorbent. Furthermore no cleavage occurred in presence of all basic and mostly all acidic compounds tested. Only using sulphuric acid in concentrations higher than 75 % an efficient cleavage of these peroxides was observed. Based on these experiments a test reactor for complete mineralisation of these peroxides using a combination of sulphuric scrubber, aqueous scrubber and biotrickling filter was designed, constructed and operated to get further information for a later industrial size scale-up.

Advisor: Dr.-Ing. D. Dobslaw

Study of feasibility for biological degradation of organic peroxides

Organic peroxides in general are highly reactive and thus show poor stability. However, a group of chemical high-stable peroxides exists, also used in chemical industry and in the production of polymers. Benzoylperoxide, dilaurylperoxide, di-tert-amylperoxide,
di-tert-butylperoxide, di-tert-amylhydroperoxide and di-tert-butylhydroperoxide for example belong to this group. The feasibility of biodegradation of these peroxides occurring as waste air compounds in air streams generated in the production of these peroxides was determined in cooperation with consulting engineers. In literature different peroxidases able to cleave peroxides in general are described. Most of them are specialised in the degradation of hydrogen peroxides. Only some of them like horseradish peroxidase are adapted for the degradation of organic peroxides. Experimental studies, focused on the di-tert-butylperoxide, showed a poor biodegradability of this compound caused by its low solubility in water and a high sterical shielding of the ternary carbon atoms.

Advisor: Dr.-Ing. D. Dobslaw

Development of a capable waste air treatment concept to fulfill limit values of the TA-Luft 2002 for emissions out of sewage sludge during sludge dehydration in belt drying systems.

Even though using state of the art techniques and optimising them, in most cases TA-Luft limit values cannot be passed. In cooperation with the industrial partner state of the art techniques were compared and most promising ones were tested under realistic waste air conditions. Adapted techniques were identified and core of further optimisation especially in the view of temperature effects, condensation effects, maintenance intervals (quick stops, maintenance stops) and elimination of odorimetric loadings.

Advisor: Dr.-Ing. D. Dobslaw

Independent Studies, Master- and Diploma Thesis

**The bacterial degradation of Isophorone**

Isophorone is a major product of the chemical industries. In this work bacterial strains were enriched, which could use isophorone as sole source of carbon and energy. The yielded strains were identified, their degradation kinetics were examined and the best performer was selected for further experiments.

To reveal the degradation pathway a transposon mutagenesis was performed. Some knock-out mutants were identified. They were incubated with Isophorone and another carbon source (their isophoron-degradation pathway was now defective – see figure), and the produced metabolites were analyzed with the GC-MS.

Thilo Hurler (technische Biologie) 2009

Supervisor: Dr. N. Strunk

Independent Study

Isophoron ($C_9H_{14}O$)

Transposon mutagenesis:
*Upper row:* One substrate (blue) is transformed by 4 enzymes (red) to a product (pink). Three metabolites (green) appear in the reaction chain. The enzymes are coded by structural genes (orange), they lie all in the same operon.

*Lower row:* One of the structural genes is damaged by a transposon (cyan). Gene 2 is disrupted, enzyme 2 is defective. Therefore only one metabolite (green) is produced, which could be extracted and analyzed.
Monitoring of benzotriazole in the Stuttgart water sanitation plant, extended by degradation experiments of carbamazepine.

The concentrations of 1-H-benzotriazol, 4-methyl-1-H-benzotriazol and 5-methyl-1-H-benzotriazol were monitored in the Stuttgart water sanitation plant. Therefore a new HPLC-MS method was developed in the laboratories of the Landeswasserversorgung in Langenau.

Samples from all five water sanitations plants in Stuttgart were examined. The results showed, that 4-methyl-1-H-benzotriazol is not degraded, while 1-H-benzotriazol and 5-methyl-1-H-benzotriazol is eliminated up to 70%.

In parallel it was tried to enrich a bacterial strain or community, which mineralize or transform carbamazepine. This substrate possesses only a low solubility in water. Hence, no bacterial strain, which uses carbamazepine as sole source of carbon and energy could be enriched. But it was possible to identify one strain, which uses carbamazepine as source of nitrogen.

Ngoc Diep Van (Umweltschutztechnik) 2009

Supervisor: Dr. N. Strunk

Independent Study

Physiology and possible industrial application of Cr(VI) reduction using biological systems

The study was conducted to evaluate the biological reduction of Cr(VI) as a possible treatment in industrial wastewater. The bacterial strain CRM100 was resistant to 1800 mg/L Cr(VI) and able to reduce 99.8% of 100 mg/L Cr(VI) within a period of 7 days under 100 mg/L. The results suggested that the isolated strain CRM100 can be used for treating industrial wastewater containing chromium hexavalent.

Diego Salamanca (WAREM) 2009

Supervisor: Dr. N. Strunk

Master Thesis

Structure of the substrates

Tryptone and glucose. Citrate was identified as a suitable electron donor used by CRM100 during the biological Cr(VI) reduction achieving the highest Cr(VI) reduction (99.7%) within a period of 7 days under 100 mg/L. The results suggested that the isolated strain CRM100 can be used for treating industrial wastewater containing chromium hexavalent.

Ngoc Diep Van (Umweltschutztechnik) 2009

Supervisor: Dr. N. Strunk

Independent Study

Physiology and possible industrial application of Cr(VI) reduction using biological systems

The study was conducted to evaluate the biological reduction of Cr(VI) as a possible treatment in industrial wastewater. The bacterial strain CRM100 was resistant to 1800 mg/L Cr(VI) and able to reduce 99.8% of 100 mg/L Cr(VI) using citrate as carbon source under anaerobic conditions. CRM100 reduced 78% of 1000 mg/L Cr(VI) within a period of 18 days. The biological Cr(VI) resistance of CRM100 was compared with P. putida. CRM100 was 180 times more resistant than P. putida. The growth of P. putida was inhibited by Cr(VI) concentrations higher than 10 mg/L Cr(VI). The influence of factors as pH, initial concentration of carbon source and Cr(VI) concentration was evaluated to determine the optimal reduction process using bacterial strain CRM100. The biological growth affected the
pH increased to alkaline conditions; optimal pH was found ranging between 7 – 7.5. The reduction process was improved by adding high amounts of citrate to the medium; the reduction percentage obtained was: 55% of 1000 mg/L Cr(VI) using 4 g/L citrate and 76% of 1000 mg/L Cr(VI) using 6 g/L citrate. The biological reduction was inhibited in the presence of ions as Pb²⁺, Zn²⁺, F⁻, Cu²⁺ and Cl⁻ in industrial wastewater containing Cr(VI). In addition, CRM100 was able to grow under anaerobic conditions within a variety of electron acceptors, including MoO₄²⁻, ClO₄⁻, AsO₄³⁻, SO₄²⁻ and MnO₄⁻ as well. The results suggested the potential applicability of CRM100 for the bioremediation of metal contaminated wastewater.

Name: Diego Salamanca (WAREM) 2009
Supervisor: Dr. N. Strunk
Master Thesis

Liquid culture of the strain CRM100. Right side: Fresh medium with 100 mg/L CrO₄²⁻. Left side: The crornate was reduced to green Cr(III)-compounds.

Efficiency comparison of biological and non biological waste air treatment procedures for economical and ecological optimised treatment of belt dryer emissions in the cement industry

Within endothermic clinker brick production processes out of lime in the cement industry high amounts of fossil fuels were necessary. Modern processes base on a thermal use of cadaver, animal meal, tyres, municipal and industrial sewage sludges instead of fossil fuels. About 5 % of the total energy demand is covered by the thermal use of sewage sludges, which are not directly combustible in the rotary furnaces, because of their high water contents. A thermal pre-drying procedure using waste heat of the rotary furnace is an efficient system. Within an air flow the evaporated water as well as volatile organic compounds as well as anorganic compounds like H₂S and NH₃ are separated from the dried matter. Poorly, high fluctuation in the composition of this air stream occurs. A treatment of this high odorous air containing high carbon freights is necessary. Up to now state of the art techniques are not adequate to fulfill the limit values of 20 mg C/m³ and 500 OU/m³ defined by the TA-Luft, respectively. The main task of this thesis was to choose adequate procedures for efficient treatment of this contaminated air and to verify and compare the efficiency of the chosen techniques in treating a real waste air flow of a cement plant. The focus lied on an evaluation of the procedures, feasibility of specific optimisation potential and selective treatment of a single and mixed waste air streams occurring on-site.

Tamara Linda Junghans (Umweltschutztechnik) 2009
Advisor: Dr.-Ing. D. Dobslaw
Diploma Thesis

Impact factors on the growth and degradation efficiency of nitrifying bacteria in a MBR-system in dairy industry

During the production process of milk sugar powder using vacuum distillation procedures waste water streams with COD contents of up to 200 mg O₂/L and total nitrogen contents of up to 100 mg N/L are generated. These waste water flows are treated by a MBR system and the separation of treated water from the biomass in done by a ultra filtration step. The filtrate is further treated by a reverse osmosis unit for desalination and the permeate is fed into the process water circle. Precondition of the use as process water is an efficient nitrogen elimination by oxidation of the ammonia to nitrate and further denitrification to gaseous nitrogen. However, no efficient nitrification occurred in this system. The goal of this diploma theses was to find out which waste water vapours and permeates as well as process steps posse a high inhibitory potential. The focus lied on the behaviour of organic acids, especially lactic acid, shear forces caused by the circulation pumps as well as the ejector system and turbulences in pH value and temperature in correlation to the ammonia oxidation rates appearing simultaneously.

Christian Wilde (Umweltschutztechnik) 2009
Advisor: Dr.-Ing. D. Dobslaw
Diploma Thesis
Optimisation of a bioscrubber system for treatment of VOC emissions in a hazardous waste recycling system under special focus on the fate of 2-butoxyethanol

VOCs within waste air streams and waste water batch phases occurring in hazardous waste recycling procedures should be biologically treated with a two-stage bioscrubber-regenerator system. The composition of waste compounds in both phases show high fluctuations. However, main compounds like butyl acetate, ethyl acetate, butanol, methyl ethyl ketone or 2-butoxyethanol are present permanently. The goal of this diploma thesis was the attendance of an on-site analytical campaign for several weeks, firstly. Based on these analytical data a synthetic waste air was defined and degradation of this carbon mixture was tested and optimised in half-technical scale. 2-butoxyethanol appeared as most critical compound within this air, because of its easy accumulation behaviour. Thus, the discovery of the biological degradation pathway was the content of further biochemical and genetical experiments.

Christine Woiski (Umweltschutztechnik) seit Juni 2009
Advisor: Dr.-Ing. D. Dobslaw
Diploma Thesis

Flow chart of the industrial scale plant for treatment of the defined hazardous waste compounds.
Contact

Prof. Dr.-rer. nat. habil. K.-H. Engesser
Tel: ++49 (0) 711/685-63734
Fax: ++49 (0) 711/685-63729
Email: karl-h.engesser@iswa.uni-stuttgart.de

Research Assistants

Dr.-Ing. Strunk
Tel: ++49 (0) 711/685-63730
Fax: ++49 (0) 711/685-63729
Email: niko.strunk@iswa.uni-stuttgart.de

Dr.-Ing. Dobslaw
Tel: ++49 (0) 711/685-65406
Fax: ++49 (0) 711/685-63729
Email: daniel.dobslaw@iswa.uni-stuttgart.de
Chair of Hydrochemistry and Hydrobiology

o. Prof. rer. nat. habil Jörg W. Metzger

Hydrochemistry ICH
o. Prof. Dr. rer. nat. habil. Jörg W. Metzger

Hydrobiology I BIO
Dr. rer. nat. Bertram Kuch
Dr.-Ing. Wolf-Rüdiger Müller
Chair of Hydrochemistry and Hydrobiology

At the chair of Hydrochemistry and Hydrobiology actual practice-oriented topics are investigated and natural science based solutions are developed in interdisciplinary co-operation with engineers. A basic knowledge in natural sciences is required to understand interdisciplinary contexts concerning all areas of Environmental Engineering. Biological and chemical processes are of high importance for the treatment processes of drinking water and wastewater as well as for composting of solid and green waste or for the decontamination of groundwater. The quality of water, no matter if it is wastewater, surface water, groundwater or drinking water, is defined by chemical and microbiological parameters, for which the legislator has set limits (e.g. in the Drinking Water Ordinance). Since it is not allowed to exceed these limits, it is important to reiterate the analytical monitoring process at regular intervals.

The task of the Environmental Analysis is to develop and to apply methods which allow to identify and quantify inorganic and organic compounds, either as single substances or in total (as so called summary parameter) in various environmental compartments, such as water, waste water, landfill leachate, soil, sediment, sewage sludge etc. The high toxicity of some substances and the problematic ecotoxicological properties, e.g. the tendency to undergo geo- or bioaccumulation, demands a specific and selective determination of substances in very low concentrations despite possible interferences with other matrix components. Therefore the methods have to be constantly optimised and interpretation of analytical data has always to consider measurement uncertainty.

New technologies in the wastewater treatment or drinking water purification are most effectively developed by a close co-operation at the interface between the Engineering and Natural Sciences, e.g. the determination of the efficiency of a water purification method. Effect-related analysis, in which the concentrations of a pollutant in a sample are correlated with its biological effects as basis for a risk-assessment is one of the numerous interdisciplinary networking areas of biology and chemistry.

Suitable biological test systems (bioassays), preferably as simply as possible, represent the basis for the practicable application of this concept. Also formation of the investigation of the environmental behaviour of native and anthropogenic substances, e.g. degradation pathways and metabolites as well as the identification of microorganisms participating in the degradation reaction, requires that chemists and biologists work hand in hand.

The Chair for Hydrochemistry and Hydrobiology at the ISWA has been supervised by Prof. Dr. rer. nat. Jörg W. Metzger since 1996, being also the Head of the Department of Hydrochemistry. The division of Applied Biology is managed by Dr. rer. nat. Bertram Kuch.

Teaching Activities

The Department of Hydrochemistry offers a broad range of basic and advanced courses for the students of the Bachelor and Master programs Civil Engineering and Environmental Engineering and the master programs WAREM and WASTE at the Universität Stuttgart. The lectures cover all important topics of Chemistry of Water and Waste Water, Water- and Soil Protection and Environmental Analysis. A deeper insight to these issues is given by practical courses, e.g. for sampling or chemical analysis in the chemical and microbiological laboratories of the department.

Courses for Environmental Engineering

- Umweltchemie mit Praktikum; Environmental Chemistry (lecture and practical laboratory work)
- Umweltanalytik II mit Praktikum; Environmental Analysis (lecture and practical laboratory work)
- Chemische Grundlagen des Gewässerschutzes; Chemical Basis for Water Resource Protection
- Ökotoxikologie und Bewertung von Schadstoffen; Ecotoxicology and Risk Assessment of Pollutants
- Wasser- und Abwasserchemie mit Praktikum; Chemistry of Water and Waste Water (lecture and practical laboratory work)
- Praktikum chemische Wassertechnologie; Chemical Water Technology (practical laboratory work)
- Qualitätssicherung in der chemischen Analytik; Quality Assurance in Chemical Analysis
- Messen und Analysieren von Gewässerverunreinigungen mit Praktikum; Measurement and Analysis of Water Pollution (lecture and practical laboratory work)
- Schadstoffanalytik mit Praktikum; Analysis of Pollutants (lecture and practical laboratory work)

Courses for Civil Engineering

- Chemie für Bauingenieure; Chemistry for Civil Engineers
- Wasser- und Abwasserchemie; Chemistry of Water and Waste Water
- Biologie und Chemie von Wasser und Abwasser mit Praktikum; Biology and Chemistry of Water and Waste Water (lecture and practical laboratory work)
Courses for WASTE

- Module: Chemistry and Biology for Environmental Engineers with the lecture Organic Chemistry
- Module: Industrial Waste Water with the lecture Water Analysis and Analytical Quality Control (lecture and practical laboratory work)
- Module: Sanitary Engineering - Practical Class
- Module: Umweltanalytik-Wasser und Boden (lecture hold in German)

Courses for WAREM

- Module: Chemistry and Biology for Environmental Engineers with the lecture Organic Chemistry
- Module: Industrial Waste Water with the lecture Water Analysis and Analytical Quality Control (lecture and practical laboratory work)
- Module: Sanitary Engineering - Practical Class
- Chemische Grundlagen des Gewässerschutzes; Chemical Fundamentals of Water Resource Protection
- Umweltanalytik II mit Praktikum; Environmental Analysis (lecture and practical laboratory work)

International

In co-operation with the Universidade Federal do Paraná, Curitiba (Brasil) and the Brazilian industry association SENAI, a postgraduate master program in Environmental Engineering EDUBRAS (Educação Brasil) was launched supported by DAAD. Within the scope of this program the lectures Environmental Chemistry, Environmental Analysis, Chemistry of Water and Waste Water and Ecotoxicology and Risk Assessment of Pollutants are offered by Prof. Jörg Metzger from March 2008 on. This master program conclude after four semester with a master of science degree.

Within the activities of proficiency testing in analytical chemistry (AQS Baden-Württemberg) the institute has co-operations with the following organisations:

- Physikalisch-Technische Bundesanstalt, Braunschweig, Germany
- International Atomic Energy Agency, Vienna, Austria
- Southern African Development Community Co-operation in Measurement Traceability, Pretoria, South Africa

Final Reports of the Chair

Development and Standardization of a test method for biodegradability of polymers under anoxic conditions by pressure measurement

The objective of this project was to develop a method for the evaluation of the biodegradability of polymers under anoxic (denitrifying) conditions in an aqueous medium. Thereupon a proposal can be submitted to the appropriate committees on European and international level to introduce a new international testing standard. The existing standards only concern to the determination of aerobic or anaerobic, but not to the anoxic biodegradability of polymers. The new approach will close this gap. The new test method will permit for instance the examination if a reuse of a waste polymer as carbon source for the denitrification of a waste water treatment plant is possible.

![Fig: Determination of the biodegradability under anoxic conditions](image)

<table>
<thead>
<tr>
<th>Financing institution:</th>
<th>German Federal Ministry of Economics and Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project partner:</td>
<td>Deutsches Institut für Normung (DIN)</td>
</tr>
<tr>
<td>Duration:</td>
<td>04/2008 - 12/2008</td>
</tr>
<tr>
<td>Contact:</td>
<td>Dr. Angela Boley</td>
</tr>
</tbody>
</table>
Kuch, Bertram; Metzger, Jörg W. (2008): Comparison of the cleaning efficiency of sand filtration and ultrafiltration by the example of a municipal wastewater treatment plant located on the „Schwäbische Alb“ . Final report of the research project sponsored by the Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie (BMBF).

Kuch, Bertram; Metzger, Jörg W. (2008): Elimination of pharmaceuticals and bacteria from hospital waste water in a membrane bioreactor. Final report of the research project sponsored by the Willy-Hager-Stiftung in cooperation with the Fraunhofer Institut für Grenzflächen- und Bioverfahrenstechnik.


Belli, Maria; Brookman, Brian; Calle, Beatriz de la; James, Vivienne; Koch, Michael; Majcen, Nineta; Menditto, Antonio; Noblett, Tracey; Perissi, Roberto; Putten, Kees van; Robouch, Piotr; Slapokas, Tommy; Taylor, Philip; Tholen, Daniel; Thomas, Annette; Tylee, Barry (2009): Proficiency testing in analytical chemistry, microbiology and laboratory medicine: working discussions on current practice and future directions. Accred. Qual. Assur. (14), 507-512.


Schiel, Detlef; Güttler, Bernd; Rienitz, Olaf; Matschat, Ralf; Koch, Michael; Borchers, Ulrich (2008): Der Weg zu international vergleichbaren Messergebnissen. Nachrichten aus der Chemie 56, 455-456


Trautwein, Christoph; Kümmerer, Klaus; Metzger, Jörg W. (2008): Aerobic biodegradability of the calcium channel antagonist verapamil and identification of a microbial dead-end transformation product studied by LC-MS/MS. Chemosphere 72, 442-450.

Contact

**o. Prof. Dr. rer. nat. habil. Jörg W. Metzger**

Tel.: +49 (0)711/685-63721
Fax: +49 (0)711/685-63729
E-Mail: joerg.metzger@iswa.uni-stuttgart.de

**Secretary’s office**

Dörte Hahn

Tel.: +49 (0)711/685-63721
Fax: +49 (0)711/685-63729
E-Mail: doerte.hahn@iswa.uni-stuttgart.de

**Hydrochemistry**

**o. Prof. Dr. rer. nat. habil. Jörg W. Metzger**

Tel.: +49 (0)711/685-63721
Fax: +49 (0)711/685-63729
E-Mail: joerg.metzger@iswa.uni-stuttgart.de

**Biology**

**Dr. rer. nat. Bertram Kuch**

Tel.: +49 (0)711 685-65443
Fax: +49 (0)711 685-63729
E-Mail: bertram.kuch@iswa.uni-stuttgart.de

**Dr.-Ing. Wolf-Rüdiger Müller**

Tel.: +49 (0)711 685-65411
Fax: +49 (0)711 685-63729
E-Mail: w-r.mueller@iswa.uni-stuttgart.de
In the hydrochemistry department the main subjects dealt with are environmental chemistry and, in particular, environmental analyses.

Some of the research work here deals with the question of the volume of medicines entering domestic wastewater, how these are degraded in a treatment plant and the influence they have on aquatic communities. We are especially interested in the volume of such chemicals retained in treatment plants, either by degradation processes in the various purification stages or by enrichment in the sewage sludge. As a consequence, we also investigate water bodies, above all with the question of whether and to what extent chemicals in the water are ingested by aquatic organisms (e.g. fish), are enriched within their bodies, or degraded or altered by their metabolism. A whole series of trace analysis methods are available for these investigations; these methods were, in part, specially developed in the hydrochemistry department. We are also engaged in the monitoring of treatment plants with regard to substances in the water that can interfere with components of the biological purification stages. A specially developed bio-sensor test system can be implemented for this purpose; it is suitable for recognition of nitrification-inhibiting compounds. Moreover, we also deal with external quality assurance in water chemistry laboratories and competence assessments. In the fields of drinking water, wastewater and groundwater analysis, this involves proficiency tests for laboratories, which are in part obligatory for state recognition of the laboratories. In addition, further water chemistry problems in the fields mentioned are investigated.
Projects

Flame retardants in organisms of Lake Constance (FLABO)
The Lake Constance is an important habitat for fish and therefore a large food resource - the fishing quota for 2008 was around 725 tones. Organic micro-pollutants, especially persistent lipophilic compounds enter Lake Constance and accumulate in the sediments, as well as in fish and shellfish.

Typical representatives of these contaminants are polychlorinated biphenyls (PCBs) which were banned because of their toxic properties already over 20 years ago, but can still be detected in various environmental samples. Polybrominated diphenyl ethers (PBDEs) have been used since the 1970s as flame retardants in textiles and electrical housings and also showed rising environmental levels over the last few decades. Since the industry signed a voluntary negotiated agreement on production and application concentrations seem to have stagnated. The study of dated sediment cores from Lake Constance in 2004/2005 (Interreg III) showed an increase of PBDE-concentrations in younger sedimentary layers. Within the current project, the PBDEs compared to the group of PCBs were determined in fish (bream - Abramis brama), zebra mussels (Dreissena polymorpha) and sediments of Lake Constance. The bream is a species of fish living close to the sediment partly feeding on zebra mussels. In addition obtaining information on the present load, the aim was to have a closer look on substance accumulation along the food chain.

The contaminants could be detected in all investigated environmental samples. The concentrations of PCBs in the sediments were at similar levels as in 2004/2005 and are thereby lower than quality objectives of the WFD (20 micrograms / kg dry matter). On examination of the upper layers lower concentration levels than in the older deeper layers could be determined. The PCB concentrations in the mussels were at small levels similar to those in the sediment. The congener pattern (concentration distribution of the various individual compounds) showed similarities with the technical mixture „Chlophen-A60“. The pattern of the PBDEs also shows similarities with the technical penta-bromo diphenyl ether mixture. While the PCB pattern between the investigated environmental samples looked similar, the PBDE profile of the various samples were significantly different. This gives us an indication of specific uptake or degradation of certain PBDE congeners.

The maximum PCB-concentrations found in the fillets of bream are far below the threshold limit for fresh water fish (Schadstoff-Höchstmengen Verordnung). Compared to PCB concentrations the PBDE concentrations are lower by an order of magnitude. Threshold limits do not exist for the group of PBDEs.
Biogas residue - a safety risk in organic farming?

Aim of the project is to determine the potential of biorest from biogas plants as fertilizers in organic farming. The focus is thereby put on organic pollutants, pesticides, heavy metals, Escherichia coli (E.coli) and Bacillus cereus (B. cereus). For this during one year on a monthly basis samples of a norwegian biogas plant are taken and analysed. The biogas residue is afterwards composted and the compost is sampled likewise. For the determination of the bio-availability plants and compost worm samples are analyzed, in addition the survival of the found bacteria in grain and milk products is observed.

In this joint project the ISWA is responsible for the analysis of the organic pollutants.
Establishment of a regional quality infrastructure in the East African Community (EAC)

An effective regional quality infrastructure (QI), in which all parties recognise each other mutually, plays a central role for the development of a common market in the member countries of the East African Community (Tanzania, Kenya, Uganda, Rwanda and Burundi) since it enables, to a large extent, a mutual and free movement of goods as well as the development of environmental and consumer protection on a liberalised market.

In a project of the German metrology institute Physikalisch-Technische Bundesanstalt (Project executing agency: Secretariat of the East African Community) this QI is to be strengthened. For this purpose among other things proficiency test for the chemical analysis of food (edible salt, wheat flour, edible vegetable oil) are performed.

Scientific support and consultancy of these PT schemes is the task of ISWA in this project.

Development of a biotechnical process with improved infiltration properties and environmental sustainability for the remediation of sites contaminated with volatile chlorinated hydrocarbons (VCH)

Sub-Project “Development of microbiological process basics for the optimization of the electron donor application in the field”

Microbiological and biotechnological studies are being carried out to develop a new remediation strategy for effective and complete dechlorination of volatile chlorinated hydrocarbons at contaminated sites. Therefore lipophilic electron donors are developed which are selectively supporting reductive dechlorination as well as favoring mass transfer of VCH from the DNAPL-phase into the electron donor phase. The most suitable electron donor is tested under laboratory and field conditions for economical dosing at little accumulation of DOC, methane and chlorinated intermediates.

Financing institution: Federal Ministry of Economy and Technology, ZIM (Central Innovation Program of Small and Medium-Sized Business)

Duration: 05/2009 - 04/2011

Contact: Prof. Dr. Jörg W. Metzger, Dr. Bertram Kuch, Dipl.-Chem. Claudia Lange
AQS Baden-Württemberg (analytical quality control Baden-Württemberg)

The Institute for Sanitary Engineering, Water Quality and Solid Waste Management is one of the largest proficiency test (PT) provider for chemical water analysis in Europe. These Pts are organized on behalf of the ministry of environment and the ministry of nutrition and rural affairs in Baden-Württemberg.

Three PT rounds for the analysis drinking water and usually two rounds for analysis of waste water are conducted per year for officially notified laboratories in Germany. Besides that one PT round for rapid test analysis in waste treatment plants and one round in the framework of a large groundwater monitoring programme are organized.

The actual programme can be found on http://www.aqsbw.de.

<table>
<thead>
<tr>
<th>Client:</th>
<th>Water authorities and chemical laboratories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific director:</td>
<td>Dr.-Ing. Michael Koch</td>
</tr>
<tr>
<td>Technical director:</td>
<td>Dr.-Ing. Frank Baumeister (TGZ AQS-BW)</td>
</tr>
<tr>
<td>Secretary’s office:</td>
<td>Heidemarie Sanwald (TGZ AQS-BW)</td>
</tr>
<tr>
<td>Further informations:</td>
<td><a href="http://www.aqsbw.de">http://www.aqsbw.de</a></td>
</tr>
</tbody>
</table>

Chemicals used for the production of PT samples

High-precision balances for the net weight of chemicals and solutions
Sample preparation for the proficiency test (PT)

High-grade steel vessel (2,1 m³) for pasteurisation of waste water, drinking water and ground water

Stock solutions for the preparation of PT samples
Master- and Diploma Thesis

Die Bestimmung der PCB und PBDE-Belastung im Sediment von Zulaufen des Bodensees
Sandra Ulbrich (Umweltschutztechnik) (2009)
Betreuer: Prof. Jörg W. Metzger, Dr. Bertram Kuch

Untersuchung ausgewählter phenolischer Verbindungen auf ihre estrogene Wirkung mit dem E-Screen-Assay.
Dompert, Katrin (Umweltschutztechnik) (2009)
Betreuer: Prof. Jörg W. Metzger, Dr. Bertram Kuch

Untersuchung von papierbasierenden Lebensmittelverpackungen auf estrogen wirksende Substanzen mittels GC/MS und Ermittlung der estrogenen Gesamtrezeptorstärke mittels E-Screen
Christina Weber (Chemie) (2008)
Betreuer: Prof. Jörg W. Metzger, Dr.-Ing. Michael Koch

In vitro-Bestimmung der estrogenen Aktivität von Deodorantien und ausgewählten Inhaltsstoffen mittels E-Screen-Assay
Claudia Lange (Chemie) (2008)
Betreuer: Prof. Jörg W. Metzger, Prof. Dr.-Ing. M. Koch

Qualitative und quantitative Untersuchung organischer Spurenstoffe im Klärschlamm unter besonderer Berücksichtigung synthetischer Duftstoffe und ihrer Abbauprodukte
Gabriele Schmidt (Umweltschutztechnik) (2008)
Betreuer: Prof. Jörg W. Metzger, Dr. Bertram Kuch

Optimierung der Entsorgung von Schlammrückständen aus der Wasseraufbereitung
Kristin Claußen (WASTE) (2008)
Betreuer: Dr.-Ing. W.-R. Müller, Prof. Jörg W. Metzger

Influence of VFAs on Feast and Famine Enrichment for PHA Production in Open Mixed Cultures
Mariana Voltolini (WASTE) (2009)
Betreuer: Dr.-Ing. W.-R. Müller; Prof. Jörg W. Metzger
Contact

o. Prof. Dr. rer. nat. habil. Jörg W. Metzger
Tel: +49 (0) 711/685-63721
Fax: +49 (0) 711/685-63729
E-Mail: joerg.metzger@iswa.uni-stuttgart.de

Secretary´s office
Dörte Hahn (Hydrochemie)
Tel: +49 (0) 711/685-63721
Fax: +49 (0) 711/685-63729
E-Mail: doerte.hahn@iswa.uni-stuttgart.de

Heidemarie Sanwald (AQS)
Tel: +49 (0) 711/685-65446
Fax: +49 (0) 711/685-67809
E-Mail: heidi.sanwald@iswa.uni-stuttgart.de

Head of Laboratory and Scientific Director AQS
Dr.-Ing. Michael Koch
Tel: +49 (0) 711/685-65444
Fax: +49 (0) 711/685-67809
E-Mail: michael.koch@iswa.uni-stuttgart.de

Technical Director AQS
Dr.-Ing. Frank Baumeister
Tel: +49 (0) 711/685-65442
Fax: +49 (0) 711/685-67809
E-Mail: frank.baumeister@iswa.uni-stuttgart.de

Scientists
Dr. rer. nat. Bertram Kuch
Tel: +49 (0) 711/685-65443
E-Mail: bertram.kuch@iswa.uni-stuttgart.de

Dipl.-Chem. Claudia Lange
Tel: +49 (0) 711/685-65741
E-Mail: claudia.lange@iswa.uni-stuttgart.de

Dipl.-Biol. Biljana Marić
Tel: +49 (0) 711/685-65447
E-Mail: biljana.maric@iswa.uni-stuttgart.de

Dipl.-Ing. Jörg Alexander Pfeiffer
Tel: +49 (0) 711/685-63720
E-Mail: joerg.pfeiffer@iswa.uni-stuttgart.de

Dipl.-Chem. Jessica Stäb
Tel: +49 (0) 711/685-63727
E-Mail: jessica.staeb@iswa.uni-stuttgart.de

Laboratory staff
Michael Braun (Chemo Technician)
Tel: +49 (0) 711/685-65446

Suse Gaiser (BTA)
Tel: +49 (0) 711/685-65496

Maria Gebauer (CTA)
Tel: +49 (0) 711/685-65454

Gertrud Joas (CTA)
Tel: +49 (0) 711/685-65454

Andrea Kern (LTA)
Tel: +49 (0) 711/685-65741

Giuseppina Müller (CTA)
Tel: +49 (0) 711/685-65454

Cornelia Orth (Dipl.-Ing., FH)
Tel: +49 (0) 711/685-65435

Ellen Raith-Bausch (Chemo Technician)
Tel: +49 (0) 711/685-65454 oder +49 (0) 711/685-65400
Biology

The biology section deals with methods for investigation of the biological degradation of pollutants, chemicals, solid organic substances and polymers in water and the soil. The focal points of our work include remediation methods and measuring and verification methods.

In many cases of biological degradation, a thorough verification of the fate of substances and their intermediate products is required, in order to address the hazard of accumulation in the environment. To be able to classify a substance as "completely degradable", its conversion to mineralization products must be proven. This is why the Sapromat, designed at the institute, was enhanced to facilitate the verification of complete, aerobic, biological degradation of an organic substance to carbon dioxide, water and biomass. Further inhouse developments, the "Denimat" and the "Methanomat", allow automated degradation investigations under anoxic and anaerobic conditions.

Typical problems involved with drinking water supplies in rural areas include the high nitrate and pesticide content in groundwater. Using our invention, which utilizes biodegradable polymers as carrier substances and as a source of carbon for a single-stage process in water treatment, it is possible to achieve simultaneous biological nitrate and pollutant elimination in drinking water treatment, in wastewater treatment, and in fish production and aquariums.

Numerous groundwater reservoirs in Germany are polluted by industrial pollutants. Chlorinated solvents are among the most widespread substances. Investigations aimed at the remediation of contaminated areas are carried out within the context of a programme sponsored by the Federal Ministry of Education and Research. The aim of this project is to gain an understanding of the fundamentals involved in the participation of microorganisms in the conversion of volatile organic hydrocarbons.

Research topics:

- Biological degradation and risk assessment of pollutants, chemicals, and organic solid substrates as well as polymers
- Development of specific test equipments
- Low-tech effective biological water treatment with biodegradable polymers
- Biological remediation of organic pollutants from contaminated aquifers
Projects

Development of Novel Processes for Simultaneous Elimination of Organic Pollutants and Nitrate from Drinking Water by Means of Biodegradable Solid Substrates

Even with many legislative regulations not everywhere efforts have been successful to diminish concentrations of Nitrate and Pesticides in groundwater. The aim of this project is the development of a simple and cost-effective combined process which allows not only the biological removal of Nitrate but also Pesticides. In this technology we use biodegradable polymers (BDP) as substrates for the heterotrophic denitrification process, e.g. PHB (Poly-ß-Hydroxy Butyric Acid) or PCL (Poly-ε-Caprolactone). The water insoluble polymer granules act as growth surface for microorganisms and at the same time as organic substrate which can be activated via bacterial exoenzymes and on this way being used for denitrification. In addition the polymers perform as sorbents for the dissolved organic contaminants, e.g. pesticides.

In the scope of the project different technical realizations in form of reactor configurations and reactor types are being examined. The performance of different available biodegradable polymers is tested in advance with long term biological test processes thus complementing the pilot testing with semi-technical reactors. As this process is aimed to be applied in drinking water treatment all aspects of the use of BDPs shall be examined. This means between others the examination of the „leachate“ products of the biodegradable polymers, the products which occur during the anoxic biodegradation step and of course also the examination of the biocenosis in the reactors. A check of potentially pathogenic bacteria will be carried out. A long-term objective of the project is the authorization of polymers according to the „List of Treatment Substances and Disinfection Processes“ as per § 11 of the German Drinking Water Ordinance (TrinkwV 2001) and the treatment processes connected with. This List is maintained at the Federal Environment Agency on behalf of the Federal Ministry of Health, Berlin.

Financing institution:
Forschungszentrum Karlsruhe - Bereich Wassertechnologie und Entsorgung, for the German Federal Ministry of Education and Research (BMBF)

Project partner:
- Forschungszentrum (Research Center) Karlsruhe (FZKA)
- Water Technology Center -, Karlsruhe (TZW)
- Universität Karlsruhe, Engler-Bunte-Institut, Chair of Water Chemistry
- Martin-Luther-Universität Halle-Wittenberg (MLU)
- Nordic Water GmbH, Neuss
- Formtechnik in Südbaden GmbH & Co. KG, Teningen
- Tsinghua University, Institute for Nuclear Energy Technology, Beijing

Duration:
10/2006 - 03/2010

Contact:
Dr. Angela Boley
Dr.-Ing. Wolf-Rüdiger Müller
Dipl.-Ing. Martin Kieninger

Pilot plant for the denitrification and pesticide removal with biodegradable polymers

„Dynasand-Reactor“ (Nordic Water)  „Roto-Bio-Reactor“ (Formtechnik in Südbaden)
Development and Standardization of a test method for biodegradability of polymers under anoxic conditions by pressure measurement

The objective of this project was to develop a method for the evaluation of the biodegradability of polymers under anoxic (denitrifying) conditions in an aqueous medium. Thereupon a proposal can be submitted to the appropriate committees on European and international level to introduce a new international testing standard. The existing standards only concern to the determination of aerobic or anaerobic, but not to the anoxic biodegradability of polymers. The new approach will close this gap. The new test method will permit for instance the examination if a reuse of a waste polymer as carbon source for the denitrification of a waste water treatment plant is possible.

Fig: Determination of the biodegradability under anoxic conditions

Financing institution:
German Federal Ministry of Economics and Technology
Project partner:
Deutsches Institut für Normung (DIN)
Duration:
04/2008 - 12/2008
Contact:
Dr. Angela Boley
Contact

Dr. rer. nat. Bertram Kuch
Tel: +49 (0) 711/685-65443
Fax: +49 (0) 711/685-67809
E-Mail: bertram.kuch@iswa.uni-stuttgart.de

Dr.-Ing. Wolf-Rüdiger Müller
Tel.: +49 (0)711 685 65411
Fax: +49 (0)711 685 63729
E-Mail: W-R.Mueller@iswa.uni-stuttgart.de

Secretary´s office
Andrea Matzig (Hydrobiology)
Tel: +49 (0) 711/685-63708
Fax: +49 (0) 711/685-63729
E-Mail: andrea.matzig@iswa.uni-stuttgart.de

Scientists

Dr. rer. nat. Angela Boley
Tel.: +49 (0)711 685 65441
Fax: +49 (0)711 685 63729
E-Mail: Angela.Boley@iswa.uni-stuttgart.de

Dr. rer. nat. Heidrun Scholz-Muramatsu
Tel.: +49 (0)711 685 65474
Fax: +49 (0)711 685 63729
E-Mail: Scholz-Muramatsu@iswa.uni-stuttgart.de

Dipl.-Ing. Martin Kieninger
Tel.: +49 (0)711 685 63733
Fax: +49 (0)711 685 63729
E-Mail: Martin.Kieninger@iswa.uni-stuttgart.de

Laboratory staff

Suse Gaiser (BTA)
Tel: +49 (0) 711/685-65496

Regina Görig (LTA)
Tel: +49 (0) 711/685-65452

Matthias Mischo (CTA)
Tel: +49 (0) 711/685-65452
The facilities of the LFKW play an important part in the traditionally practice-oriented education at our institute. Within the scope of practical training measures, the assistance in research projects and working on Master’s theses, the students are provided with plenty of opportunities to become familiar with the details of the equipment and the operation of a highly mechanized sewage treatment plant.

The LFKW is operating under real conditions: its primary task is the purification of the wastewater from the university campus in Stuttgart-Vaihingen and from the nearby Büsnau district of which the total daily volume is about 2.000 cubic metres. In order to comply with the strong official discharge regulations and to provide opportunities for research at the same time, the LFKW has a multitrack purification system: all process steps required for advanced wastewater treatment consist of at least two parallel units. In this way separate plant components can be used at any time for fullscale research, independent of the other units and without any adverse effects on the quality of the final effluent. Additional experimental areas inside and outside of a large two-storey hall offer a wide variety of options for research work and individually contracted investigations on a semi-technical scale. The LFKW also offers its services to technical companies, operators of municipal environmental facilities and engineer’s offices: from the testing of measuring devices, chemical aids etc. under practical conditions through the manufacturing of laboratory test equipment to the leasing of complete pilot plants for the treatment of wastewater, sludge and exhaust air.
### Annual Report 2009 - Overallview

#### Overall view (1)

<table>
<thead>
<tr>
<th>Source flow</th>
<th>Raw sewage</th>
<th>Inflow biology</th>
<th>Effluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>total annual flow</td>
<td>795,230 m³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>annual wastewater discharge</td>
<td>916,293 m³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>portion of extraneous water</td>
<td>13.5 %</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Concentrations of polluting matter (annual average) [mg/L]

<table>
<thead>
<tr>
<th></th>
<th>Raw sewage</th>
<th>Inflow biology</th>
<th>Effluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>486.3</td>
<td>315.8</td>
<td>10.5</td>
</tr>
<tr>
<td>Ntot</td>
<td>49.3</td>
<td>45.0</td>
<td>9.8</td>
</tr>
<tr>
<td>Ptot</td>
<td>8.9</td>
<td>6.6</td>
<td>0.2</td>
</tr>
<tr>
<td>SS</td>
<td>228.9</td>
<td>115.9</td>
<td>1.6</td>
</tr>
</tbody>
</table>

#### Pollution load (annual average) [t/y]

<table>
<thead>
<tr>
<th></th>
<th>Raw sewage</th>
<th>Inflow biology</th>
<th>Effluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>955.08</td>
<td>255,204</td>
<td>14,692</td>
</tr>
<tr>
<td>Ntot</td>
<td>36.67</td>
<td>33,803</td>
<td>7,420</td>
</tr>
<tr>
<td>Ptot</td>
<td>5.196</td>
<td>4,489</td>
<td>186</td>
</tr>
<tr>
<td>SS</td>
<td>85,991</td>
<td></td>
<td>3,257</td>
</tr>
</tbody>
</table>

#### Frequency of values in excess

<table>
<thead>
<tr>
<th></th>
<th>Concentration [mg/L]</th>
<th>Value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>&gt;76</td>
<td>0.0 %</td>
</tr>
<tr>
<td>NH₄-N</td>
<td>&gt; 8</td>
<td>0.5 %</td>
</tr>
<tr>
<td>No₃-N</td>
<td>&gt; 16</td>
<td>0.0 %</td>
</tr>
<tr>
<td>PO₄-P</td>
<td>&gt; 1</td>
<td>0.0 %</td>
</tr>
<tr>
<td>SS</td>
<td>&gt; 15</td>
<td>0.0 %</td>
</tr>
</tbody>
</table>

#### Chemical aids, residues, digester gas characteristics

**Mechanical part**
- specific quantity of screenings: 3.7 kg/m³ (m³)
- specific quantity of grit: 1.2 kg/m³ (m³)

**Biological part** (activated sludge plant)
- N₂/O, COD inflow biological stage: 6.16
- sewage temperature: 9.5 °C
- COD sludge loading: 0.20 kg/kg(TMP)
- O₂ sludge loading: 0.28 kg/kg(O₂/TMP)
- sludge volume index (mean-max) | 109 | m³/g
- resusitation  | 450 | m³/g
- contact time centrifugation tank: 310 s
- specific excess sludge production: 0.9 m³/g
- sludge vol. surface load final stage: 276 m³/m²
- detention time final sedimentation: 51 s

**Phosphate precipitation**
- X value | 0.2 | mol Me(M) / mol ZU
### Overall View

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wastewater levy (Fr 2007)</td>
<td>27,464.18 Fr</td>
</tr>
<tr>
<td>Groundwater withdrawal</td>
<td>81,143 m³</td>
</tr>
</tbody>
</table>

### Sludge Pretreatment by Centrifugation

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific polymer consumption</td>
<td>3.3 g AAOg TR⁻¹</td>
</tr>
<tr>
<td>Dewatering factor (TS_dry/TSRaw)</td>
<td>4.4</td>
</tr>
</tbody>
</table>

### Sludge Digestion

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic space loading</td>
<td>1,480 kg sTR(m³d⁻¹)</td>
</tr>
<tr>
<td>Digestion time</td>
<td>55.7 d</td>
</tr>
<tr>
<td>Specific quantity of sludge produced</td>
<td>0.228 LTSW-1(RW d⁻¹)</td>
</tr>
<tr>
<td>Specific gas yield</td>
<td>31.4 LgTSR-1(RW d⁻¹)</td>
</tr>
<tr>
<td>Specific gas yield</td>
<td>17.3 LgTSR-1(RW d⁻¹)</td>
</tr>
</tbody>
</table>

### Efficiency Comparison 2006

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen demand stage (CO₂ + N₂O)</td>
<td>1.0</td>
</tr>
<tr>
<td>Current loading stage (fMeth + fAna)</td>
<td>1.0</td>
</tr>
</tbody>
</table>

### Power Consumption

<table>
<thead>
<tr>
<th>Category</th>
<th>Specific Power Consumption (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return sludge pumping station</td>
<td>2.30 kWh(EW-a)</td>
</tr>
<tr>
<td>Intermediate pumping station</td>
<td>1.92 kWh(EW-a)</td>
</tr>
<tr>
<td>Mechanical sludge dewatering</td>
<td>1.93 kWh(EW-a)</td>
</tr>
<tr>
<td>Microstrainer plant</td>
<td>1.95 kWh(EW-a)</td>
</tr>
</tbody>
</table>

### Accidents at Work

- 2 accidents (lost working days: 21)
### Annual Report 2009 - Monthly Data

#### Water Quality Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COD</td>
<td>mg/L</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphorous</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspended Solids</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inlet Biological Part</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum pH-value</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum pH-value</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Conductivity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Conductivity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Inlet Biological Part (2)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>COO*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NH-N*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FeCO*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FePO*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solute Solids</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspended Solids</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COD Load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Nitrogen Load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Phosphorous Load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspended Phosphorous Load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Pre-Destillation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residual ratio</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact time DN-tank</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substrate loading</td>
<td>kg/ha</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Notification

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLSS Activated Sludge</td>
<td>g/L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Met. Activated Sludge</td>
<td>g/L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alkalinity Load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sludge Volume Load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSLP Volume Load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min. Sludge Volume Load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min. Sludge Volume Load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min. Sewage Temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. Sewage Temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

138
### Sewage Treatment Plant for Research and Education | LFKW

#### Annual Report 2009

### Simultaneous precipitation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Okt</th>
<th>Nov</th>
<th>Dec</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>sludge dosage</td>
<td>188</td>
<td>267</td>
<td>236</td>
<td>229</td>
<td>245</td>
<td>267</td>
<td>234</td>
<td>256</td>
<td>228</td>
<td>256</td>
<td>256</td>
<td>256</td>
<td>256</td>
<td>256</td>
</tr>
<tr>
<td>iron dosage</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S-value</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### Effluent

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Okt</th>
<th>Nov</th>
<th>Dec</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>min pH-value</td>
<td>6.7</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>6.7</td>
<td>6.7</td>
</tr>
<tr>
<td>max. pH-value</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
</tr>
<tr>
<td>max settleable solids</td>
<td>mg/L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7.0</td>
<td>7.0</td>
</tr>
<tr>
<td>suspended solids</td>
<td>mg/L</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>turbidity</td>
<td>mU</td>
<td>5.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>COD</td>
<td>mg/L</td>
<td>78.6</td>
<td>78.6</td>
<td>78.6</td>
<td>78.6</td>
<td>78.6</td>
<td>78.6</td>
<td>78.6</td>
<td>78.6</td>
<td>78.6</td>
<td>78.6</td>
<td>78.6</td>
<td>78.6</td>
<td>78.6</td>
</tr>
<tr>
<td>NH₄-N</td>
<td>mg/L</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>NO₂-N</td>
<td>mg/L</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>NO₃-N</td>
<td>mg/L</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>nitrogen</td>
<td>mg/L</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
</tr>
<tr>
<td>total nitrogen</td>
<td>mg/L</td>
<td>45.6</td>
<td>45.6</td>
<td>45.6</td>
<td>45.6</td>
<td>45.6</td>
<td>45.6</td>
<td>45.6</td>
<td>45.6</td>
<td>45.6</td>
<td>45.6</td>
<td>45.6</td>
<td>45.6</td>
<td>45.6</td>
</tr>
<tr>
<td>total phosphorus</td>
<td>mg/L</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>COD load</td>
<td>kg/m³</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>total nitrogen load</td>
<td>kg/m³</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>total phosphorus load</td>
<td>kg/m³</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

### Loading of activated sludge plant

<table>
<thead>
<tr>
<th>Parameter</th>
<th>kg/m³</th>
<th>kg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD sludge loading</td>
<td>0.26</td>
<td>0.26</td>
</tr>
<tr>
<td>sludge age</td>
<td>0.26</td>
<td>0.26</td>
</tr>
</tbody>
</table>

### Treatment efficiency total plant

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Okt</th>
<th>Nov</th>
<th>Dec</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
</tr>
<tr>
<td>total nitrogen</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
</tr>
<tr>
<td>total phosphorus</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
<td>78.8</td>
</tr>
</tbody>
</table>

### Treatment efficiency biological stage

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Okt</th>
<th>Nov</th>
<th>Dec</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
</tr>
<tr>
<td>total nitrogen</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
</tr>
<tr>
<td>total phosphorus</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
<td>80.4</td>
</tr>
</tbody>
</table>

### Exceeding of permissible effluent limits

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Okt</th>
<th>Nov</th>
<th>Dec</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ &gt; 75 mg/L</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>NH₄-N &gt; 5 mg/L</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Nitrates &gt; 15 mg/L</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>SS &gt; 15 mg/L</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

### Most important consumers of electricity

<table>
<thead>
<tr>
<th>Parameter</th>
<th>kWh</th>
<th>kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>blower station</td>
<td>850</td>
<td>850</td>
</tr>
<tr>
<td>return sludge pumping</td>
<td>123</td>
<td>123</td>
</tr>
<tr>
<td>tapwater pumping</td>
<td>216</td>
<td>216</td>
</tr>
<tr>
<td>grot chamber group</td>
<td>192</td>
<td>192</td>
</tr>
<tr>
<td>internal recirculation</td>
<td>192</td>
<td>192</td>
</tr>
<tr>
<td>intermediate pumping</td>
<td>192</td>
<td>192</td>
</tr>
<tr>
<td>centrifuge</td>
<td>192</td>
<td>192</td>
</tr>
<tr>
<td>microchannel</td>
<td>192</td>
<td>192</td>
</tr>
<tr>
<td>extraction cleaning</td>
<td>192</td>
<td>192</td>
</tr>
</tbody>
</table>

---

139
### Annual Report 2009 - Institute for Sanitary Engineering, Water Quality and Solid Waste Management

#### Parameters

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw sludge</td>
<td>m³/da</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VF (vowels) sludge</td>
<td>g/L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MLSS excess sludge</td>
<td>g/L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VS primary sludge</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TS primary sludge</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VS primary sludge</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VF/MLSS ratio</td>
<td>m³/da</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TS/VS ratio</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digestion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digestor temperature</td>
<td>°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digestor gas (1)</td>
<td>m³/day</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bio gas scheme</td>
<td>m³/day</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digestion gas (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methane content</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fe-H₂O dosage</td>
<td>ppm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₂O raw gas</td>
<td>ppm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₂O-deshifted gas</td>
<td>ppm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Screeners</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>coarse</td>
<td>kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fine</td>
<td>kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Notes

- **M**: monthly mean or annual mean
- **S**: individual value (minimum or maximum measurement)
- **T**: total
- **U**: exceeding
- **AA**: active agent
- **E**: population equivalent
- **VF**: volume flow
- **TS**: total solids
- **VS**: volatile solids
- **MLSS**: mixed liquor suspended solids
- **ND**: not determined (no values or basic values not representative)
Annual Report 2009 - Performance Diagram
Master- and Diploma Thesis

Untersuchungen zu den Auswirkungen eines längeren Stromausfalls auf die Reinigungsleistung von Belebungsanlagen

Sebastian Pfost (Bauingenieurwesen) (2009)
Betreuer: Dr.-Ing. M. Roth,
Prof. Dr.-Ing. H. Steinmetz

Contact

Dr.-Ing. Peter Maurer

Tel:  ++49 (0)711/685-63724
Fax:  ++49 (0)711/685-67637
E-Mail: peter.maurer@iswa.uni-stuttgart.de

In 2009 retired:

Dr.-Ing. Manfred Roth
Imprint

Publisher:
Institute for Sanitary Engineering, Water Quality and Solid Waste Management
Bandtäle 2
70569 Stuttgart
Germany

www.iswa.uni-stuttgart.de/index.en.html

Cover:
Solutioncube GmbH

Conception:
Dipl.-Geol. Detlef Clauß
M.A. Constanze Sanwald
Dörte Hahn

© 2010