LIFE Project Number

LIFE 03 ENV/D/000025

TECHNICAL INTERIM REPORT

Reporting Date

31.07.2005

LIFE PROJECT NAME

Sanitation Concepts for Separate Treatment of Urine, Faeces and Greywater (SCST)

Project Data

Project location	Wastewater Treatment Plant Stahnsdorf Schenkendorfer Weg 1-9 14532 Stahnsdorf
Project start date:	01.01.2003
Project end date:	30.06.2006
Total project duration (in month)	42 months
Total budget	2,223,474€
EC contribution:	465,635 €
(%) of total costs	20.9
(%) of eligible costs	30.0

Beneficiary Data

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1. List of Contents

2. LIST (I) KEY-WORDS AND (II) ABBREVIATIONS

Key-Words: new sanitation concepts, gravity separation toilet, vacuum separation toilet, waterless urinals, compost separator, digestion, constructed wetland, septic tank

Abbreviations:

KWB Kompetenzzentrum Wasser Berlin (Center of Competence for Water Berlin)
BWB Berliner Wasserbetriebe
AR Anjou Recherche

3. EXECUTIVE SUMMARY

The main goal of this project is to develop new sustainable sanitation concepts which have significant advantages in relation to ecological as well as to economical aspects compared to the conventional systems (end-of-pipe-system). After successful project completion the new sanitation concepts should be used in Berlin areas, where sewer systems are not installed and these concepts are appropriate, as well as other locations (national and international).

The technical management of the project has been achieved as foreseen, but the administrative project manger has changed in July 2005 since the head of the Berlin Centre of Competence for Water has changed.

All technical equipments, besides of the bio-gas plant, are realised. The bio-gas plant will be installed about the end of 2005. In contrary to the EU-proposal the concept with vacuum separation toilets has been installed for technical reasons in the office building instead in the apartment house. Before installing of these toilets gravity separation toilets have been operated for 1 ½ years. Furthermore not in 15 but in 10 flats of the apartment house was it possible to install gravity separation toilets.

The addition tasks *Life-Cycle-Assessment* (Task 5), *Industrial style urine treatment for utilization* (Task 7) and *Fertiliser usage* (Task 8) undertaken by different Universities are in the works.

The users accept the separation toilets in general, but more the gravity than the vacuum separation toilets. Both have to be improved, especially the flush. The worse assessment for the vacuum separation toilets was expected since they are altered gravity separation toilets. An optimised vacuum separation toilet is not available on the market at present. The results from the faeces separator show that far the most solids can be retained in the filter bags, but there is still a high solids-concentration in the filtrate. For huge settlements a different, continuously working separator is necessary. Due to the high solid concentration in the faecal filtrate the soil filter as a pre-treatment step was blocked very soon and went out of operation. With the 2-chamber septic tank for greywater and faecal filtrate treatment an effluent quality could be obtained which does not lead to clogging of the downstream constructed wetland. The results of the constructed wetland are as expected.

From the work of Task 5 and the experiments of Task 7 no reliable results are available until now. The experiments of Task 8 show that the fertilising results from the urine are similar with those from mineral fertilisers.

Until the end of the project the different tasks will continue. The digestion of the faeces from the vacuum separation toilets with the bio-gas plant will start in January 2006.

In relation to the financial issues 790,482 € (51 %) of the total eligible costs of 1,552,116 € and 1,230,640 € (55 %) of the total real costs of 2,223,474 € respectively have been spent until now. Herewith, the 30 % threshold of the total real costs is transcended.

Das Hauptziel dieses Projektes ist neue Sanitärkonzepte zu entwickeln, welche signifikante Vorteile hinsichtlich ökologischer und ökonomischer Aspekte im Vergleich zu konventionellen Sanitärsysteme (End-of-pipe-system) haben. Nach einer erfolgreichen Beendigung dieses Projektes sollten diese neuen Sanitärkonzepte sowohl in Gebieten in Berlin genutzt werden, welche keine Kanalisation haben und diese Konzepte zweckmäßig sind, als auch an anderen Orten (national und international).

Das technische Management des Projektes erfolgte wie geplant. Beim administrativen Management ergab sich im July 2005 ein Wechsel, da auch der Geschäftsführer des KompetenzZentrum Wasser Berlin wechselte.

Alle technischen Ausrüstungen, mit Ausnahme der Biogasanlage, sind ausgeführt. Die Biogasanalge wird voraussichtlich Ende 2005 installiert. In Abänderung zum EU-Antrag wurden die Vakuumtrenntoiletten aus technischen Gründen im Betriebsgebäude und nicht im Wohnhaus installiert. Bevor dies Toiletten installiert wurden, wurden Schwerkrafttrenntoiletten in diesem Gebäude über 1 ½ Jahre betrieben. Weiterhin konnten im Wohnhaus nicht wie ursprünglich vorgesehen 15, sondern nur in 10 Schwerkafttrenntoiletten installiert werden.

Die zusätzlichen Aufgaben „Ökobilanz“ (Aufgabe 5), „Industrielle Urinbehandlung“ (Aufgabe 7) und „Düngeversuche“ (Aufgabe 8), die von Universitäten durchgeführt werden, sind in Arbeit.

Die Benutzer der Trenntoiletten akzeptieren sie grundsätzlich, jedoch mehr die Schwerkrafttrenntoiletten als di Vakuumtrenntoiletten. Beide müssen verbessert werden, insbesondere die Spülung. Die schlechtere Beurteilung der Vakuumtrenntoiletten wurde erwartet, da es sich um umgerüstete Schwerkrafttrenntoiletten handelt. Eine optimierte Vacuumtrenntoilette ist zurzeit auf dem Markt noch nicht erhältlich. Die Ergebnisse vom Fäkalienseparator zeigen, dass bei weitem der Größte Teil der Feststoffe im Filter zurückgehalten werden, aber dennoch eine hohe Feststoffkonzentration im Fäkalfiltrat ist. Für große Siedlungen ist eine anderer, kontinuierlich arbeitender Separator erforderlich. Aufgrund der hohen Feststoffkonzentration im Fäkalfiltrat war der als Vorreinigungsstufe vorgesehene Bodenfilter bald verstopft und wurde außer Betrieb genommen. Mit der Zweikammergube für die mechanische Reinigung von Grauwasser und Fäkalfiltrat konnte eine Ablaufqualität erreicht werden, die zu keiner Kolmation des nachgeschalteten bewachsen Bodenfilters führt. Die Ergebnisse des bewachsenen Bodenfilters sind wie erwartet.

Von der Arbeit der Aufgabe 5 und den Experimenten der Aufgabe 7 sind noch keine zuverlässigen Ergebnisse verfügbar. Die Experimente von Aufgabe 8 zeigen, dass die Düngeergebnisse von Urin vergleichbar sind mit denen von Mineraldüngern.

Bis zum Ende des Projektes werden die verschieden Aufgaben fortgesetzt. Mit der anaeroben Behandlung der Fäkalien aus den Vakuumtrenntoiletten wird im Januar 2006 begonnen.

Bezüglich des finanziellen Teils wurden 790,482 € (51 %) der gesamten bezuschussbaren Kosten von 1.552.116 € und 1.232.110 € (55 %) von den gesamten Kosten des Projektes in Höhe von 1,230,640 € ausgegeben. Damit ist nun die 30 %-Schwelle der gesamten Projektkosten überschritten.

4. INTRODUCTION

The conventional centralised concepts for water supply and wastewater, developed in the last century in industrialized countries, imply high costs and high water consumption, which make them not in any case suitable as a sustainable solution especially for developing countries. Further development, testing and dissemination of alternatives to conventional wastewater systems are therefore becoming more and more indispensable for ecological, economic and societal reasons. More sustainable approaches should consider the reuse of treated water as well as the recycling of the nutrients if possible. Furthermore the energy consumption for wastewater discharge and treatment should be minimised. Such techniques and concepts are already available and in use, but further developments and validations are necessary. The main goal of this project is to develop new sustainable sanitation concepts which have significant advantages in relation to ecological as well as economical aspects compared to the conventional systems (end-of-pipe-system). After successful project completion the new sanitation concepts should be used in Berlin areas, where sewer systems are not installed and these concepts are appropriate, as well as other locations (national and international).

Two new innovative sanitation concepts have been installed in the office building and the apartment house at the grounds of the wastewater treatment plant Stahnsdorf. In both sanitation concepts urine, faeces and Greywater are discharged and treated separately in order to recycle nutrients and water, and to save energy and water. For these purpose gravity separation toilets, vacuum separation toilets and waterless urinals are used. Urine is discharged waterless in all cases. Gravity is the driving force. Urine is collected in tanks. The nutrients within the urine are extracted and used with different methods. The faeces together with the flush water (Brownwater) are discharged. Using the gravity separation toilets solids are separated by filtration. The solids are collected, composted and used as fertiliser. The germ reduced filtrate, after the soil filter passage, is transferred together with the Greywater through a constructed wetland for further cleaning. Using the vacuum-separation-toilet the Brownwater together with biowaste is digested. The digestion sludge is used in agriculture. The bio-gas can be used as energy. For examination purposes Greywater is cleaned parallel in with a membrane bio-reactor and with a constructed wetland. Dependingt on the phosphate concentration it could be necessary to remove the phosphate (e.g. precipitation). The cleaned Greywater can be used for irrigation or can be discharged into the water body. Furthermore the Greywater reuse (e.g. washing machine) is worked out within this project. For this case additional cleaning processes are necessary which are not determined yet.

The expected uses of project-results are:

- Demonstration of the technical feasibility to collect and treat separately three components of the domestic effluents: urine, faeces and Greywater;

- Obtaining n a more detailed and reliable information concerning
  - design and planning
  - operation and maintenance and
  - investments and operation costs

  of the new sanitation concepts (SCST);
- Testing of the consumers acceptance of the proposed solution and identify possible technical improvements in order to enjoy good acceptance;
- Identification of the nature and the content of the service to be provided in order to operate and maintain the system;
- Demonstration case for interested costumers, specialists, citizens, etc.;
- Identification of ecological advantages and disadvantages by Life-Cycle Assessment (LCA);
- Developing of a decision support method based on the results of the assessment;

The main objective of this demonstration project is to establish new sanitation concepts in a way that nearly the complete nutrient and sludge from the different volumes (urine, faeces, Greywater and biowaste) will be used as fertiliser. In cases where the treated Greywater should be used for irrigation (e.g. dry or semi dry areas) it can be used for that purpose. Mainly in cases of drinking water shortages Greywater will be treated in a way that it can be used e.g. for clothing washing or even for showers. Depending on the situation the whole sludge can be digested for energy production (methane gas) before using it as fertiliser. The yield of fertiliser and energy is always much higher compared to the conventional sanitation concepts. This is due the separation of faeces from Greywater which will not be treated aerobically where about 50 % of the carbon content is transferred into carbon dioxide. Realising such new sanitation concepts does not only mean saving nutrient resources like phosphate deposits (which are not endless, important deposits will last about 70 to 100 years) but also a prevention of carbon dioxide production.

5. LIFE-PROJECT FRAMEWORK

For the realisation of this project 8 main tasks are considered. The original and actual timetable of each is shown in **Annex 5.1**.

Task 1 *Management and reporting to EC*: During the reporting period following main tasks were carried out by the management: organisation of the project start (distribution of tasks to the planning departments), preparation and execution of 16 project meetings, preparation and execution of the Stahnsdorf workshop, controlling of the project progress, controlling of the project finances, controlling of the technical performance, controlling of the work of the three subcontractors, preparation of the progress report, preparation of the interim report.

Task 2 *Realisation of the sanitation concepts for the office building*: The sanitation concept inside the office building has been realised until Oct. 2003 and the main facilities outside until March 2004. This is four months later as original planned. Since the gravity separation toilets have been exchanged against vacuum separation toilets in spring 2005 the related bio-gas plant is still not installed. It will be installed at the end of 2005.

Task 3 *Realisation of the sanitation concepts for the apartment building*: The sanitation concept inside the apartment house was realised until March 2005 and the main connection to the outside facilities was finished in June 2005. This is eleven month later than planned.

Task 4 *Operation and testing*: Operation and testing of the first facilities (gravity separation toilets and waterless urinals) started like planned, the other facilities always after installing like mentioned above.

Task 5 *Life-Cycle-Assessment (LCA)*: The preparation of this task started five months before the original planning. The different tasks for this topic for which the two new sanitation concepts will be compared with a conventional sanitation system are in time.

Task 6 *Dissemination*: Since the interest for this project is strong a huge number of presentations and information's have been given: 28 presentations national and international, 17 information's in newspapers etc. and 52 presentations in the Berlin Centre of Competence for Water and/or at the project site in Stahnsdorf.

Task 7 *Industrial style urine treatment for utilization*: The preparation of this task (finding the appropriate partner) took seven months. The contract with the chosen University was signed seven months later as original intended. The investigation plants are installed and the experiments are under way.

Task 8 *Fertiliser usage*: The contact with the chosen University was signed five months later as original planned. The time seven months was necessary for the preparation (finding the appropriate partner). The necessary investigations with pot and field experiments are ongoing.

For "***Presentation of Beneficiary, partners and project-organisation***" see **Annex 5.2**.

The relevant "***Description of modifications according to initial proposal (technical, financial, project-organisation)***" in listed in **Annex 5.3**.

6. TECHNOLOGY

Two new sanitation concepts will be tested in general in an office building and apartment house, respectively. These buildings are on the ground of the wastewater treatment plant (WWTP) Stahnsdorf (south of Berlin) which belongs to the Berliner Wasserbetriebe. In one case vacuum separation toilets and in the other case gravity separation toilets will be used. The primarily, general process scheme of the proposal for the new sanitation concepts can be seen in **Fig. 6.1**.

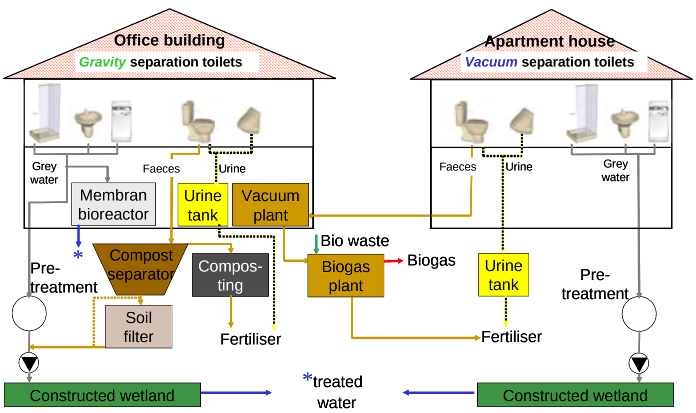

Fig. 6.1: New sanitation concepts with *gravity* separation toilets in the office building and with *vacuum* separation toilets in the apartment house of the WWTP Stahnsdorf

In the new sanitation concept for the office building ten gravity separation toilets are installed. In the men toilets five waterless urinals (three different types: Urimat, Ernst, Duravit) installed additionally. The type of the gravity separation toilet is shown in **Fig. 6.2**.

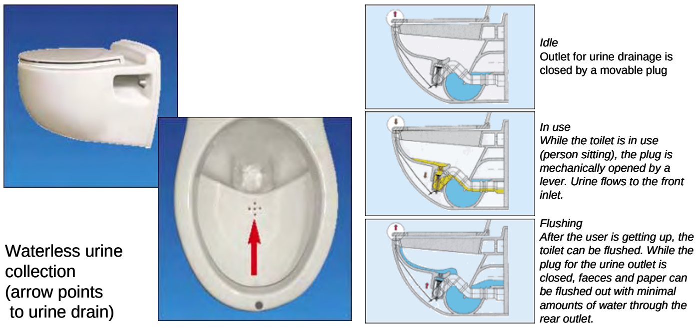

Fig. 6.2: Gravity separation toilet (Roediger-No Mix Toilet)

The faeces (brownwater) are drained and will be composted. The filtrate from the compost separator flows through a soil filter before mixing it with greywater. The greywater passes a septic tank before treatment in a constructed wetland. In parallel to the constructed wetland a membrane bio-reactor will also be tested for greywater treatment. The urine flows into storage tanks. Different methods will be tested for handling and treatment of urine before using it as fertiliser. The methods are :

a) adjusting different pH values during urine storage;
b) vacuum evaporation;
c) steam stripping;
d) additional processes (e.g. struvit precipitation, ozonation, UV-treatment, crystallisation) to process b) and c).

For the new sanitation concept for the apartment house (10 flats) vacuum separation toilets have been taken into consideration in the proposal from May 2003. In this concept urine and greywater are discharged and transported by gravity, while faeces are transported by a vacuum system. Each flow is also treated separately. Urine will be treated as mentioned above. The faeces will be digested together with ground biowaste. Digested sludge is also a fertiliser, e.g. for farmlands. Biogas can be used either in gas cookers or in a combined heat and power unit (CHPU). This topic will not be tested in this project. Greywater passes like in the case of the office building through a septic tank its treatment in a constructed wetland.

Since dish washing powders have a high content of phosphates (often more than 30 %) and dishwashing machines are more and more common, for both concepts a phosphate precipitation could also be necessary during greywater treatment. The treated greywater can be used e.g. for irrigation in general. In this project the effluent of the membrane bioreactor will be investigated with respect to the different options of reuse as water with a lower quality than drinking water.

For the above described new sanitation concept for the apartment house only provisional vacuum separation toilets are available on the market at present. One of it is testing in the office building since December 2003. This toilet is an altered gravity separation toilet from the company Roediger. The experience shows that it works in general but, among others, the flushing system has to be improved. For that reason and to make maintenance easier it was decided by the project team to realise the vacuum separation toilet concept in the office building and not in the apartment house. To change the concepts for both buildings is not difficult. Vacuum pipelines are already installed in additional to the pipelines necessary for the concept with gravity separation toilets in the office building. The gravity separation toilets have been operated until the installation of the gravity separation toilets in the apartment house in April 2005. The altered concepts are shown in **Fig. 6.3**.

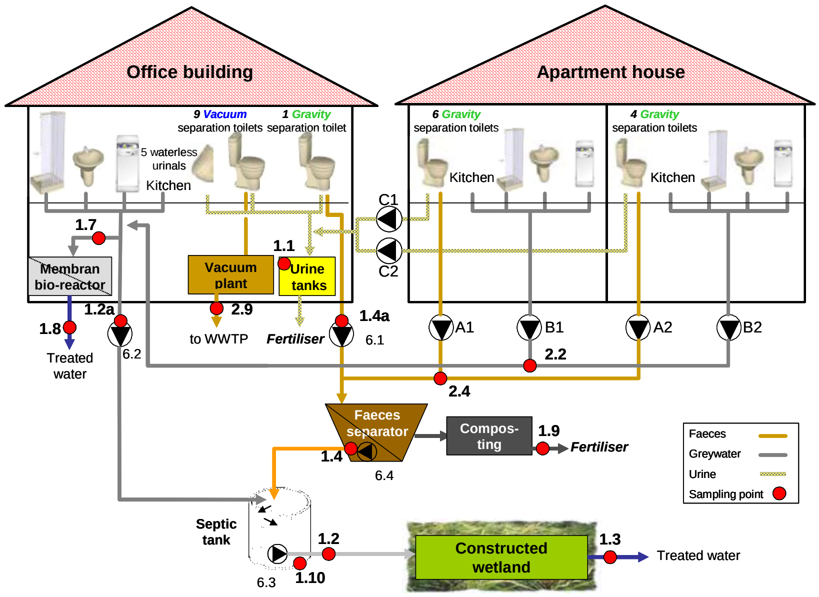

Fig. 6.3: New sanitation concepts with *vacuum* separation toilets in the office building and with *gravity* separation toilets in the apartment house of the WWTP Stahnsdorf

For both concepts different process configurations (8 *Variants* (*V*)) should be tested. For fulfilling the main tasks of the variants mentioned below additional connecting pipelines in both concepts are installed.

Main tasks of the operation of the different variants (V):

V1 (With soil filter): Effectivity of source separation (nutrient in urine); Composition of the different flows (effectivity of source separation); Effectivity of compost separator (quality of raw material for composting); Quality of compost; Effectivity of pathogens reduction of soil filter; Effectivity of greywater treatment in constructed wetland.

V2 (Without soil filter): Effectivity of constructed wetland, soil filter compared to *V1*

V3 (Grey- and brownwater mixture and with soil filter): Common treatment of the mixture greywater and brownwater in compost separator/soil filter

V4 (Grey- and brownwater mixture and without soil filter): Effectivity of constructed wetland compared to V2.

V5 (With membrane biology): Effectivity of greywater treatment in membrane biology with the purpose of water reuse.

V6 (With digester): Effectivity of the digestion of brownwater collected and transported by vacuum in a digester together with biowaste; Digester performance: organic matter reduction, gas production, pathogen reduction, impact of biowaste reduction; Quality of liquid fertiliser; operation experience with vacuum transport systems.

V7 (Membrane biology with greywater from apartments): Effectivity of digestion like V6; Effectivity of greywater treatment of the apartments in the membrane biology.

V8 (Faeces from office building via vacuum and composting): Impact of vacuum collection and transport of brownwater on the process in the compost separator.

Different project photos can be seen in **Annex 6.1.**

In the framework of this project different tasks will be carried out by subcontractor:

Task 5: Life-Cycle-Assessment (see **Annex 6.2**)

Task 7: Industrial style urine treatment for utilisation (see **Annex 6.3**)

Task 8: Fertiliser usage (see **Annex 6.4**)

7. PROGRESS, RESULTS

For the following description see also **Annex 7.1**.

1	**Project Management** **Participants:** Mr. Peter-Fröhlich (KWB), Mr. Pawlowski (Mr. Luck until 30 June 2005) (KWB) **Planned:** Organisation of the Project in a way that the main goal of this project formulated can be proved. Report of all necessary information to EC. Controlling of the different investigation phases of the project and the budget. **Realised/Problems/Delay consequences:** The following main tasks were carried out by the management: - organisation of the project start (distribution of tasks to the planning departments) - preparation and execution of 15 project meetings - controlling of the project progress - controlling of the project finances - controlling of the technical performance - preparation of the progress report - preparation of the interim report **Deliverable 1:** Progress Report Deliverable Date: 07/2004 Date realised: 08/2004 **Deliverable 2:** Interim Report Deliverable Date: 03/2005 Date realised: 12/2005 **Milestone 1:** Progress Report Deliverable Date: 07/2004 Date realised: 08/2004 **Milestone 2:** Interim Report Deliverable Date: 03/2005 Date realised: 12/2005	Planned 06/2006 continuing

2	**Realisation of the sanitation systems for the office building** **Participants:** Mr. Peter-Fröhlich (KWB), Mrs. Kraume (BWB), Mrs. Miels (BWB), Mrs. Bauer (BWB) **Planned:** Planning, designing and building of the sanitation systems for the office building. Sanitation installation inside the office building. Installation of all transport, storage and treatment units outside the office building. **Realised/Problems/Delay consequences:** Sanitation concept for the office building including all sanitation facilities inside the office building and the treatment units for the different streams is realised. Installations inside the office building were finished in time (10/2003). Due to the tendering duration and the winter the completion of the outside treatment units were delayed by 5 month. This time delay has no consequence on the project result, as the two systems are run in parallel and the original planned operation time for this system is not compromised. **Deliverable 4:** Project plans (see **Annex 7.2**) for the office building, evidence of the office building sanitation system due to invoice of sanitation and construction enterprises (see financial interim report) and photos (see **Annex 6.1**) of the sanitation system of the office building. Deliverable Date: 07/2004 Date realised: 09/2004 **Milestone 4:** Complete installation of the equipment for the new sanitation concept with gravity-separation-toilets. Deliverable Date: 10/2003 Date realised: 02/2004	Planned 10/2003 (actually 02/2004)

3	**Realisation of the sanitation systems for the apartment building** **Participants:** Mr. Peter-Fröhlich (KWB), Mrs. Miels (BWB), Mrs. Wolf (BWB), Mrs. Bauer (BWB) **Planned:** Planning, designing and building of the sanitation systems for the apartment building. Sanitation installation inside the apartment building. Installation of all storage and transport units outside the apartment building. **Realised/Problems/Delay consequences:** Sanitation facilities inside the apartment building are installed. Connections to the urine tanks, the greywater treatment and brownwater to the compost separator are realised. Biogas plant for digestion of the brownwater from the vacuum separation toilets is ordered. Estimated delivery is 12/2005. Actual time delay of 11 months is mainly caused by designing and delivery delays of different equipments like the gravity separation toilets. This delay does not endanger the goal of the project. If the operation time of the bio-gas plant from January until June 2006 is enough for reliable results can not be decided now. Since this plant is now testing with the faeces from the office building instead of the apartment house (see **Annex 5.3**) the operation time is shortened over one year. It has to be decided latest in March 2006 if the project time has to be extended until the end of 2006. **Deliverable 5:** Project plans (see **Annex 7.3**) for the apartment building, evidence of the apartment building sanitation system due to invoice of sanitation and construction enterprises (see financial interim report) and photos of the sanitation system of the apartment building (see **Annex 6.1**). Deliverable Date: 07/2004 Date realised: 03/2005 **Milestone 5:** Complete installation of the new sanitation concept with vacuum-separation-toilets. Deliverable Date: 07/2004 Date realised: in the works	Planned 07/2004 (actually 06/2005)

4	**Operation and testing** **Participants:** Mr. Peter-Fröhlich (KWB), Mrs. Kraume (BWB), Mr. Bonhomme (KWB), Mrs. Gnirß (BWB), Mr. Lesjean (KWB), Mr. Bloch (BWB), Trainees (BWB/KWB). **Planned:** Operation of the two new sanitation concepts under regular condition and different wastewater and sludge treatment processes in order to obtain data about the operation stability, which is needed to evaluate the best operation concepts, about the composition of the fertilisers and the use in agriculture, about the effluent water quality and the possible reuse of the treated wastewater, about pharmaceuticals and their degradation in urine and about the consumer acceptance of the proposed solutions to identify possible technical improvements in order to enjoy good acceptance. **Realised/Problems/Delay consequences:** The sanitation concept with gravity separation toilets realised in the office building was operated from March 2004 until March 2005. Four different variants have been tested. The variant in which a pre-treatment of the faecal filtrate was foreseen has to be stopped after about two months since too much solids have been in the influent. Until now a reduction of these solids concentration could not be realised. But this does not endanger the goal of the project. The results of the treatment of greywater together with faeces filtrate with the constructed wetland are in general positive. The growths of the reed showed the distribution system could be optimised what have been realised. The membrane bio-reactor for greawyter treatment is in operation since Mai 2005. Since April 2005 the gravity separation toilets in the office building has been exchanged against vacuum separation toilets. Results from users questionnaires show that both types of toilets are accepted in general, but the results for vacuum separation toilets are worse. The gravity separation toilets in the apartment house are in use since winter/spring 2005. Grey- and braunwater flows are connected to the outside treatment facilities since July 2005. Until now the users reacted in general positive about the new toilets. The installation of the bio-gas plant for digesting the faeces from the vacuum separation toilet will be installed at the end of 2005. It has to be decided latest in March 2006 if reliable results from the bio-gas plant can be expected until June 2006 or if the project time has to be extended until the end of 2006. A comprehensive description of the project and results are undertaken in **Annex 7.4**. **Deliverable 8:** First important results about the different investigation phases with the gravity separation toilets (part of the progress report from Task 1) Deliverable Date: 07/2004 Date realised: 08/2004 **Deliverable 7:** New important results about the different investigation phases with the gravity and vacuum separation toilets (part of the interim report from Task 1) Deliverable Date: 03/2005 Date realised: 12/2005 **Milestone 6:** Start up of the new sanitation concept with gravity-separation-toilets Deliverable Date: 10/2003 Date realised: 03/2004 **Milestone 7:** End of testing the new sanitation concept with gravity-separation-toilets Deliverable Date: 12/2004 Date realised: still running **Milestone 8:** Start up of the new sanitation concept with vacuum-separation-toilets Deliverable Date: 07/2004 Date realised: 04/2005	Planned 06/2006

5	**Life-Cycle-Assessment (LCA)** **Participants:** Mr. Alex Ruhland (TUB), Mr. Christian Remy (TUB) **Planned:** ▸ Inventory and ecological impact assessment of a typical conventional sanitation concept and 4 new sanitation concepts for separate treatment of urine, faeces, greywater and biowaste. ▸ Comparison of the systems and identification of advantages, disadvantages and ecological hotspots of the analysed systems, including the ecological expenses of the operation and construction of all associated downstream processes. ▸ Revealing the ecologically preferred sanitation concept under varying conditions. **Realised/Problems/Delay consequences:** Literature survey of alternative sanitation concepts, LCA studies and SCST processes is completed. Data acquisition of construction phase is nearly completed, difficulties emerged in acquiring data for decentralized treatment facilities. Development of software model for substance flows has started. Interim report (04/2005) includes detailed description of LCA methodology, definition of system boundaries, selected preliminary results of impact assessment and extensive literature overview (see **Annex 6.2**). Complete documentation of material flow and impact assessment of construction phase are provided in the final report (see deliverable 10). Data of construction phase (see milestone 10) has to be complemented and adjusted with consultant (Otterwasser) to match with cost calculation. Substance flow model for operation of conventional and SCST systems is partly completed, operational data from Stahnsdorf pilot plant has to be included. Although some subtasks are slightly behind schedule (status 04/2005), completion of LCA study will be realized in time, as other subtasks are brought forward (e.g. modelling of SCST operation). **Deliverable 9:** Literature survey, material flow analysis and LCA of construction phase. Comparison with conventional system (part of the interim report from Task 1, **Annex 6.2**) Deliverable Date: 04/2005 Date realised: 04/2005 **Milestone 10:** Collection of construction phase data completed Deliverable Date: 12/2004 Date realised: 06/2005	Planned 02/2006

6	**Dissemination** **Participants:** Mr. Peter-Fröhlich (KWB), Mrs. Kraume (BWB), Mr. Bonhomme (KWB), Mrs. Gnirß (BWB), Mr. Lesjean (KWB) **Planned:** Dissemination of the demonstration project and its results via internet, project workshop, presentation and publication on national and international conferences, papers in appropriate national and international journals and on demonstration site. **Realised/Problems/Delay consequences:** Website is realised (www.kompetenz-wasser/research/SCST). Project presentations for different persons at KWB, Stahnsdorf etc. (see **Annex 7.5**). Papers in national and international newspapers and specialised journals are publicised (see **Annex 7.6**). Project was presented at several national and international conferences (see **Annex 7.7**). Furthermore a workshop was realised at the project site Stahnsdorf with 30 participants, mainly from Germany (**Annex 7.8** and **Annex 7.9**). **Deliverable 11:** Information about the web address Deliverable Date: 09/2003 Date realised: 09/2003 **Deliverable 12:** Report about all dissemination activities like presentations and publications of the demonstration project (part of the progress report from Task 1) Deliverable Date: 07/2004 Date realised: 08/2004 **Deliverable 13:** Report about all dissemination activities like presentations and publications of the demonstration project including the 1st CD-ROM (part of the interim report from Task 1) Deliverable Date: 03/2005 Date realised: 12/2005 **Milestone 15:** Installation of an internet page, installation of links to the SCST-page Deliverable Date: 09/2003 Date realised: 09/2003 **Milestone 16:** 1st CD-ROM with the description of the demonstration project, first results and presentations is available Deliverable Date: 06/2005 Date realised: 12/2005 **Milestone 17:** Realisation of a project workshop Deliverable Date: 06/2005 Date realised: 06/2005	Planned 06/2006

7	**Industrial style urine treatment for utilization** **Planned:** Installation and operation of semi-technical plants to investigate the treatment for the utilization of human urine. The liquid urine will be concentrated (volume reduction) in order to improve the handling, the storage possibility and the utilization. Main goal of the tasks is, in comparison to already existing lab-scale examinations, to investigate the operation of a real plant in order to determine the feasibility and the efficiency of such processes. The focus is on industrial style production processes that are aiming to produce market products including different types of fertilisers. Among options for the extraction of pure chemicals with a specific market value, the possibilities for the production of crystalline dry matter will be a major goal. An important issue for urine treatment are the micro-pollutants from pharmaceutical residues. It has to be worked out if these residues can be eliminated from urine with the methods mentioned below. This would increase the acceptance for using urine as fertilizer. **Realised/Problems/Delay consequences:** Pre-tests for yellowwater evaporation and ammonia stripping in laboratory scale have been undertaken. The demonstration units for urine evaporation and steam stripping are installing at present at the investigation site WWTP Köhlbrandhöft in Hamburg. More details see within the "*Interim Report March '05 for the SCST Project, Task 7: Industrial style urine treatment for utilisation*" (**Annex 6.3**). **Deliverable 15:** Report including the first qualitative and quantitative figures about the produced fertilisers (part of the progress report from Task 1) Date: 31 July 2004 Date realised: It was not possible as part of the progress report from July 2004 (see footnote 1). The status of the work was presented on project meeting 4 November 2004 in Stahnsdorf. **Deliverable 16:** Report including the first qualitative and quantitative figures about the produced fertilisers (part of the Interim report from Task 1) Date: 30 March 2005 Date realised: not yet *Problems:* in-process difficulties, such heavy foam production during stripping, have not solved satisfactory, so no representative data could be obtained, as of yet. Furthermore see problems under *Milestone 19.* *Consequences:* To overcome the foam problematic de-foamer will be used in the small stripping unit. Implementation of mechanical devices on the semi-technical stripping plant will be investigated. **Milestone 19:** Start up of a part of the production unit on a semi-technical scale Date: 30 September 2005[1)] Date realised: not yet *Problems:* delay in manufacturing of the stripping unit and technical problems of subcontractors *Consequences:* Delay time was used for the set-up start of a more detailed continuous flow stripping unit in laboratory scale. **[1)]** 31 December 2005 according proposal from May 2003 but the contract with TUHH was signed have a year later as planned to start this task July 2004 (see progress report from July 2004)	Planned 06/2006[1)]

8	**Fetiliser usage** **Planned:** Investigations • of the crop yield effect of urine and faeces derived fertilisers • of the acceptance by farmers and consumers towards use of urine and faeces derived fertilisers **Realised/Problems/Delay consequences:** Until March 05 yield data of the first pot experiments could be derived. The experiments were designed as comparisons of the fertilising effects of urine and conventional mineral fertiliser using the following crops: Spring wheat, maize, oats, hemp. Reasonable results could be reached. The field experiments with winter oilseed rape and winter rye started in August/September 04. The first share of fertiliser and urine will be applied soon. No problems or delay expected The experiments with spring wheat, flax and maize are aimed to be carried out as comparisons of the fertilising effects of conventional mineral fertiliser and faeces as well as compost of faeces. They will be started with planting in March/April 05. The limited total amount of faeces derived from the pilot plant in Stahnsdorf will also limit the size of these experiments. However, the amount of faeces will last for at least one experiment with maize. The acceptance of urine as fertiliser at the farmer's as well as at the consumer's side will be carried out in form of a student's B.Sc. thesis. Preparations concerning this are in progress. **Deliverable 18:** Report including the first documentation about the effect on corn yield due to different fertilisers (part of the progress report from Task 1) Deliverable Date: 07/2004 Date realised: 08/2004 **Deliverable 19:** Report including the documentation about the effect on corn yield due to different fertilisers from the first year (part of the interim report from Task 1 Deliverable Date: 03/2005 Date realised: 04/2005 **Milestone 22:** Fertiliser experiment 1 started Deliverable Date: 05/2004 Date realised: 05/2004 **Milestone 23:** Attitude study 1 finished Deliverable Date: 01/2005 Date realised: 01/2005 **Milestone 24:** Fertiliser experiment 2 started Deliverable Date: 05/2005 Date realised: 05/2005 [1)] 31 December 2005 according proposal from May 2003 but the contract with HUB was signed five months later as planned to start this task May 2004 (see progress report from July 2004)	Planned 06/2006[1)]

Remark: For all eight tasks was and is the company Otterwasser GmbH, especially Mr. Oldenburg, the consultant.

8. Dissemination activities and deliverables

During the actual project duration an intensive dissemination was already carried out. Beside several publications in reputable journals and presentations at appropriate symposia and conferences (see **Annex 7.7**), a presentation for local and trade journals was arranged on 24 November 2003 (see **Annex 7.6**). More press publications can be seen also in **Annex 7.6.** In addition the project was often presented to interested people and institutions in KWB and at the project site Stahndorf, respectively (see **Annex 7.5**). Furthermore the project is presented on the KWB-internet-page http://www.kompetenz-wasser.de/engl/projekte/proj_scst.htm in German, English and French. The internet page was updated in Feb. 2005. A project board is installed at the project site in Stahnsdorf.

All activities in relation to the dissemination of this project show an increasing interest to this subject nationally and internationally. Examples are the presentations in Philadelphia and Prague (No 12 and 18, **Annex 7.7**). Both presentations are based on an invitation of members of the Scientific/Technical Committees. One more important example is the *4th IWA-World Water Congress and Exhibition* in Marrakech from 19-24 September 2004. On this important international conference a side event on *Sustainable Sanitation* took place for three days.

From all dissemination activities it can be concluded that these sanitation concepts for the most people are very interesting and that they are curious if these concepts may be alternatives to the conventional sanitation system.

9. Evaluation and Conclusions

Points for assessment

- the process

The experience with the two testing sanitation concepts until now is as following:

Gravity separation toilet concept

The toilets are in general accepted by the users but they have to be improved in different points like flushing for a wide application. The using faeces separator is applicable for single houses or small settlements but not for huge settlements. For this a continuous working facility is necessary. Furthermore the concentration of the suspended solids in the faeces filtrate is too high with the used faeces separator for a pre-treatment with a soil-filter before the biological treatment with a constructed wetland. The results from the constructed wetland are as expected, but for huge settlements a conventional wastewater treatment plant for the treatment of greywater is necessary.

Vacuum separation toilet concept

Like for the gravity separation toilets the vacuum separation toilets are accepted by the users in general but the tendency of acceptance is wore compared to the gravity separation toilets. This is not surprising since no optimised vacuum separation toilet is available on the market until now. The used toilets are just altered gravity separation toilets from the company Roediger. This type of toilet has also to be improved, especially flushing. At present, this type of toilet can not be used for a wide application. But the experience with the vacuum technique is positive in general. Only two disturbances have happened since December 2003 which never appeared again. Since the bio-gas plant is not yet installed no remarks can be given to this facility.

For an assessment if both concepts are real alternatives to the conventional sanitation system more experience is necessary. But it is for sure that both types of toilets have to be improved.

- The project management, the problems encountered, the partnerships and their added value

The experience with the project management is in general positive. Very important is the part of the Berliner Wasserbetriebe since the project is realised in facilities of it, a great part is financed by it and much knowledge is coming from it. Important is also the partner Anjou Recherché since knowledge is coming from it and they underline the importance of this project.

- Technical and commercial application (reproducibility, economic feasibility, limiting factors)

At this time no reliable assessment to this topic is necessary.

- Results for potential target groups

At this time the most important point is to show and present this project to many different persons, groups, institutions, politicians etc. national and international to give them the idea of the project and that these concepts may be future alternatives to the conventional sanitation system. This information's are very well undertaken.

- Comparison to the project-objectives

The status of the project does not allowed to assess if the formulated objectives

"*The main goal of this project is to develop new sustainable sanitation concepts which have significant advantages in relation to ecological as well as to economical aspects compared to the conventional systems (end-of-pipe-system)*"

in the EU-proposal can be achieved. The tasks for ecological and economical aspects of the two sanitation concepts are still not finish.

- Environmental benefits

  - qualitative and quantitative, (if possible in a European context)

  - cost-benefit analysis (compared with standard approach, situation at the start, other appropriate measures, or other relevant)

Like in the topic above this topic can also not be assessed at present for the same reasons.

- Application possibilities in same and other sectors (transferability) on local and EU level (limiting factors)

Since not all investigations are undertaken until now it is not possible to asses if these sanitation concepts are applicable local or on EU level. But, at least because of the not optimised toilets mentioned above these concepts will not be applicable on a grant scale immediately after the end of the project. Further developments will be necessary.

- The innovative aspects of the project on (inter)national level

The innovative aspects of the project are mainly that all three volumes (greywater, brownwater and yellowwater) shall be discharged separately which enables that much greater parts of the nutrients from wastewater can be used as fertiliser or fertiliser production compared to the conventional sanitation system. Furthermore, a better source for irrigation can be provided just with greywater.

- Effectiveness of dissemination activities

The way we are doing all the dissemination activities is effective since we can give a lot of interested national and international people the information about these new sanitation concepts and it was always a very good possibility to discuss these concepts.

- Job creation – potential if replicated

If these sanitation concepts can be used world-wide it will also be positive for job creation in the field of planning/designing, facility production and installation, operation, management etc. It should be positive especially for the EU since many companies can produce high quality equipments which are necessary for those concepts. One example is the German company Hans Huber who is a factory for production of facilities for water and wastewater and has a strong interest for these new approaches for wastewater. This is the reason why it has already installed a new sanitation concept in his office building for about 200 employs (www.huber.de).

- Relevance to the EU legislative framework (directives, policy development, etc.).

Since a better effluent quality by treating only greywater instead of municipal wastewater the energy consumption is less and the effluent quality better. In cases of storm weather less pollution of surface waters will happen when only greywater and not municipal wastewater will overflow from wastewater channels. Furthermore a better recycling of nutrient is given with the new sanitation concepts. Only with these few aspects the EU directives etc. can be better fulfilled.

- The future: sustainability and continuation of the project + remaining threats

Some important aspects for a better sustainability are mentioned in the top before.

The main next steps of the project are described in the next chapter.

Remaining threats can be seen at present that optimised separation toilets will not be available until the end of the project. At least this aspect will prevent a quick, wide application of the new sanitation concepts.

10. PLANNED PROJECT PROGRESS

The main next steps of the project will be as following:

a) Continuing the operation of the faeces separator mainly with faeces from the apartment house;
b) Upgrading of the analysis to dissolved organic nitrogen and phosphorus in the brownwater for having the possibility of assessment of the effectiveness of the different separation toilets;
c) Continuing the operation of the septic tank and constructed wetland with filtrate from faeces separator and greywater from office building and from apartment house;
d) Continuing greywater treatment with the membrane bio-reactor, especially with the mixture of greywater from office building and apartment house:
e) Continuing pumping yellowater from apartment house to the urine tanks in the office building for collecting the yellowater but also to find out if the pressure pipeline will be clogged by precipitants;
f) To install the bio-gas reactor at the end of 2005 and to test it with the faeces from the vacuum separation toilets of the office building and biowaste from the apartment house;
g) Continuing the investigations of the three subcontractors in relation of
   - Life-Cycle-Assessment (Task 5),
   - Industrial style urine treatment for utilisation (Task 7) and
   - Fertiliser usage (Task 8).
h) Preparation of the final report at the end of the project.

The original planed durations for the different tasks and the actual status of the tasks are shown in the Gantt-chart in **Annex 7.1**.

11. ANNEXES

	subject	chapter/form
Annex 5.1	Gantt-chart, baseline and actual	chapter 5
Annex 5.2	Project organisation chart	chapter 5
Annex 5.3	Tasks of the different persons	chapter 5
Annex 6.1	Project fotos	chapter 6 and 7
Annex 6.2	Interim Report *Life-Cycle-Assessment* , Task 5	chapter 6 and 7
Annex 6.3	Interim Report *Industrial style urine treatment for utilisation, Task 7*	chapter 6 and 7
Annex 6.4	Interim Report *Fertiliser usage, Task 8*	chapter 6 and 7
Annex 7.1	Gantt-chart, original and actual	chapter 7
Annex 7.2	Project plans office building, Task 2	chapter 7
Annex 7.3	Project plans apartment house, Task 3	chapter 7
Annex 7.4	Project description and results, Task 4	chapter 7
Annex 7.5	Presentations at KWB, Stahnsdorf etc, Task 6	chapter 7
Annex 7.6	Presentations in different media, Task 6	chapter 7
Annex 7.7	Presentations on national and international conferences, Task 6	chapter 7
Annex 7.8	Summary, Agenda, Partisipants of the Stahndorf-Workschop (in German), Task 6	chapter 7
Annex 7.9	Thesis of the Stahnsdorf-Workshop (in German), Task 6	chapter 7

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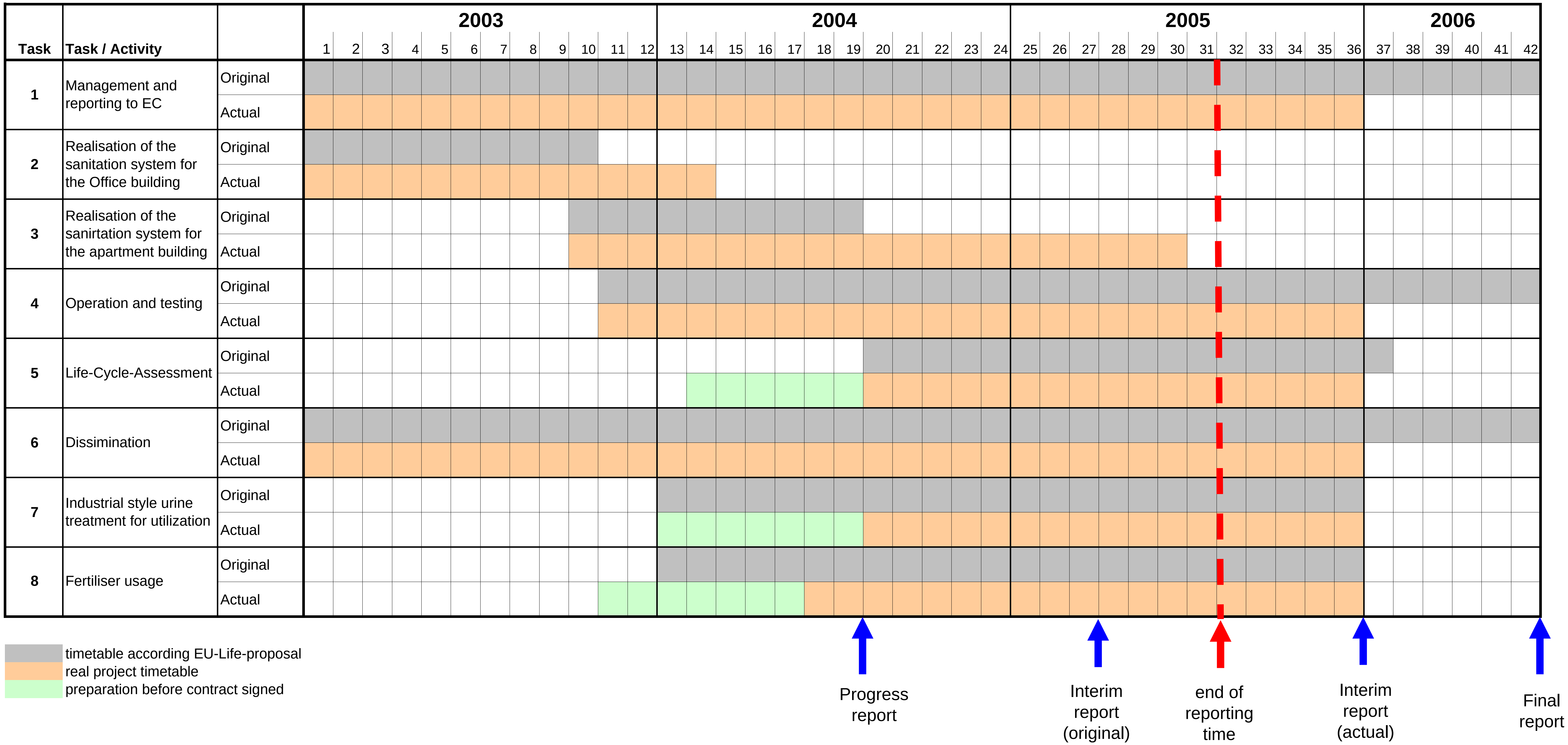
Annex 5.1

Gantt-chart with original and actual times for the different tasks



Annex 5.2

Presentation of Beneficiary, partners and project-organisation
(organigram: functions and tasks, persons and companies)

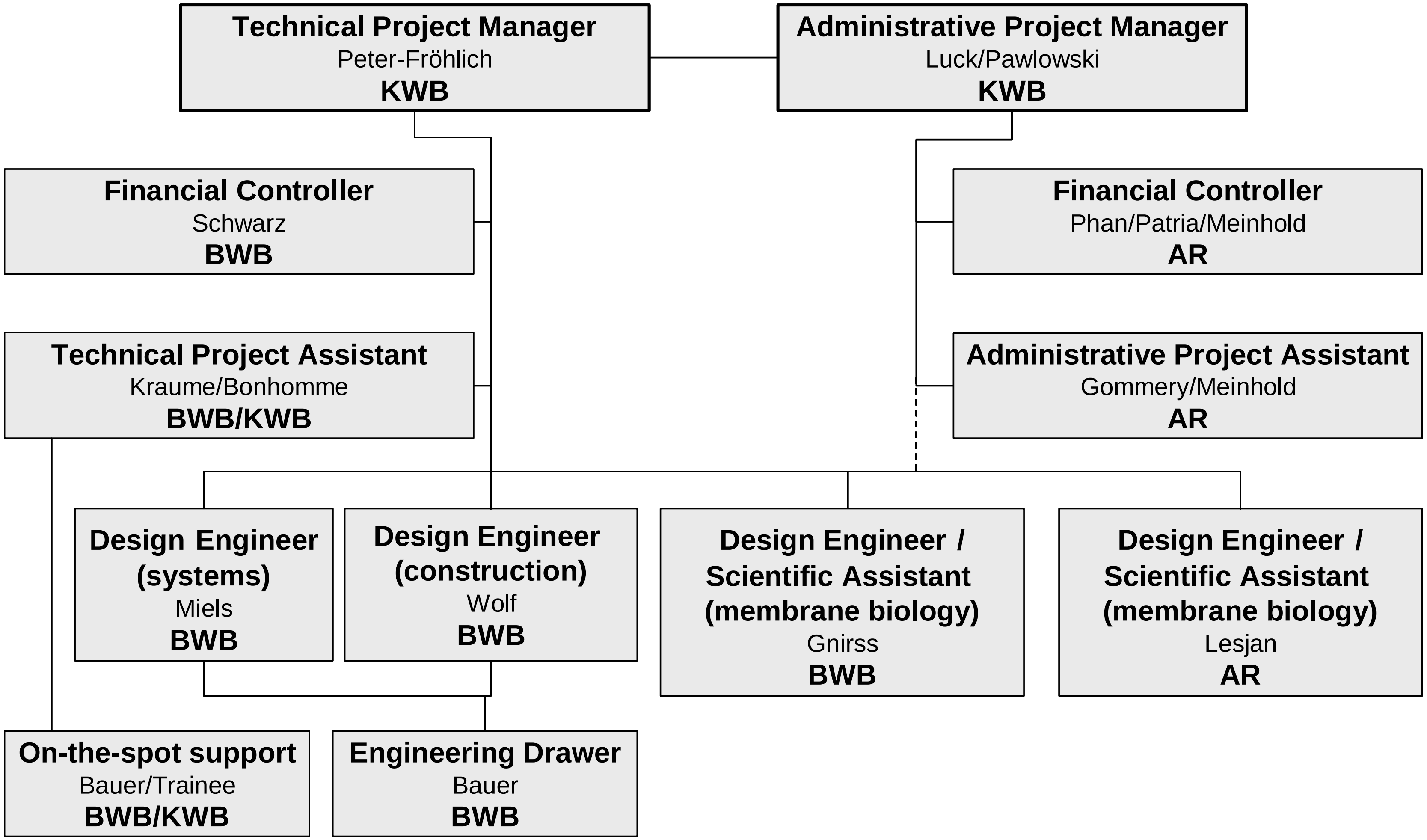
The Kompetenzzentrum Wasser Berlin (KWB - Berlin Centre of Competence for Water) is an international centre for water research and knowledge transfer. Capacities of the Berlin universities and research institutes, the Berlinwasser group of companies and Veolia Water are combined into the KWB. This association enables the various companies and partners to carry out projects in cooperation with the best national and international water technology centres.

The partner Berliner Wasserbetriebe (BWB) is the German largest enterprise in relation to drinking water preparation/delivery and wastewater discharge/treatment. The BWB is not only operating in Berlin but also in the surrounding area. Besides of designing and building the necessary equipments and the operating of it, the BWB did and is still doing R&D-activities which partly are trend-setting, e.g. in the field of biological phosphate elimination from wastewater.

Anjou Recherche is the research centre for water treatment, water supply, sewerage and environment of the Veolia (former Vivendi). Its task is to develop experiment and validate treatment processes, technical tools and methodologies that are to be used in the water and environmental domains. It represents around 160 employees, mainly engineers and technicians, working on water, wastewater, sludge treatment, water reuse, chemical and biological analysis processes, environmental studies, ground pollution removal, water supply and sewerage systems management and design. It includes the Central Laboratory of analysis for water and treatment sludge of Generale des Eaux, the water activity part of the Vivendi Environment Group. Further to the Vivendi Group companies, Anjou Recherche has developed many scientific and technical partnerships either with private companies and public bodies or universities. It has successfully participated in several European projects.

The organigram of the project and tasks of the different persons are showed on the next three pages.

SCST-Project organigram



Tasks of the beneficiary and partners

(explanation of the numbers 1 to 14 see page 4)

Name/Organisation (see assignment below) Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14
project management	X	X												
technical project advising											X			
financial control (KWB)	X													
financial control (BWB)		X					X							
financial control (AR)										X			X	
international scientific networking										X			X	
reports	X	X	X											
dissemination (publications, presentations, press, internet-page)	X	X	X											
preparation of meetings		X	X											
execution of meetings		X												
minutes writing			X									X		
basic evaluation for the system engineering planning for the outside treatment units of the office building			X											
preliminary systems engineering planning for the outside treatment units of the office building				X										
preliminary constructional engineering planning for the outside treatment units of the office building						X								
engineering drawings for the SCST-project for the office building					X									
implementation systems engineering planning for the outside treatment units of the office building				X										
implementation constructional engineering planning for the outside treatment units of the office building						X								
construction supervision of the systems engineering for the outside treatment units of the office building				X										
start up of the outside treatment units of the office building				X										

Continuing *Tasks of the beneficiary and partners*

Name/Organisation (see assignment below) Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14
supervision of the SCST-unit operations inside and outside the office building		X	X											
monitoring of the pilot test phase		X	X											
evaluation of results		X	X											
preliminary and implementation planning of the membrane biology for the greywater treatment								X					X	
employee survey (questionnaires preparation and evaluation)			X											
talk concerning the realisation of the separation concept with the apartment house tenants		X												
basic evaluation for the system engineering planning for the outside treatment units of the apartment house			X											
preliminary systems engineering planning for the outside treatment units of the apartment house				X										
preliminary constructional engineering planning for the outside treatment units of the apartment house						X								
engineering drawings for the SCST-project for the apartment house					X									
On-the-spot support of the unit operations									X					X

No	**Name**	**Organisation**	
1	Luck/Pawlowski	KWB	(Mr. Pawlowski instead of Mr. Luck since 1 July 2005)
2	Peter-Fröhlich	KWB	
3	Kraume/Bonhomme	BWB/KWB	(Mr. Bonhomme instead of Mrs. Kraume since 1 June 2005)
4	Miels	BWB	
5	Bauer	BWB	
6	Wolf	BWB	
7	Schwarz	BWB	
8	Gnirss	BWB	
9	Bloch	BWB	
10	Phan/Meinhold	AR	(Mr. Meinhold instead of Mr. Phan since 2004)
11	Gommery/Meinhold	AR	(Mr. Meinhold instead of Mr. Gommery since 2004)
12	Lesjan	AR/KWB	
13	Patria/Meinhold	AR	(Mr. Meinhold instead of Mrs. Patria since 2004)
14	Trainee	BWB/KWB	

Annex 5.3

Description of modifications according to initial proposal (technical, financial, project-organisation)

a) Toilet system in office building and apartment house

The sanitation systems for the office building and for the apartment house described in the proposal have been changed. At the moment vacuum separation toilets are only available as modified gravity separation toilet delivered by the company Roediger. Experiences with vacuum toilets are available, but not known for the use of vacuum separation toilets. Due to the prototype status of the toilets problems especially during the first time after their introduction have been expected. Therefore it was decided to install the toilets in the office building instead in the apartment buildings, because maintenance is here much easier than in the apartment building.

The first provisional vacuum separation toilet is in operation in the office building since the end of 2003. The experience shows that it worked in general without significant problems, but the flushing system has to be improved. This first toiled was only used by one woman and this very infrequently. In addition two vacuum separation toilets were installed at the end of 2004 at the 2nd floor of the office building here the management of the WWTP is located. The user frequency could be improved and the technical behaviour and the user acceptance could be investigated. This experience was the prerequisite for the conversion of all office building toilets which has been realised in April 2005. Because in the office building installations for gravity and vacuum separation toilets are installed already the gravity separation toilets could be easy exchanged by vacuum separation toilets.

b) Number of flats (reduction from 15 to 10)

After a personal introduction of the new sanitation concept and intensive discussion with the tenants of the 34 flats concerning the feasibility of the concept by Mr. Peter-Fröhlich 12 tenants from the apartment house agreed with the installation of gravity separation toilets in their flats. As the flats of two of these tenants are in the first floor the installation of the additional pipes was not possible without construction works in the flats beneath. Therefore the final number of the flats integrated in the project was reduced to ten.

c) Complete retrofitting of the baths

In contrary to the description in the proposal the bathrooms had to be retrofitted completely. The main reason for this decision was the improvement of the number of tenants who participate in this demonstration project.

d) No urine tank nearby of the apartment house

For testing a long main pipeline for the transport of urine (about 200 m) and for an easier management of all facilities the urine from the apartment house will not be stored nearby the house but pumped to the urine tanks in the office building.

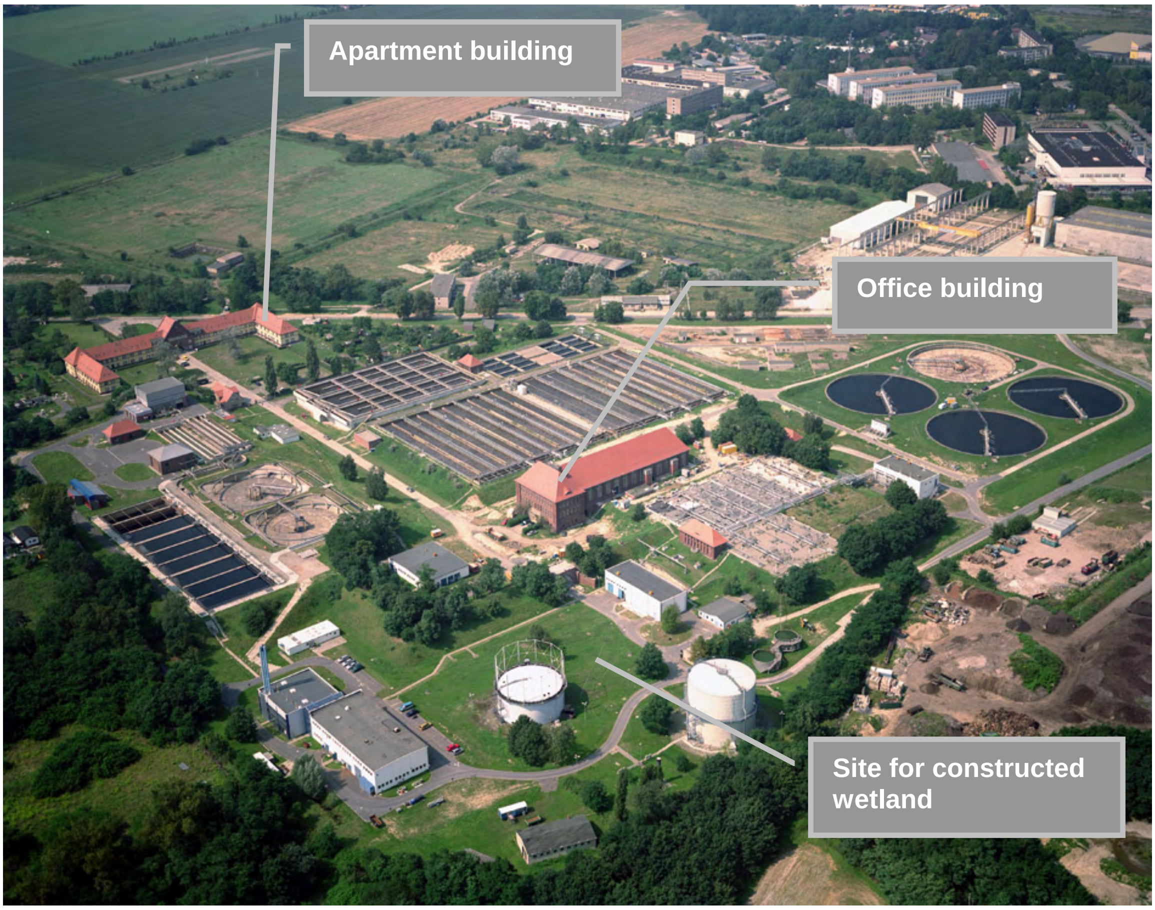
e) Fertiliser usage: field tests in addition

The Humboldt University Berlin (HUB) was chosen as a partner for the task *Fertiliser Usage* (Task 8 - see **Annex F6).** Depending on the fertiliser mass availability not only pot experiments but also field tests were carried out. In different discussions with experts for fertiliser usage on farmlands we had to realise that field tests is one very important prerequisite for the acceptance of faeces and urine based fertilisers for farmers.

f) Engineer/Design Partner 2 (BWB): partly external assistance (Berlinwasser Services)

In contrast to the proposal a part of the designing and supervision (*Engineer/Design*) of the construction had to be realised by external assistance (Berlinwasser Services) since Berliner Wasserbetriebe (BWB) has not had the capacity of appropriate engineers (see **Annex F3**).

Annex 6.1 Project Photos



Aerial view of the project site Stahnsdorf

Annex 6.1 Project Photos

Gravity separation toilet

Waterless urinals (Ernst urinal left); Urimat right))

Vacuum separation toilet

Vacuum toilet control valves

User information

User questionnaires

Annex 6.1 Project Photos

Urine tank facility

Vacuum plant

3-chamber-clarification-tank

Compost-separator filter bags

Compost-separator pump sewer and filter bag dewatering place

Constructed wetland outflow inspection chamber with water tip meter

Annex 6.1 Project Photos

Construction work for the connection of the apartment house to the treatment units

Connection pipes between the apartment house and the treatment units

Apartment Mr Danneberg during the reconstruction

Apartment Danneberg pipelines

Apartment Winkelmann pipelines

Apartment Moldenhauer during the reconstruction

Annex 6.1 Project Photos

Apartment Lange during reconstruction

Annex 6.2

Interim report for task 5
Life Cycle Assessment of new sanitation concepts

Contents

1 Goals and schedule

New sanitation concepts for separate treatment of urine, faeces and greywater (SCST systems) claim to be environmentally preferable compared to existing conventional sanitation systems (CS Systems), particularly with regard to recycling of nutrients, water saving and providing better preconditions for water reuse. However, there are different variants of new sanitary concepts. It should be analysed, which design is ecologically preferable under which conditions. Further on, there might be drawbacks compared to the traditional systems, for instance a shift of emissions or a higher energy demand. Finally there are competing systems like centralised recovery of phosphorus from sewage plants. In order to compare such competing systems with SCST-Systems, quantitative data, considering all relevant parts of the process systems is a precondition. Because of these reasons, the SCST-Project is accompanied by a Life Cycle study according to ISO 14041, 1998 that pursues the following goals:

- Substance flow analysis (inventory) and ecological impact assessment of a typical conventional sanitation concept and 4 new sanitation concepts for separate treatment of urine, faeces, greywater and biowaste.
- Comparison of the systems and identification of advantages, disadvantages and ecological hotspots of the analysed systems, including the ecological expenses of operation and construction of all associated downstream processes.
- Revealing the ecologically preferred sanitation concept under varying conditions.

In accordance with the SCST-project management the following schedule shown in figure 1 has been framed. The corresponding milestones and deliverables are listed in chapter 7 of the main report.

Schedule SCST-LCA																								
project duration																								
duration subtask																								
finished																								
year	2004						2005												2006					
quarter	3			4			1			2			3			4			1			2		
month	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
duration																								
general tasks																								
evaluation of existing studies																								
combination and comparison of technical variants																								
evaluation of results, sensitivity analyses																								
interim report																								
final report																								
method of ecological evaluation																								
goal definition including functional unit																								
definition of the system boundaries																								
selection and quantification of ecological evaluation criteria, impact assessment																								
inventory of operational substance flows																								
water demand and operation of toilets																								
chemical composition of black-, grey, yellow and brownwater																								
composition of bio waste (kitchen, greens)																								
conventional urban drainage																								
substance flow model of conventional sewage treatment (activated sludge process)																								
conventional treatment of sewage sludge, incineration and land fill																								
composting kitchen and garden waste																								
usage and output of compost																								
equivalency process industrial production of fertilizers																								
equivalnecy process industrial fertilizer on crop land																								
equivalnecy process conventional production of thermal energy																								
composting faeces und bio waste																								
preliminary sedimentation / P-precipitation of greywater																								
substance flow model constructed wetland																								
interim storage of urine and output on crop land																								
substance flow model conventional small sewage plant																								
operation vacuum system																								
fermentation of faeces and bio waste																								
combined heat and power unit (biogas)																								
substance flow model greywater treatment																								
inventory of construction expenditures																								
conventional sanitary installations																								
sanitary installations for gravity separation																								
sanitary installations vacuumseparation																								
conventional house connections																								
house connection s for separate treatment																								
conventional blackwater drainage																								
greywater drainage for separate treatment																								
vacuum plant																								
brownwater interim storage																								
urine interim storage																								
ev. greywater interim storage																								
composting faeces, bio waste and ev. secondary efluent sludge																								
construction conventional sewage plant																								
construction of wetland																								
construction greywater treatment plant																								

Figure 1: Schedule of the Life Cycle Assessment study of new sanitation concepts

2 Basics of Life Cycle Assessment and methodological definitions

For comparative ecological studies meanwhile the tool "Life Cycle Assessment" (LCA) became accepted and is widely used as it is (roughly) defined in ISO 14040 ff. LCA aims to evaluate environmental burdens associated with a product, process or service by quantifying all material and energy flows linked with the analysed economic activity. The assessment includes the entire economic system that is necessary to fulfil the economic activity, encompassing extracting and processing raw materials, production, transportation, use, recycling and final disposal. A detailed description and discussion of LCA-models include for instance Guinée et al., 2002 or Frischknecht, 1998.

Figure 2 shows the simplified structure of a LCA-system.

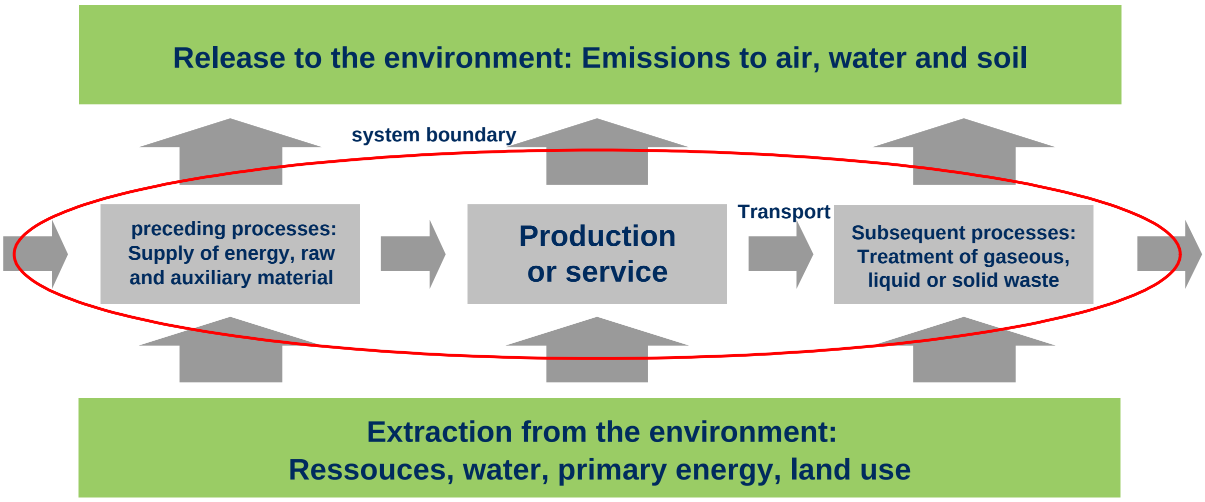


Figure 2: Simplified structure of a LCA-system

ISO 14040, 1997 defines the following elements of an LCA study that are treated iteratively:

- Goal and scope definition
- Inventory analysis
- Impact assessment and
- Interpretation

This study follows the structure and the main requirements of ISO 14040 ff. However, it does not cover all requirements like a peer review that is obligatory for comparative studies according to ISO. The following chapters comprise the most important methodological definitions for goal and scope definition and inventory analysis. Impact assessment and interpretation are a part of the final report.

2.1 Goal and scope definition

2.1.1 Goals and target group

The study analyses a typical conventional sanitation concept (CS system) and 4 new sanitation concepts for separate treatment of urine, faeces, greywater and biowaste (SCST systems) in order to compare the systems with regard to their ecological effects and to identify advantages, disadvantages and ecological hotspots. Depending on different boundary conditions the ecologically preferred sanitation concept shall be revealed.

No existing marketable products are compared, but integrated concepts of urban drainage and disposal of biowaste. The results of the study are intended for experts from research and innovative companies in order to expand the knowledge in the field of municipal disposal concepts and to get hints to improve existing approaches.

2.1.2 Function, functional unit and reference flows

The primary function of the analysed systems is to fulfil the services:

- removal and disposal of human urine and faeces from households,
- drainage and treatment of waste water, charged with substances resulting from domestic washing machines, kitchen residuals and water from personal hygiene (greywater) and
- disposal of solid biowaste resulting from kitchen, garden and municipal greens.

The material and energy flows associated with the above mentioned services, respectively the LCA results, are related to the functional unit, which is defined as the performance of the above mentioned services for one person during one year (e.g. 30 kg CO_2 $P^{-1}a^{-1}$). As further boundary conditions an urban area of 360,000 m^2 (value may still change) is assumed, populated by 5,000 Inhabitants. A typical pattern of Western Europe countries with the following quantities is considered:

- 0.14 kg $P^{-1}d^{-1}$ faeces
- 1.5 kg $P^{-1}d^{-1}$ urine
- 100 kg $P^{-1}d^{-1}$ greywater
- 0.3 kg $P^{-1}d^{-1}$ garden and municipal green waste
- 0.16 kg $P^{-1}d^{-1}$ organic kitchen waste

Multiplied with 365 days and 1 person, these quantities result in the following reference flows:

- 51.1 kg faeces (wet mass)
- 547.5 kg urine
- 36,500 kg greywater
- 109.5 kg garden and municipal green waste (wet mass)
- 58.4 kg organic kitchen waste (wet mass)

Decisive for the environmental characteristics is the composition of the waste flows shown in table 1 and table 2. It must be emphasised that the quantities and the composition represent average values. Especially loppings show a wide variety during the seasons of a year with regard to quantity and composition. The structure of the urban area, the share of garden area and municipal greens define the quantity and quality of loppings. The value 0.3 kg/(P d) wet mass represents the average potential of organic garden waste in Germany. In addition there is an average potential of 0.2 kg/(P d) wet mass for municipal greens [Wintzer et al., 1996]. The range of the mass flow of mixed urban biowaste during one year is about factor 2, the range of the volume flow about factor 3 [Fricke, 1990].

Depending on the design, SCST systems may produce additional products beside the disposal service, like energy generated by use of biogas in combined heat and power units or fertilizers produced by nutrient recycling. Usually, different SCST- and CS systems generate different amounts of additional products or services. Therefore the systems fulfil different functions and thus are not comparable on an equivalent base of reference. In order to establish the same base of reference, the systems have to be expanded by the corresponding deficient amount of equivalent products. This procedure is called system expansion and is described in detail for instance in ISO/TR 14049 (2000) and Fleischer (1994).

Table 1: Average composition of faeces, urine, greywater and biowaste

	unit	urine	faeces	greywater*	org. kitchen residuals
Quantity	kg/(P d)	1.50	0.14	100.00	0.16
Main constituents and nutrients					
dry matter	mg/(P d)	60,000	45,000	74,000	50,000
organic dry matter	mg/(P d)				36,000
COD	mg/(P d)	15,000	35,000	60,000	
TOC	mg/(P d)	6,600	16,000	18,000	13,000
N-total	mg/(P d)	10,000	1,700	1,300	900
P-total	mg/(P d)	900	600	500	200
K	mg/(P d)	2,200	550	2,000	600
Na	mg/(P d)	3,500	150	6,000	1.200
Ca	mg/(P d)	210	1,000	14,000	1.000
Mg	mg/(P d)	120	200	3,000	220
Cl	mg/(P d)	4,800	60	7,000	3,000
S-total	mg/(P d)	800	200	7,500	100
Metals					
Cd	mg/(P d)	0.00	0.02	0.20	0.01
Cr	mg/(P d)	0.01	0.02	3.00	0.50
Cu	mg/(P d)	0.05	1.50	20.00	1.00
Hg	mg/(P d)	0.0004	0.02	0.02	0.01
Ni	mg/(P d)	0.04	0.20	2.00	0.20
Pb	mg/(P d)	0.01	0.02	3.00	0.60
Zn	mg/(P d)	0.25	10.00	46.00	7.30

* including loads from flush water after contact with pipes (particularly relevant for Cu and Zn)

The procedure of system expansion is outlined in figure 3. Two systems S_1 and S_2 are assumed. S_1 is producing the products P_1 and P_2, whereas S_2 only produces P_1. S_1 and S_2 are not comparable within LCA, because they fulfil different functions $F_1 = P_1 + P_2$ and $F_2 = P_1$. By expanding system S_2 with an alternative production route of product P_2, an equal function can be defined: $F_1 = F_2 = P_1 + P_2$.

Table 2: Average composition of flush water and loppings

	unit	flush water	unit	loppings
Quantity	kg/(P d)	depends on system	kg/(P d)	0,30
Main constituents and nutrients				
dry matter	mg/L	520	% wet mass	41
organic dry matter	mg/L		g/kg dry matter	710
TOC	mg/L		g/kg dry matter	370
N-total	mg/L	1.00	g/kg dry matter	11
P-total	mg/L	0.08	g/kg dry matter	7
K	mg/L	7.50	g/kg dry matter	13.6
Na	mg/L	36.00	g/kg dry matter	0.2
Ca	mg/L	103.00	g/kg dry matter	33
Mg	mg/L	10.00	g/kg dry matter	4.5
Cl	mg/L	18.00	g/kg dry matter	0.3
S-total	mg/L	40.50	g/kg dry matter	0.5
Metals				
Cd	mg/L	0.001	mg/kg dry matter	0.40
Cr	mg/L	0.01	mg/kg dry matter	4.60
Cu	mg/L	0.16	mg/kg dry matter	19.00
Hg	mg/L	0.00	mg/kg dry matter	0.20
Ni	mg/L	0.01	mg/kg dry matter	3.70
Pb	mg/L	0.01	mg/kg dry matter	4.80
Zn	mg/L	0.37	mg/kg dry matter	110.00

In this study, the conventional system is expanded by the conventional production and supply of the equivalent amount of fertilizers (K, N, P, Mg, Ca, C) and products for soil improvement that is saved by nutrient recycling within SCST systems. The production of thermal and electric energy by use of biogas takes place in SCST- as well as in conventional systems. If additionally produced thermal and / or electric energy can actually be used, the systems are expanded by conventional production of energy in order to establish functional equivalency between all analysed systems.

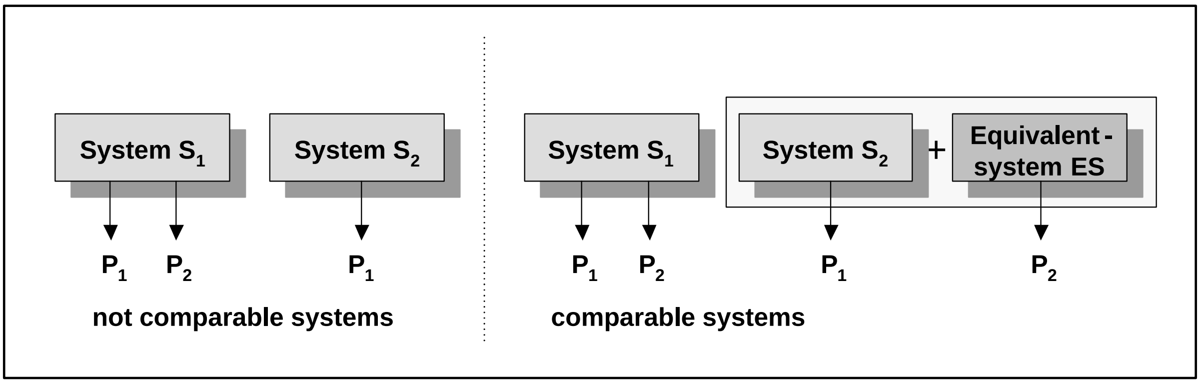


Figure 3: Principle of system expansion

2.1.3 Description of the systems

5 concepts of sewage drainage and disposal are analysed: First, the drainage of mixed domestic waste water and the subsequent treatment in a conventional activated sludge plant is regarded as reference system (variant 1), complemented with separate collecting and composting of domestic biowaste. Further, four different SCST – designs are considered (variants 2a/b and 3a/b). Variants 2a and b provide gravity separation toilets, variants 3a and b vacuum toilets. The letter "a" indicates a constructed wetland, "b" a technical plant for greywater treatment. In the following, the respective variants are described more precisely.

2.1.3.1 Variant 1, reference system

For basis of comparison a conventional system for drainage and treatment of sewage for 5,000 inhabitants is regarded (figure 4). The system considers only domestic wastewater without storm water, which is treated separately.

Within the system the drainage and treatment of domestic waste water is considered as well as the collection and composting of organic waste from kitchen, garden and municipal loppings, including the supply of energy, auxiliary material and transports. Sewage is treated by an activated sludge process. The excess sludge is stabilised by anaerobic digestion. The produced biogas can be used for production of electricity and thermal energy. However, for economic reasons this option normally is only considered when more than 10.000 inhabitants are connected to the sewage plant. For sensitivity analysis the percentage of biogas use can be varied. After stabilisation the sludge is thickened to a heating value of about 2,600 kJ/kg and co-incinerated within a municipal waste incineration plant.

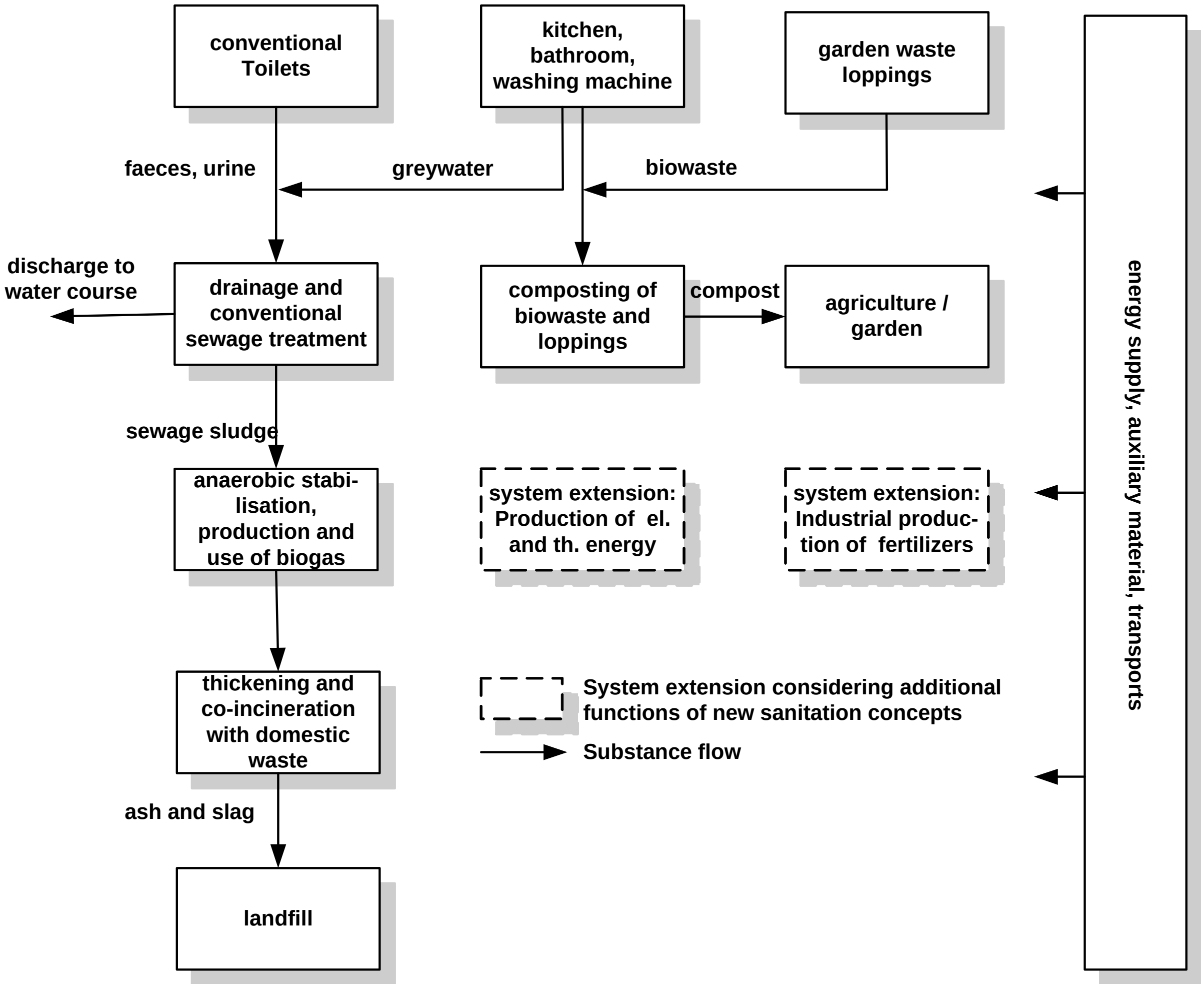


Fig. 4: Conventional system for reference of comparison (variant 1)

New sanitary systems provide nutrient recycling by recovery of the high nutrient concentration in urine. The corresponding amount of nutrients must be supplied by industrial produced fertilizers. In order to compare the systems, the conventional system is expanded by the industrial production of fertilizers. Depending on the design of the new sanitary system, this applies also for thermal energy, in particular if biogas is not used in the conventional system.

2.1.3.2 Variant 2a and 2b

Variant 2a considers gravity separation toilets and waterless urinals, composting of faeces together with kitchen and loppings, constructed wetland for treatment of greywater and faeces filtrate (figure 5). Urine is interim stored for 0.5 years, then diluted and applied on agricultural land. Depending on results of task 7 (industrial style urine treatment for utilization), also the option of an industrial urine conditioning is considered. With regard to the industrial urine treatment the following alternatives are discussed:

a) Vaporisation
b) Stripping with vapour
c) Precipitation as Magnesium-Ammonia-Phosphate (MAP), followed by vapour stripping,
d) In addition to a), b) and c): Treatment by ozone and UV

Variant 2b (figure 6) is similar to variant 2a. However, greywater and filtrate of faeces are treated by a small technical plant instead of a constructed wetland (immersed biological filter, trickling filter or membrane treatment).

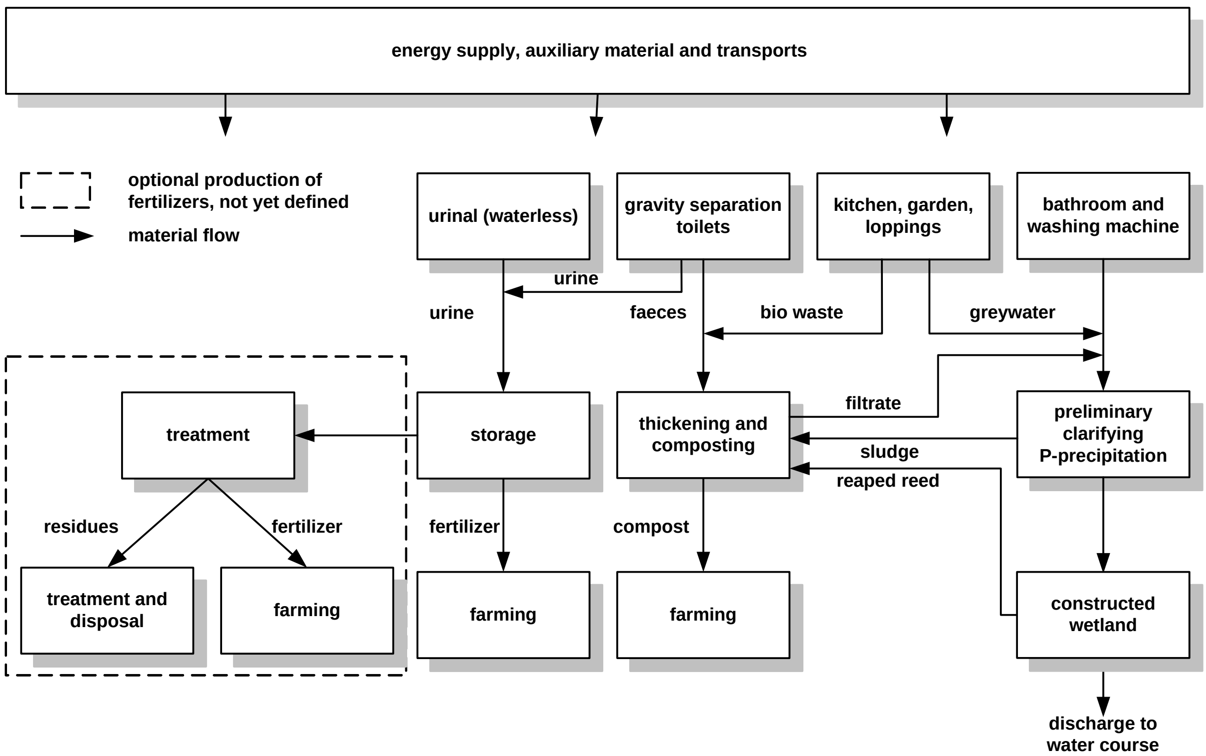


Figure 5: SCST variant 2a

2.1.3.3 Variant 3a and 3b

The variants 3 a and b provide vacuum technology in order to drain off faeces and urine (figure 7 and 8). Faeces are treated in an anaerobic digestor together with kitchen- and garden waste and municipal loppings. The generated biogas is used in a combined heat and power unit. After aerobe stabilisation and thickening the residuals from the digestor are used in agriculture. Urine and greywater (together effluents from digestor) are treated the same way like in variant 2a and 2b respectively.

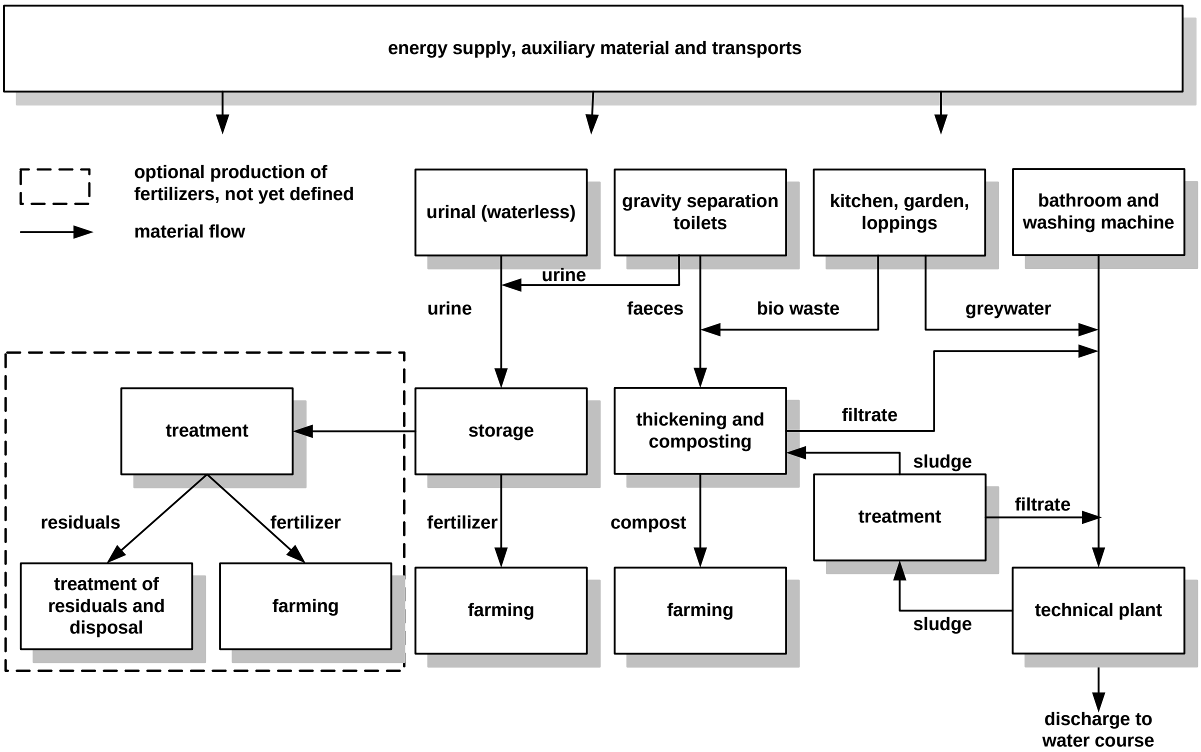


Figure 6: SCST variant 2b

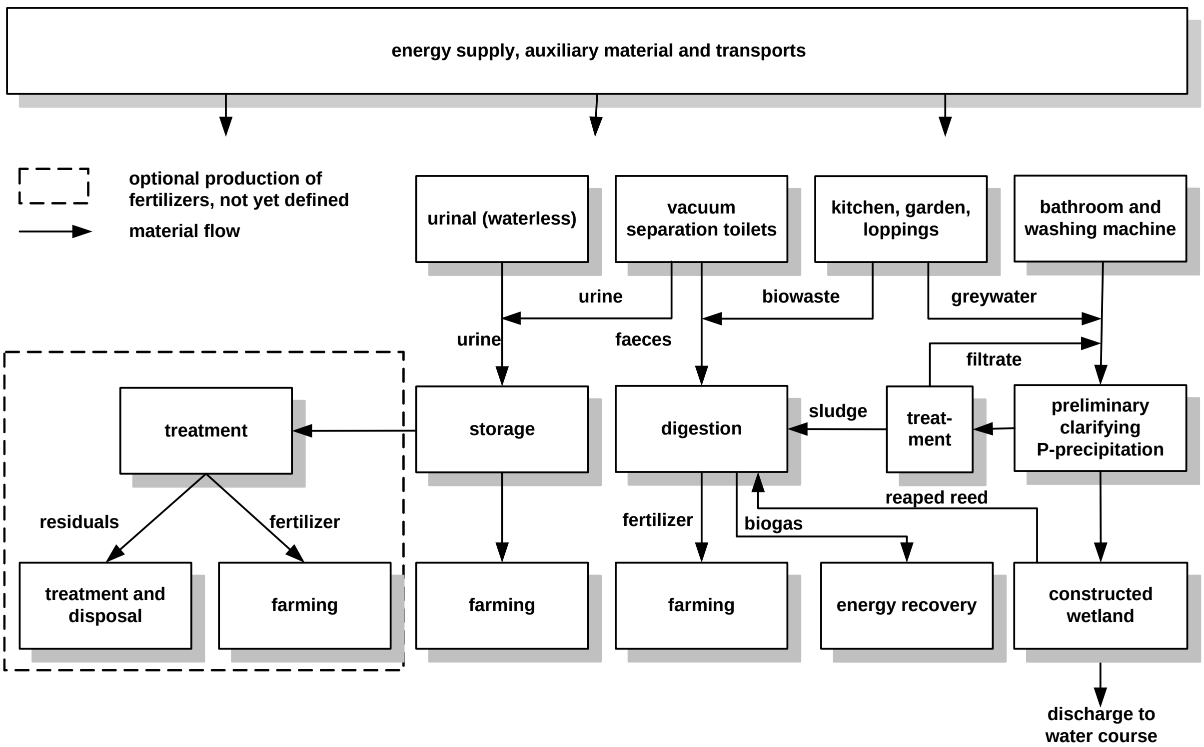


Figure 7: SCST variant 3a

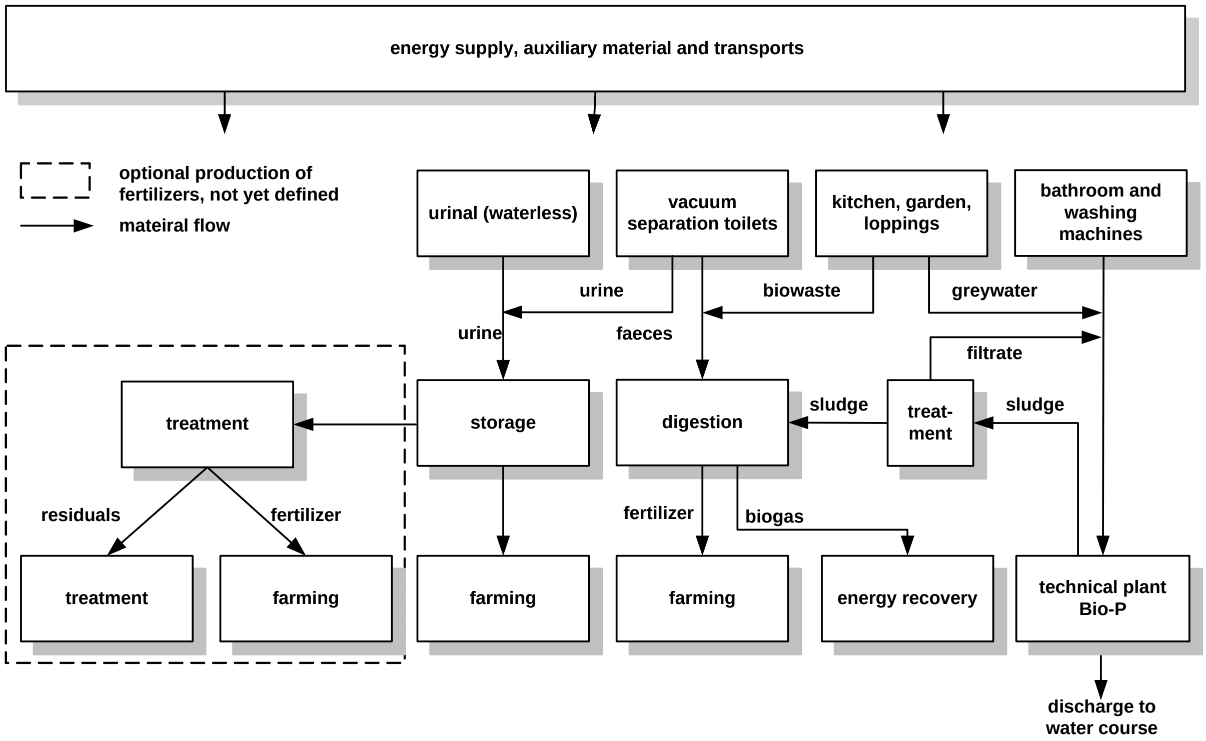


Figure 8: SCST variant 3b

In all SCST-variants the treated water is discharged to a water course. The quality of treatment should meet at least the current EU-regulations for effluents of municipal wastewater treatment plants.

2.1.4 System boundaries

In order to make a specific statement about the object of interest (i.e. the sanitary systems) and to keep the LCA manageable, system boundaries must be defined that run [Guinée et al., 1993]:

- between the analysed economic system and the environment
- between the analysed system and other economic systems (allocation problem)
- between relevant and not relevant life cycle phases and unit processes
- between relevant and not relevant substance and energy flows
- between considered and not considered geographical regions (local, regional, intercontinental, global) and
- between considered and not considered time periods (period of production, life time of products, time horizon of emissions, etc.).

In the following important definitions with regard to the system boundaries are made.

2.1.4.1 System boundaries between the analysed economic system and the environment

Normally it is obvious where the economic system ends and the environment begins: Emissions from factories or engines, etc. to air, water and soil pass the system boundary to the environment. However, processes in agriculture or landfill sites have characteristics that apply to ecosystems as well as to economic systems [Guinée et al., 2002].

In this study agricultural soil is regarded as a part of the environment system. Nutrients, other fertiliser ingredients and trace components applied to the agricultural soil are treated as emissions into the environment. The incorporation of nutrients and other substances into crops is not specified because there is no relevance concerning the interests of this LCA study. However, the percentage of the nutrient availability to the crop is considered with regard to the amount of fertilisers that can be substituted by urine or other recycled fertilisers. Secondary emissions by soil erosion or migration of nitrate into the groundwater are not specified in the inventory. These effects are difficult to quantify in a general way and are not included within the impact assessment. Emissions of NH_3 and N_2O due to fertiliser volatilisation, foliar emissions and decomposing vegetation are included in the inventory.

Landfill processes are considered as a part of the economic system. A model of the Umberto® - Database is used that applies to average landfill sites in Germany [IFU and IFEU, 2004]. Gaseous emissions are allocated according to the organic carbon content in the solid waste. The leachate quantity determined is related to the mass of waste to be deposited. However, pollutants in waste gas and leachate are not allocated according to certain waste composition, because this can not be validated scientifically. Instead, the average pollutant composition is allocated according to the gas and leachate volume. A period of 50 years is selected as reference period for the leachate emissions. After that period emissions are only small and are supposed to be near to the background concentration.

2.1.4.2 Multi function processes and recycling

Economic systems often imply processes that generate several products or fulfil more than one function. This particularly applies in the following cases:

- Combined production of co-products
- Combined waste air, waste water and solid waste treatment as well as combined services like transports within different economic systems
- Reuse and recycling processes

In such cases the associated input and output flows must be allocated between the functions of interest and other functions on the base of physical or economical relationships. Because allocation is often regarded as subjective, ISO 14041 recommends avoiding allocation, for example by dividing the respective unit processes in suitable sub processes, by modelling the processes according to causal relationships or by including additional functions. Latter is done by expanding the system with alternative production routes like it is described in chapter 2.1.2 with regard to nutrient and energy recycling. ISO 14041 recommends the following hierarchical procedure:

1. Avoiding the allocation problem by changing the model of the product system, e.g. dividing the respective unit processes in suitable sub processes
2. Avoiding the allocation problem by system expansion and including additional functions (see chapter 2.1.2)
3. Allocation of input and output flows to the respective products / services on the base of physical relationships (mass, energy or molar fraction, etc.)
4. Allocation of input and output flows to the respective products / services on the base of other suitable relationships, e.g. economic values of the products / services

Examples of these approaches are included in ISO/TR 14049. Nevertheless, this hierarchy is not generally accepted in either case and suitable procedures are still discussed in literature [Frischknecht, 2000; Guinée et al., 2002; Ekvall and Finnveden, 2001]. System expansion should only be applied, when there actually exist meaningful equivalent processes to expand the original system. With regard to recycling processes it should be checked, whether they actually are able to displace conventional production routes and how the production volumes of the respective processes do affect each other.

Similar to system expansion, systems may also diminished by expenses and emissions of alternative productions routes in order to establish equivalent functions.

In extreme cases however, this so called "avoided burden" approach may lead to negative emissions, which is physically meaningless.

In this study the following procedures are chosen:

Recycling of biowaste:

Several types of biowaste are considered: Urine and faeces, sewage sludge, loppings, kitchen waste. Depending on the system design, biowaste is used for generation of biogas, composting and recycling of nutrients. In every case, a system expansion is applied, as it is generally described in chapter 2.1.2. Table 3 shows the products delivered by new sanitary concepts in addition to the disposal service and their respective equivalent conventional products used for system expansion.

Table 3: Products delivered by new sanitary concepts and their respective equivalent conventional products

Additional products delivered by SCST systems	Equivalent products considered in system expansion
Compost out of faeces, kitchen residues and loppings	Organic culture media out of conventional biocompost, peat or bark mulch, partly augmented with industrial fertilisers
Electric energy produced out of biogas in combined power and heat units	Electric energy, low voltage, produced by power plant mix of Germany
Thermal energy produced out of biogas in combined power and heat units	Thermal energy, produced by conventional domestic heating systems (70% natural gas, 15% oil, 15% long distance heating)
Residuals from digestion used as fertilisers	Organic culture media out of conventional biocompost, peat or bark mulch, partly augmented with industrial fertilisers
Stabilised urine or fertilisers produced out of urine	Fertilising equivalents of industrial fertilisers

With regard to the substitution potential of recycled fertilisers, special attention has to be paid to the availability of nutrients. Also the way, fertilizers and organic culture media for amelioration of humus are applied to agricultural soil should be considered. Thereby the emission of ammonia seems to be of particular importance [Vogt et al., 2002]. In this study a good professional practice is assumed for all types of fertilisers.

It is assumed, that compost produced by combined treatment of faeces, kitchen residues and loppings substitutes mainly compost from conventional biowaste, which is meanwhile widely used. Only the surplus amount is substituted by peat or bark mulch, partly augmented with industrial fertilisers. The use of peat today is decreased in favour of bark mulch [Vogt et al., 2002]. As bark mulch is also biowaste that is produced with similar expenditures, the substitution potential is probably small. Significant effects are supposed only when bark is incinerated (with flue gas cleaning) instead of being processed to bark mulch or bark humus.

It should be recognised that the application of recycled or industrial fertilisers not generally involve positive effects, as in many regions in Germany there is an excess supply of nutrients delivered by manure.

Combined production of co-products:

Co-production applies mainly to energy and fuel production as well as to the production of caustic soda and chlorine within the production of auxiliary material. For these purposes pre-allocated data sets form literature and software data base are used, which are widely accepted [IFUIFEU, 2004; Boustead, 1998; Boustead, 1999]. Generally the allocation is done there on the basis of physical relationships (mass-, energy- molar- proportions).

Combined waste treatment:

The combined treatment of solid waste in waste incineration plants and the treatment of sewage in municipal sewage plants modelled widely on the basis of physical and chemical relationships. For waste incineration a model within the software Umberto® is used, where emission, residuals and the demand of subsidiary materials are calculated based on the waste composition and boundary conditions of operation [IFU and IFEU, 2004]. For sewage treatment a model is used that has been developed by the authors especially for the use in LCA studies and is described in the final report.

Disposal of construction material after using phase:

Depending on the type of material, the following procedures are considered:

- *Concrete, limestone, cement:* Although concrete is partially recycled after the using phase, no recycling or system expansion is modelled, because concrete needs approximately the same amount of energy to be recycled, as can be later substituted due to the further use of the recycled material [Baitz et al., 2004]. After recycling, concrete is used as substitute for primary gravel, split or sand in ancillary applications.
- *Construction steel:* The general recycling share of steel in Germany amounts to 42% in the year 2000. As there is a lack of exact data, this share is also assumed for construction steel [BDSV, 2005]. Steel is 100 percent recyclable, without downgrading to a lower quality product. For this reason a quasi closed loop recycling is considered according to the mentioned recycling share without system expansion, credits or allocation. Simplifying, scrap recycling is assumed along the electric arc furnace process chain, primary iron ore is processed along the basic oxygen furnace process chain.
- *Plastic components:* Plastic components are assumed to be incinerated for disposal, including the recovery of feedstock energy. Additionally produced thermal and / or electric energy is considered within system expansion by conventional production of energy.
- *Cast steel piping:* For cast steel, a recycling share of 88% is assumed according to the scrap use for cast steel in Germany [BDSV, 2005]. Like in the case of construction steel, a quasi closed loop recycling is considered according to the mentioned recycling share without system expansion, credits or allocation.
- *HDPE piping:* PE piping is assumed to be incinerated for disposal, including the recovery of feedstock energy. Additionally produced thermal and / or electric energy is considered within system expansion by conventional production of energy.
- *Vitrified clay piping:* No recycling or system expansion is modelled. Often the pipes remain in the ground. Further, like concrete, vitrified clay needs approximately the same amount of energy to be recycled, as can be later substituted due to the further use of the recycled material [Baitz et al., 2004].

2.1.4.3 Considered life cycle phases and sub-systems

With regard to life cycle phases and sub-systems considered it is distinguished between operational flows and flows associated with the production of capital equipment.

Operation

All unit processes needed for the operation of the analysed systems are included with the exception of processes that are identical in all systems, because these would not result to differences relevant for environmental evaluation. Generally all unit processes are linked again with all preceding und succeeding processes needed for the production of raw and auxiliary material, energy as well as the treatment and disposal of residuals. In particular the following Life Cycle phases are included:

- Domestic processes: Urination and defecation including flushing, water consumption and pollution by laundry washing and personal hygiene; production of kitchen waste and loppings
- Water supply: Pumping and delivery
- Production and supply of electric and thermal energy
- Transports
- Waste treatment in conventional systems including digestion of sewage sludge and incineration of residuals
- Greywater treatment
- Recycling of biowaste by composting and digestion
- Urine storage and application as fertiliser, possibly industrial nutrient recycle
- Application of conventional fertilisers including nutrient availability

The single data sets are documented in detail in the final report.

Not included is the production of products like food, cleaning agents or agents of personal hygiene, resulting in human egesta, solid waste and waste water. These processes are assumed to be identical for all analysed systems. However, thinking in long term cycles, for instance a lower content of heavy metals in fertilisers used in food production certainly leads to a lower content of heavy metals in human faeces, urine and kitchen waste. But as such long term effects are not decisive for the environmental comparison of the analysed systems these are not considered in this study. The transfer of pollutants from agriculture soil in crop and animals till human beings is not a matter of this study.

Also not included are inspection and repairing expenditures as well as human work and transport of workers: Although this items may be significant, no data is available that is suitable for quantifying environmental related input and output flows.

Finally, drainage and treatment of stormwater and additional percolating water are not considered. Stormwater is supposed to be drained and treated / trickled separately.

Capital equipment

Because of a long lifetime, capital equipment makes often only a minor contribution to the overall environmental impacts and is excluded in many LCA studies. However, taking into account the results of Zimmermann et al. 1996, the environmental expenditures for the construction of sanitary systems may have a significant share of the overall expenditures. In this study capital equipment needed for construction of the sanitary systems is included, as far as the respective components are not identical in each system. However, capital equipment of the background system (i.e. Production and supply of conventional energy, any industrial production plant, road construction, etc.) is not included.

The new sanitary systems are assumed to be integrated in new buildings and a new urban development area. With regard to the construction the following components are considered:

- piping for in-house and external offtake of black and grey water, urine, faeces and kitchen waste
- Excavation of trenches
- Containers, tanks and vessels for in-house and external storage
- Pumps
- Black- and greywater treatment plant
- Digestor and combined power and heat unit

The following components of sanitary systems are not included:

- Production of urinals, toilet bowls: It is assumed that the comfort of the sanitary configuration and the associated expenses are approximately equal for SCST and CS systems
- Construction of composting plant: Both, CS and SCST systems include composting of bio waste. The scale of the plants depends on the volume to be treated rather than on the mass. As the volume variation of kitchen waste and loppings is much bigger than the additional volume of faeces, the scale of the composting plant within the SCST systems is assumed to be equal to the composting plant of the conventional system.
- Human work and transport of workers
- Energy demand for the installation of in-house facilities
- Electric control systems
- Drainage and treatment of stormwater and additional percolating water: This is of particular relevance with regard to the size of the sewer and the sewage plant. In this study stormwater is supposed to be drained and treated and trickled separately.

Figure 9 shows the procedure with regard to the consideration of capital equipment for sanitary systems and the background system.

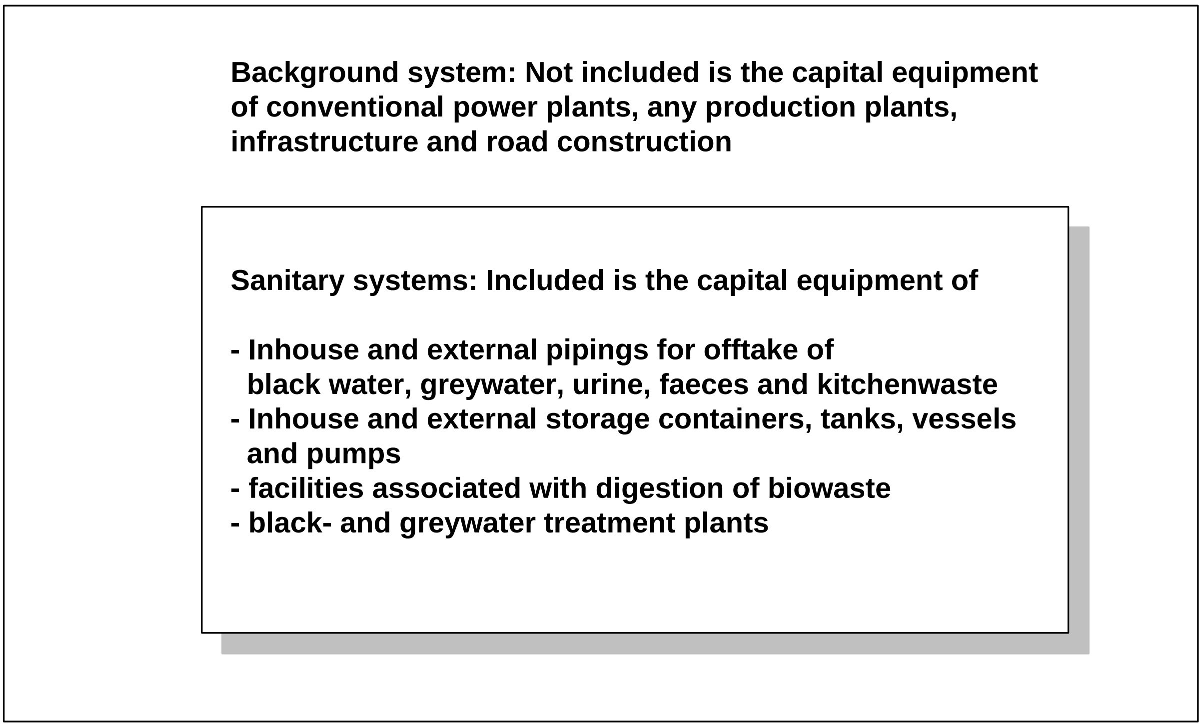


Figure 9: consideration of capital equipment for sanitary systems and the background system

<u>Cut-off criteria</u>

In order to make LCA's manageable and to avoid unlimited datasets, unit processes and subsystems are usually excluded from further analysis, which are considered not to be relevant for the environmental performance of the analysed functions. For this purpose commonly intermediate product or waste flows are cut off that are smaller than a certain mass or energy share of the total intermediate product or waste input or output (e.g. 3%).

In this study no generally cut-off-criteria is defined. For each process it is decided separately, whether or not an intermediate product (or waste) flow is linked to its preceding or succeeding processes according to its estimated environmental relevance and the availability of data. However, the aggregated share of all substances cut off may not exceed 5% of the total intermediate product input or output mass, respectively energy. With regard to data from literature, cut off criteria mentioned there is used.

2.1.4.4 Considered elementary flows

According to ISO 14041 environmental interventions linked to unit processes are denoted as elementary flows. Elementary flows are for instance resources like crude oil, emissions to air like Ammonia or also land use. In the face of numerous chemical compounds, the number of elementary flows potentially released to the environment is extremely high. Although up to date datasets provide large lists of elementary flows for Life Cycle Inventory, in this study only selected substances are considered with regard to the following criteria:

- elementary flows should be considered in particular that have a known significance in wastewater and biowaste management as well as in agricultural processes
- elementary flows of general environmental interest should be also included
- the selected elementary flows must quantify the considered impact categories in a sufficient way
- the respective elementary flow should be known for each unit process of the system, at least for the most important ones, in order to provide a symmetrical database and to avoid unproved conclusions
- elementary flows that are considered as possibly relevant but are not yet investigated well must be neglected (e.g. organic medical trace substances in urine)

Table 4 shows the preliminary selected elementary flows. The respective impact categories and the method of the impact assessment are documented in the final report. In order to get an impression of the distribution of the single elements within the analysed systems, some material flows are decomposed to their elementary composition. Table 5 shows the respective materials.

Table 4: Considered elementary flows

Emissions to air	Emissions to water	Emissions to soil	Resources in geol. deposit
CO_2 CO CH_4 N_2O NH_3 NO_x SO_x HCl HF In discussion: PM 10 NMVOC Benzene Formaldehyde BaP, PAH PCDD / PCDF (TE) As, Be, Pb , Cd, Cr, Co, Cu, Ni, Hg, Se, Th, Zn	C, N, K, P, S and respect. species Cd, Cr (III/VI-mix), Cu, Hg, Ni, Pb, Zn	C, N, K, P, S and respect. species Cd, Cr (III/VI-mix), Cu, Hg, Ni, Pb, Zn, Fe Ca, Mg Na, Cl In discussion: BaP, PAH PCDD / PCDF (TE), Uranium	Lignite Hard coal Uranium Natural gas Crude oil Phosphorus (Phosphate rock and marine phosphorite)

Table 5: Material flows and their elementary composition analysed inside the system

Flows inside the system	
Main materials	**Components in main materials considered separately**
Domestic waste streams: Waste water, urine, faeces, greywater, domestic and municipal biowaste	C, N, K, P, S Cd, Cr, Cu, Hg, Ni, Pb, Zn, Fe Ca, Mg Na, Cl
Fertilizers (in addition if needed: peat and bark mulch)	(C), N, K, P, S, Ca, Mg Cd, Cr, Cu, Hg, Ni, Pb, Zn
Electric and thermal and mechanic energy	
Auxiliary material, e.g.: Precipitation and flocculation chemicals, fuels	Fe, Al (if needed in addition heavy metal contaminations: Cd, Cr, Cu, Hg, Ni, Pb, Zn)
Construction material, e.g.: Concrete, construction steel, piping materials (stoneware-, PE-, PVC, cast steel), sand, copper, cement, limestone	No elementary decomposition is considered

2.1.4.5 Geographical and temporal scope

The reference system refers mainly to average German or Western Europe conditions during 1995 and 2004. The SCST systems represent possible future prospects, however the considered technology also bases mainly to average German or Western Europe conditions during 1995 and 2004. In some cases, when no up-to-date data is available, older data has to be used.

The international origin of some materials and resources (crude oil, phosphate rock, etc.) is taken into account by local production conditions and respective transport distances.

According to the nature of LCA, no spatial or temporal differentiation of environmental interventions is done. Environmental interventions are aggregated without accounting for time and location. Long term emissions from land fill sites are taken into account for 50 years [see documentation in the IFU and IFEU, 2004 data base].

With regard to impact assessment, the CML-method applied in this study mostly assumes an infinite time horizon, with the exception of the global warming potential, where a time horizon of 100 years is considered [Guinée et al., 2002]. The method is described separately in the final report.

2.1.5 Considered impact categories, method of impact assessment and interpretation

See final report

2.1.6 Requirements to data and data quality

See final report

2.1.7 Assumptions and limitations

In the following some general and specific limitations of the study are listed.

General limitations

- LCA considers only loads of emissions, without quantifying the concentration of pollutants and without differentiation of time and location of the emission. Particularly with regard to the evaluation of human and ecotoxic impacts this is a crucial limitation.
- Some future environmental interventions cannot be quantified by expert knowledge (e.g. final storage of radioactive waste) and must be neglected.
- Sum parameters (NMVOC, COD, etc.) allow only a restricted evaluation of the ecological significance of emissions

Specific limitations

- The results are strongly influenced by the system expansion with conventional production and supply of fertilizers. However, the datasets of these processes are of limited quality as they refer to the beginning of the 1990 decade and within the fertiliser production only airborne emissions are included [Patyk and

Reinhardt, 1997]. The heavy metal content of the fertilisers lies between wide ranges, so that averaging is problematic [Boysen, 1992; Vogt et al., 2002].

- Only a limited set of environmental interventions and impact categories are included (e.g. no odour exposure) throughout the analysed systems, because of lack of data and missing symmetry of data
- No workplace emissions or pathogens are assessed. Such emissions may be particularly associated with the treatment of biowaste.
- Accidents, the risk of accidents or undesirable system behaviour are ignored
- The migration of nitrate into the groundwater and associated impacts are not considered
- The constructional design of waste water systems, the operational expenses and the associated environmental impacts depend on local conditions. Emissions linked with fertilising also depend strongly on several variable boundary conditions (atmospheric conditions, dilution of fertilisers, technique and agricultural machines used, etc.).

3 Selected preliminary results (reference system)

In order to provide a rough basis of comparison, in this intermediate report preliminary results of the reference system are included. In addition, the maximum amount of mineral fertilisers is considered according to the nutrient equivalents that can be substituted by urine. In the following some important results are presented. Detailed documentation is provided in the final report.

3.1 Carbon dioxide equivalents

Figure 10 shows the carbon dioxide equivalents of the conventional reference system, expanded by fertiliser equivalents of urine (5,000 inhabitants, 100% use of digester gas, co-incineration of sewage sludge in municipal waste incineration plant). The total emission of carbon dioxide equivalents amounts to 462,800 kg CO_2-eq. 49% of this amount is attributed to the production and application of mineral fertilisers. The amount of mineral fertilisers corresponds with the total nutrient content of urine produced by 5,000 inhabitants during one year.

About 25% are associated to the construction of the system. This fraction may still decrease as the used quantity of construction material of the sewage plant seems to be somewhat overestimated (see final report). The credit of about -14% is contributed to the energy recovery from the incineration of sewage sludge and also a small amount for the thermal recycling of plastic pipes after the use phase. The energy recovered by the use of digestor gas is already offset with the energy demand of the sewage treatment plant and does not appear in figure 10.

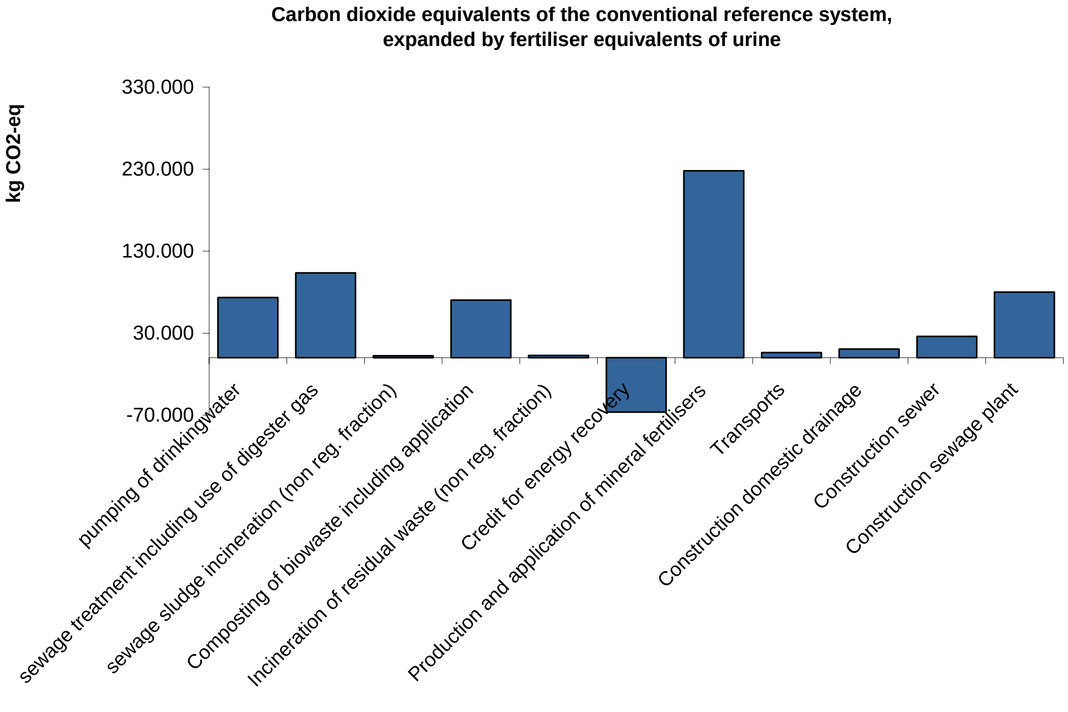


Fig. 10: carbon dioxide equivalents of the conventional reference system, expanded by fertiliser equivalents of urine

The high significance of the fertilisers is associated with the high energy demand of the production of nitrogen fertilisers (49 MJ cumulated demand of fossil energy per kg N), the emission of N_2O during the production route of N-fertilisers and the volatilisation of N_2O after application [Patyk and Reinhardt, 1997]. For N_2O an emission factor of 0.0125 kg kg^{-1} N in fertiliser is assumed [according to the simple approach in EMEP/CORINAIR 2004].

Figure 11 shows the carbon dioxide equivalent shares for production and application of mineral fertilisers.

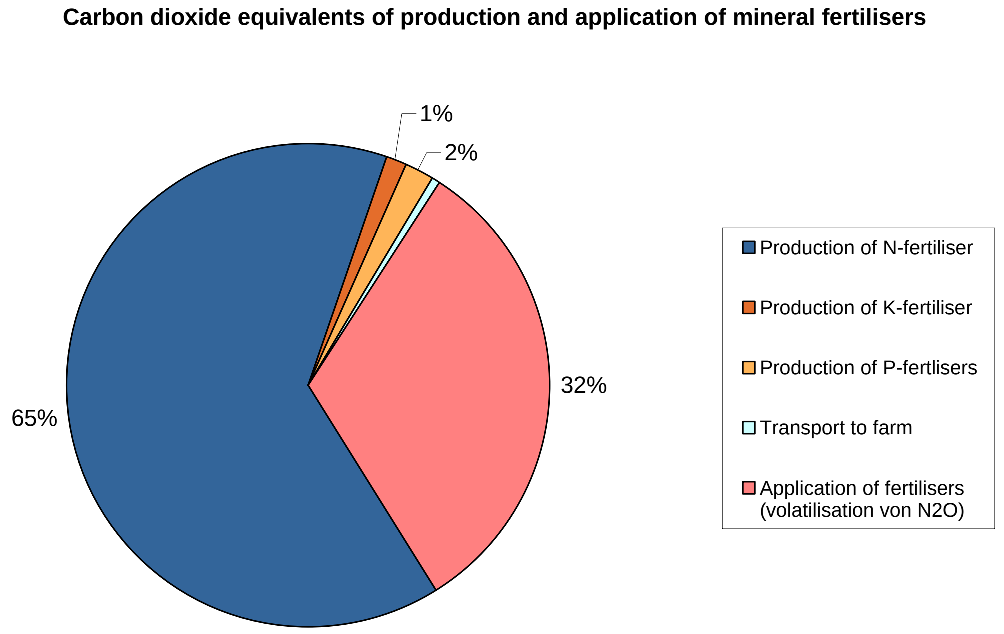


Figure 11: Carbon dioxide equivalents of the production and application of mineral fertilisers (nutrient equivalents of urine)

3.2 Heavy metals

Table 6 shows the emitted amount of some heavy metals into agricultural soil and surface water. With regard to soil it is differentiated between the impact by mineral fertilisers and by compost from domestic and municipal biowaste. When interpreting these figures one should always keep in mind that the amount of mineral fertilisers considered here corresponds to the equivalent amount of nutrients in urine. Therefore the ratio of the heavy metal loads between mineral fertilisers and compost does not essentially reflect the actual ratio in reality.

In addition to the heavy metal mass emitted by the reference system, table 6 includes the average mass of the respective metals emitted per capita in Germany. From these figures per-capita equivalents can be calculated. Small values of capita equivalents indicate a small significance with regard to the relative quantity, high values accordingly a high significance. Per-capita equivalents support the evaluation of different environmental impacts [Guinée et al., 2002].

Table 6: Heavy metals emitted into agricultural soil and surface water (reference system)

	Heavy metal impact agricultural soil				Heavy metal impact surface water		
Metal	**Min. fertilisers (eqv. process)**	**Compost**	**mass per capita and year [1]**	**Equiv. capita**		**mass per capita and year [2]**	**Equiv. capita**
	kg	kg	g/(P a)		kg	g/(P a)	
arsenic	0.21	--	--	--	--	--	--
lead	0.56	1.42	2.30	855	2.56	6.00	427
cadmium	0.22	0.06	0.30	840	0.26	0.22	1,182
chromium	1.25	2.60	--	--	2.20	5.00	440
copper	0.33	3.60	52.20	75	12.09	8.00	1,511
mercury	0.00	0.04	--	--	0.01	0.08	131
nickel	0.66	0.71	--	--	3.17	4.70	674
zinc	4.00	23.07	158.00	171	36.72	50.90	721

[1] Rough estimation from specifications for the Netherlands (1997) and Western Europe (1995) in proportion to the number of inhabitants [Guinée et al., 2002].
[2] All sources are considered (treated sewage, drainage, direct discharge, erosion, etc.) [UBA, 2001]

3.3 Comparison of normalised data

ISO 14042 defines normalisation as "Calculation of the magnitude of indicator results relative to reference information". Using per-capita emission over 1 year in Germany as reference information, the normalisation procedure is described by equation 1. The resulting figures have the unit "number of inhabitants" and are further called per-capita equivalents.

$$CE_i = \frac{IR_{i,S}}{IR_{i,C}} \frac{[kg \times a \times capita]}{[a \times kg]} \qquad (1)$$

CE_i: per-capita equivalents of a environmental indicator i

$IR_{i,S}$: Result of an environmental indicator associated with the analysed system [kg/a, MJ/a]

$IR_{i,\,capita}$: Total load of a environmental indicator per capita and year in Germany [kg $Capita^{-1}$ a^{-1}, MJ $Capita^{-1}$ a^{-1}]

According to ISO 14042 the reference system should be consistent with the spatial and temporal scales of the environmental mechanisms of the respective indicator. Thus, in order to normalise for instance indicators with global implications like carbon dioxide equivalents, the world should be selected as reference area. Using Germany as reference area, the Global Warming Potential (GWP) will be rated lower compared to other indicators as Germany has relatively high per-capita GWP-loads. Nonetheless in this study Germany is used as reference area, because for most of the considered environmental interventions the emphasis is in this region. Further, differentiating in several reference regions would require normalisation data for all regions involved in this study. At present such data is not available.

Figure 12 shows Per-capita equivalents of the Eutrophication Potential (EP) Water (only water emissions, without terrestrial eutrophication), cadmium emissions and the Global Warming Potential associated with the reference system (variant 1). According to the normalised results the EP of water emissions have quantitatively the highest significance, followed by cadmium emissions as example for heavy metals.

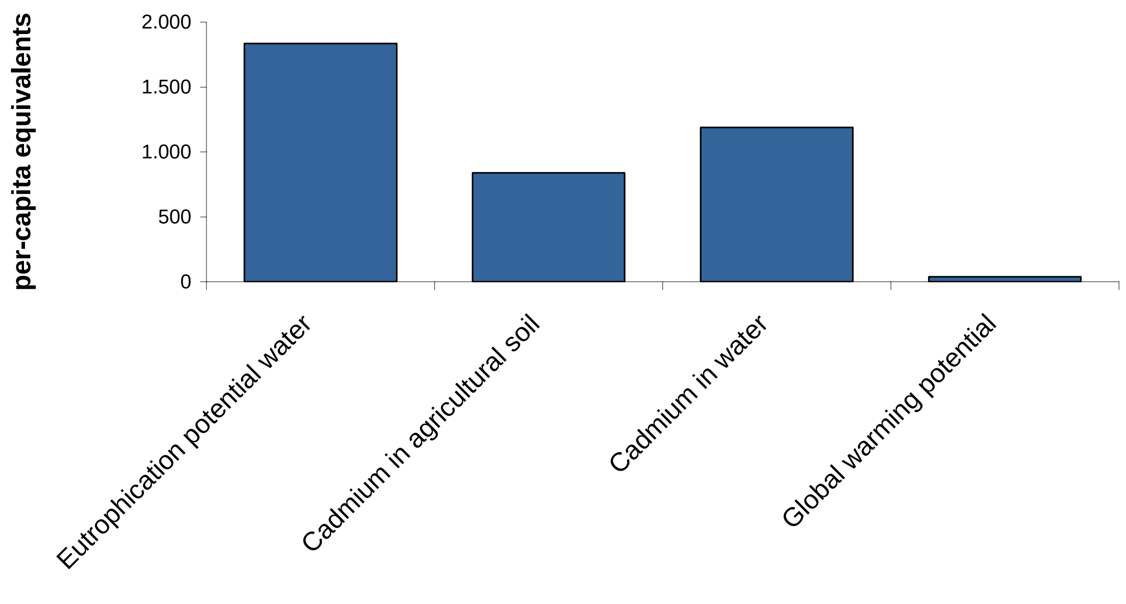


Figure 12: Per-capita equivalents of the Eutrophication Potential (only water emissions, without terrestrial eutrophication), cadmium emissions and the Global Warming Potential associated with the reference system (variant 1)

As the normalised results shown in figure 12 concern only the quantitative aspects of the environmental evaluation, it is not allowed to conclude that the GWP would have only a minor significance with regard to the analysed sanitary system.

A decision oriented evaluation step would require offsetting quantitative and qualitative evaluation criteria with regard to every environmental indicator considered within a weighting procedure. However, such weighting steps base on subjective values. In the valuation approach for LCA studies of the German environmental protection agency a general offsetting is not applied and only allowed in specific situations [Schmitz and Paulini, 1999].

Nevertheless, simplifying and keeping in mind the problems associated with weighting steps, the qualitative aspects of the GWP must be rated about 20 – 50 times higher than the qualitative aspects of the EP Water or the cadmium emissions in order get the same overall significance with regard to the analysed system.

A more detailed evaluation of the results is provided within the final report.

4 Literature Overview

Composition of domestic sewage and waste streams

Almeida, M.C.; Butler, D.; Friedler, E.: At-source domestic wastewater quality. Urban Water 1 (1999), S. 49-55

Bahlo, K. (1999): Bewachsene Bodenfilter zur Grauwasserreinigung. In: Grauwasser-Recycling. Schriftenreihe fbr Nr. 5. Fachvereinigung Betriebs- und Regenwassernutzung e.V. fbr. Darmstadt

Becker, K; Kaus, S.; Krause, C.; Lepom, P.; Schulz, C.; Seiwert, M.; Seifert, B.: Umwelt Survey 1998, Bd. III: Human-Biomonitoring. Stoffgehalte in Blut und Urin der Bevölkerung in Deutschland. WaBoLu-Heft 1/02, Umweltbundesamt, Berlin 2002

Butler, D.; Friedler, E.; Gatt, K. (1995): Characterising the Quantity and Quality of Domestic Waste Water Inflows.

Ciba-Geigy (1977): Wissenschaftliche Tabellen Geigy, Teilband Körperflüssigkeiten, 8. Ed, Basel. (ggf. Mittelwerte)

Fittschen, I. & Hahn, H.H. (1998): Characterization of the Municipal Wastewaterpart Human Urine and a Preliminary Comparison with Liquid Cattle Excretion. Wat. Sci. Tech. 38(6), 9-16.

Hagendorf, U. (1992):Organische Halogenverbindungen (AOX) aus diffusen Quellen im Haushalt (Papier, Geschirrspül- und Waschmaschinen). KA - Korrespondenz Abwasser 12, S. 1776-1783. (nur Toilettenpapier)

Ingenieurbüro Otterwasser (2002): Mittelwerte verschiedener Teilstromzusammensetzungen (Persönliche Mitteilung)

Jönsson et al. (1997): Source Separated Urine-Nutrient and Heavy Metal Content, Water Saving and Faecal Contamination. Wat. Sci. Tech. 35(9), 145-152.

Jönsson, H. & Vinneras, B. (2003): Adapting the Proposed Swedish Default Values for Urine and Faeces to Other Countries and Regions. 2nd International Symposium on ecological sanitation. 7.-11. April 2003, Lübeck. Session F

Kübler et al. (1999), zitiert in Kujawa-Roeleveld, K. (2001): Types, characteristics and quantities of domestic solid waste. In: Decentralised Sanitation and Reuse - Concepts, systems and implementation, S.73 - 91. Piet Lens, Grietje Zeeman and Gatze Lettinga (Edits.)

Kujawa-Roeleveld, K.; Elmitwalli, T.; Gaillard, A.; van Leeuwen, M.; Zeeman, G. et al. (2003): Co-digestion of concentrated black water and kitchen refuse in an accumulation system within the DESAR (decentralised sanitation and reuse) concept. Wat. Sci. Tech. 48(4), 121-128

Paik et al. (1999), zitiert in Kujawa-Roeleveld, K. (2001): Types, characteristics and quantities of domestic solid waste. In: Decentralised Sanitation and Reuse - Concepts, systems and implementation, S.73 - 91. Piet Lens, Grietje Zeeman and Gatze Lettinga (Edits.)

Palmquist. H. & Jönsson, H. (2003): Urine, faeces, greywater, and biodegradable solid waste as potential fertilisers. 2nd International Symposium on ecological sanitation. 7.-11. April 2003, Lübeck. Session F, 8 pages.

Pöpel, F. (1973/1993): Lehrbuch für Abwassertechnik und Gewässerschutz. Deutscher Fachschriftenverlag, Wiesbaden. Zit. nach Larsen, T.A. & Gujer, W. (1996): Separate Management of Anthropogenic Nutrient Solutions (Human Urine). Wat. Sci. Tech. 4(3-4), 87-94.

Raach et al. (1999): Stoffflußanalyse Abwasser - eine Abschätzung der Substanzflüsse deutscher Kläranlagen (berechnet aus Eintrag durch Küchenabfälle, Waschen und Reinigen und sonstige Einträge, ohne Trinkwasser, Urin und Fäzes; die Rubrik "sonst. Haushalt" beinhaltet auch Kleingewerbe

Vinneras, B. (2001): Faecal separation and urine diversion for nutrient management of household biodegradable waste and wastewater. Report 244, Swedish University of Agricultural Sciences (SLU), Department of Agricultural Engineering. Uppsala.

Woffersdorff, S. (2004): Untersuchungen zu Sortiertoiletten unter besonderer Berücksichtigung der Urinverwertung. Diplomarbeit an der Agrar- und

Umweltwissenschaftlichen Fakultät, Insititut für Umweltingenieurwesen, der Universität Rostock

Wolff, F. (2004): Biomasse in Baden-Württemberg – ein Beitrag zur wirtschaftlichen Nutzung der Ressource Holz als Energieträger. Universität Karlsruhe, Fak. f. Wirtschaftswissenschaften. Diss.

Composting of biowaste

Baky, A. and Eriksson, O. (2003): Systems Analysis of Organic Waste Management in Denmark. Environmental Project No. 822. Danish Ministery of the Environment

Bidlingmaier, W.; Gottschal, R.; Petersen, U.; Stöppler-Zimmer, H.; Kehres, B.; Kranert, M.; Phillipp, W.; Strauch, D.; Vagedes, M; Widmann, R. (2000): Biologische Abfallverwertung. Eugen Ulmer GmbH, Stuttgart

Clemens, J., and Cuhls, C. (2003): Greenhouse Gas Emissions from Mechanical and Biological Waste Treatment of Municipal Waste. Environmental Technology 24, 745-754.

Cuhls, C. (2001): Schadstoffbilanzierung und Emissioneminderung bei der mechanisch-biologischen Abfallbehandlung. Hannover

Emberger, J. (1993): Kompostierung und Vergärung. Vogel Verlag. Würzburg

Fricke, K., Turk, T., Vogtmann, H. (1990): Grundlagen der Kompostierung. Hrsg.: K.J. Thome-Kozmiensky, TU Berlin. EF-Verlag für Energie- und Umwelttechnik GmbH, Berlin

Gronauer, A., Claassen, N., Ebertseder, T., Fischer, P., Gutser, R., Helm, M., Popp, L., and Schön, H. (1997): Bioabfallkompostierung - Verfahren und Verwertung. Bayrisches Landesamt für Umweltschutz (Hrsg). Schriftenreihe Heft 139. München

Leinemann, B. (1998): Die Bildung klimarelevanter Spurengase während der Kompostierung in Abhängigkeit von der Bioprozeßführung und dem Inputmaterial. Dissertation, Naturwissenschaftliche Fakultät, TU Braunschweig

Roth, T.; Fricke, K.; Müller, W.; Vogtmann, H. (1990): Menge und Qualität von Sickerwasser und dessen Aufbereitungsmöglichkeiten. In: Grundlagen der Kompostierung. Fricke, K.; Turk, T.; Vogtmann, H.. EF-Verlag für Energie- und Umwelttechnik, Berlin

Digestion

Gruber, W. (2003): Biogasanlagen in der Landwirtschaft. aid infodienst Verbraucherschutz, Ernährung, Landwirtschaft e. V. Bonn

Ronchetti, C.; Bienz, P.; Pridal, R. (2002): Ökobilanz Klärgasvertromung. Bundesamt für Energie, Bern

Tidden, F. (2003): Leistungsmerkmale und Grenzen der mehrphasigen anaeroben Behandlung kommunaler Bioabfälle.Berichte aus Wassergüte und Abfallwirtschaft Nr. 176. TU München

Fertilisers and fertilisation

Boysen, P (1992): Schwermetalle und andere Schadstoffe in Düngemitteln - Literaturauswertung und Analysen-. UBA Texte No. 55/92.

Deisenroth, G.; Heyn, J.; Hüsch, S.; Schelle, E. (2004): Leitfaden zur Umsetzung der Düngeverordnung in Hessen. Fachinformation – Pflanzenproduktion 3/2004. Hessisches Dienstleistungszentrum für Landwirtschaft, Gartenbau und Naturschutz. Kassel

EMEP/CORINAIR (2004): EMEP/CORINAIR Emission Inventory Guidebook - 3rd edition September 2004 UPDATE. Group 10: Agriculture. Jessica Sully and Nikolas Hill (Edtrs.). Technical Reprot No 30. EEA (European Environment Agency)

Kratz, S. (2004): Uran in Düngemitteln. Vortrag zum 1. Statusseminar zum Thema Uran. Bundesforschungsanstalt für Landwirtschaft (FAL). Institut für Pflanzenernährung und Bodenkunde. Braunschweig

Patyk, A. and Reinhardt, G. (1997): Düngemittel – Energie- und Stoffstrombilanzen. Vieweg, Braunschweig / Wiesbaden

Schütze, G. Becker, R.; Dämmgen, U.; Nagel, H.-D.; Schlutow, A.; Weigel, H.-J. (2003): Risikoabschätzung der Cadmium-Belastung für Mensch und Umwelt infolge der Anwendung von cadmiumhaltigen Düngemitteln. Landbauforschung Völkenrode 2/3 / 2003 (53). P. 63-170

UBA 2004: Umweltdaten Deutschland. http://www.env-it.de/umweltdaten

Conventional sewage treatment (selection)

ATV (1996): ATV-Handbuch Klärschlamm. Ernst & Sohn Verlag, Berlin.

ATV-DVWK (2000): Bemessung von einstufigen Belebungsanlagen. ATV-DVWK-Arbeitsblatt A -131. Abwasser und Abfall e.V. (ATV-DVWK) Deutsche Vereinigung für Wasserwirtschaft (Hrsg.), Hennef

ATV-DVWK (2002): Stickstoffbilanz in Deutschland: Landwirtschaft, Futtermittel- und Ernährungsindustrie, Abwasser- und Abfallentsorgung. ATV-DVWK-

Arbeitsbericht, Bd. AK-9. Abwasser und Abfall e.V. (ATV-DVWK) Deutsche Vereinigung für Wasserwirtschaft (Hrsg.), GFA, Ges. zur Förderung der Abwassertechnik, Hennef

ATV-DVWK (2004): Leistungsvergleich kommunaler Kläranlagen. http://www.dwa.de/download/leistungsvergleich2003.pdf

Haberkern, B. (1998): Energieeinsparung in Kläranlagen - Seminardokumentation. IMPULS-Programm Hessen, Institut Wohnen und Umwelt (IWU), Darmstadt

Imhoff, K. (1990): Taschenbuch der Stadtentwässerung, 27. Auflg., Oldenbourg Verlag, München

LFU (1998): Stromverbrauch auf kommunalen Kläranlagen. Handbuch Wasser 4. Landesamt für Umweltschutz Baden-Württemberg (LfU) (Hrsg.)

Müller, E.A., Thommen, R. und Stähli, P. (1994): Handbuch Energie in ARA - Energiesparmassnahmen in Abwasserreinigungsanlagen, Bern

Scheer, H. (1998): Bemessung von Kläranlagen auf Stickstoff- und Phosphorelimination im internationalen Vergleich. Veröffentlichungen des Institutes für Siedlungswasserwirtschaft und Abfalltechnik der Universität Hannover, Bd. 102. K.H. Rosenwinkel (Hrsg.), Hannover

Schumann, H., Obst, K., Frierich, C., Pattard, M., Pluta, H.-J. und Hahn, J. (1997): Umweltverträglichkeit von Chemikalien zur Abwasserbehandlung. UBA-Texte, Bd. 39/97. Umweltbundesamt (Hrsg.), Berlin

Construction domestic drainage, sewer and sewage treatment plant

DIN 1986-100 (2002): Entwässerungsanlagen für Gebäude und Grundstücke, Teil 100: Zusätzliche Bestimmungen zu DIN EN 752 und DIN EN 12056. Deutsches Institut für Normung (Hrsg.), Beuth Verlag, Berlin.

DIN EN 12056-2 (2000): Schwerkraftentwässerungsanlagen innerhalb von Gebäuden, Teil 2: Schmutzwasseranlagen, Planung und Berechnung. Deutsches Institut für Normung (Hrsg.), BeuthVerlag, Berlin.

Düker (2004): Produktübersicht im Internet, abgerufen am 15.12.2004 unter http://www.dueker.de/abflusstechnik/german/abflussrohre-sml.html

Euroceramic (2004): Produktübersicht im Internet, http://www.euroceramic.de, abgerufen am 18.01.2005.

Geberit (2004): Produktübersicht im Internet „Der Geberit 2004“, http://www.geberit.de/de/dergeberit/00_start.html, abgerufen am 22.11.2004.

Hagedorn, S. (2000): Ökologische Bewertung des Berliner Entwässerungssystems unter Anwendung der Ökobilanzmethode. Projektarbeit am Fachgebiet Wasserreinhaltung. TU Berlin

Jeschar, R., Specht, E., Steinbrueck, A. (1995): Energieverbrauch und CO2-Emission bei der Herstellung und Entsorgung von Abwasserrohren aus verschiedenen Werkstoffen. Korrespondenz Abwasser 42, 537-549.

Jeschar, R., Specht, E., Steinbrueck, A. (1996): Umweltbeeinflussung bei der Herstellung von Abwasserrohren aus verschiedenen Werkstoffen. Korrespondenz Abwasser 43, 61-70.

KÖHLER, A. (2001): Modellierung der Energie-und Stoffströme für die Wasserwirtschaft Berlins am Beispiel der Kläranlage Ruhleben; Diplomarbeit am Fachgebiet Wasserreinhaltung, Institut für Technischen Umweltschutz, Technische Universität Berlin, Berlin

Ostendorf (2004): Produktübersicht im Internet, abgerufen am 15.12 2004 unter http://www.ostendorf-kunststoffe.com/produkte/ht/ht_abflussrohre/index.html

Reckerzügl, T. (1997): Vergleichende Materialintensitätsanalyse zur Frage der zentralen oder dezentralen Abwasserbehendlung anhand unterschiedlicher Anlagenkonzepte. Diplomarbeit an der Universität-GH-Paderborn, Abteilung Höxter, Fachbereich technischer Umweltschutz. Zitiert in Schneidmadl (1999)

Reusser, L. (1998): Ökobilanz von Rohrleitungssystemen – Eine Fallstudie am Beispiel der Erstellung der Trinkwasserversorgung und Schmutzwasserentsorgung für eine Einfamilienhaussiedlung. EMPA St. Gallen, 1998

Simona (2004): Produktübersicht im Internet, http://www.simona.de/simona, abgerufen am 23.11.2004.

Specht, E; Jeschar, R. (1997): Kumulativer Energieverbrauch bei verschiedenen Produktionslinien von Abwasserrohren aus Steinzeug. Korrespondenz Abwasser. 5/97 Vol 44. S. 841 - 847

Life cycle assessment - methodology (selection)

Boustead, I. (1999): Eco-profiles of plastics and related intermediates - methodology. APME Association of Plastics Manufacturers in Europe (Hrsg.), Brussels

Ekvall, T. und Finnveden, G. (2001): Allocation in ISO 14041 - a critical review. Journal of Cleaner Production 9, 197-208

Fleischer, G. (1994): Methodik des Vergleichs von Verwertungs-/ Entsorgungswegen im Rahmen der Ökobilanz. AbfallwirtschaftsJournal 6 (10), 697-701

Frischknecht, R. (1998): Life Cycle Inventory Analysis for Decision Making. Swiss Federal Institute of Technology Zurich, ETH

Guinée, J.B., Gorree, M., Heijungs, R., Huppes, G., Kleijn, R., Wegener Sleeswijk, A., Udo de Haes, H.A., Bruijn, de, J.A., Duin, van, R., Huijbregts, M.A.J., Lindeijer, E., Roorda, A.A.H., Ven, van der, B.L. und Weidema, B.P. (2002): Handbook on Life Cycle Assessment - Operational Guide to the ISO

Standards. Jeroen B. Guinée (Hrsg.), Kluwer Academic Publishers, Dordrecht, Boston, London

Guinée, J. B., Udo de Haes, H. A., and Huppes, G. (1993): Quantitative life cycle assessment of products (part 1) - goal definition and inventory. Journal of Cleaner Production 1, 3-13.

ISO 14040 (1997): DIN EN ISO 14040: Umweltmanagement - Ökobilanz - Prinzipien und allgemeine Anforderungen. Deutsches Institut für Normung (Hrsg.), Beuth Verlag, Berlin

ISO 14041 (1998): DIN EN ISO 14041: Umweltmanagement - Ökobilanz - Festlegung des Ziels und des Untersuchungsrahmens sowie Sachbilanz. Deutsches Institut für Normung (Hrsg.), Beuth Verlag, Berlin

ISO 14042 (2000): DIN EN ISO 14042: Umweltmanagement - Ökobilanz - Wirkungsabschätzung. Deutsches Institut für Normung (Hrsg.), Beuth Verlag, Berlin

ISO/TR 14049 (2000): Environmental management - Life cycle assessment - Examples of application of ISO 14041 to goal an scope definition and inventory analysis. International Organization for Standatization (Hrsg.), Beuth Verlag, Berlin

Schmitz, S., and Paulini, I. (1999): Bewertung in Ökobilanzen. Umweltbundesamt. Berlin.

Life cycle assessment - data (selection)

AG Energiebilanzen (1997): Heizwerte der Energieträger und Faktoren für die Umrechnung von spezifischen Mengeneinheiten in Wärmeeinheiten zur Energiebilanz 1997. Arbeitsgemeinschaft Energiebilanzen (Hrsg.), Berlin, Köln

Baitz, M., Kreißig, J., Byrne, E., Frees, N., Bey, N., Hansen, M. S., Hansen, A., Bosch, T., Borghi, V., Watson, J., and Miranda, M. (2004): Life Cycle Assessment of PVC and of principal competing materials, Commissioned by the European Commission, Leinfelden-Echterdingen, Lyngby, Barcelona.

BDSV (2005): Stahlschrott - ein "güner" Rohstoff. Bundesvereinigung Deutscher Stahlrecycling- und Entsorgungsunternehmen e.V. Düsseldorf.

Boustead, I.: Ecoprofiles of plastics and related intermediates. Report 14: HDPE pipe (total). APME, Brussels. Stand der Web-Publikation: Februar 2000. http://lca.apme.org

Frischknecht, R., Bollens, U., Bosshart, S., Ciot, M., Ciseri, L., Doka, G., Dones, R., Gantner, U., Hischier, R. & Martin, A. (1996): Ökoinventare von Energiesystemen, 3. Auflg.; Projekt- und Studienfonds der Elektrizitätswirtschaft (PSEL) Bundesamt für Energiewirtschaft (BEW) (Hrsg.). ENET, Arbon ifu - ifeu: Datenbank der Umberto - Software für das betriebliche Stoffstrommanagement, Version Umberto 4.2. Institut für Umweltinformatik Hamburg GmbH und Institut für Energie- und Umweltforschung Heidelberg GmbH (Hrsg.), Hamburg, 2003

UBA (2001): Bilanzierung des Eintrags prioritärer Schwermetalle in Gewässer. Berlin.

Zimmermann, P., Doka, G., Huber, F., Labhardt, A. und Ménard, M. (1996): Ökoinventare von Entsorgungsprozessen - Grundlagen zur Integration der Entsorgung in Ökobilanzen. ETH Zürich Institut für Energietechnik (Hrsg.), 1. Auflg., ENET, Bern

Overall publications

Gujer, W., 1999: Siedlungswasserwirtschaft. Springer. Berlin Heidelberg New York

Koppe, P. & Stozek, A. (1999): Kommunales Abwasser. 4. Aufl. Vulkan-Verlag, Essen.

Lange, J.; Otterpohl, R. (2000): Abwasser - Handbuch zu einer zukunftsfähigen Wasserwirtschaft. Zusammenstellung aus div. Literaturangaben

MUNLV (2001): Co-Fermentation von biogenen Abfällen in Faulbehältern von Kläranlagen. Ministerium für Umwelt und naturschutz, Landwirtschaft und Verbraucherschutz des Landes Nordrhein-Westphalen (Hrsg.); gemittelter Jahresdurchschnitt, Bioabfall (Grünschnitt + Küche)

Schneidmadl, J. (1999): Ökologischer Vergleich von Abwassersystemen. Diplomarbeit im Studienfach Geoökologie an der Universität Karlsruhe (TH)

Schneidmadl, J.; Fuchs, S.; Hillenbrand, T. (2000): Vergleichende Ökobilanz unterschiedlicher Abwasserkonzepte. KA - Korrespondenz Abwasser 47 / 5. 681 – 695

Stadtmüller, U. (2004): Grundlagen der Bioabfallwirtschaft. TK Verlag Karl Thomé-Kozmiensky. Neuruppin.

Vogt, R.; Knappe, F.; Giegrich, J.; Detzel, A. (2002): Ökobilanz Bioabfallverwertung. Inititiativen zum Umweltschutz - Band 52. Erich Schmidt Verlag, Berlin. (dort angesetzte Rechenwerte)

Vogt, R.; Knappe, F.; Giegrich, J.; Detzel, A. (2002): Ökobilanz Bioabfallverwertung. Inititiativen zum Umweltschutz - Band 52. Erich Schmidt Verlag, Berlin

Wintzer, D.; Leible, L.; Rösch, C.; Bräutigam, R.; Fürniß, B.; Sardemann, G. (1996): Wege zur umweltverträglichen Verwertung organischer Abfälle. Erich Schmidt Verlag, Berlin

Annex 6.3

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Arbeitsbereich kommunale und industrielle Abwasserwirtschaft

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Interim Report March '05
for the SCST Project
Task 7: *Industrial style urine treatment for utilisation*

Introduction

Within the project "Sanitation Concepts for Separate Treatment" (SCST), the Institute of Wastewater Management of the Hamburg University of Technology (TUHH) is investigating processes for the treatment of yellow water (urine) to recover resources in an industrial style.

The SCST demonstration project started in January 2003. The aim of the project is to find and investigate new sanitation concepts and treatment steps for separately collected urine, faeces and greywater.

The task "Yellow water treatment" was assigned to TUHH in September 2004. Herein several treatment possibilities for resource recovery from separately collected urine are investigated. The most promising processes for the reclamation of contained nutrients in urine are evaporation for volume reduction and content concentration -following nutrient extraction in form of crystallisation, and drying of residues of the evaporation-, steam stripping of ammonia from yellow water, and struvit precipitation. Additional processes, such as UVC-radiation and ozonisation will be used further elimination of micropollutants, such as pharmaceutical residues.

Realisation

For the set up of the demonstration units TUHH is able to use a well fitted place at the main wastewater treatment plant in Hamburg. The set up of the research container and the needed infrastructure is mainly completed. Currently two operation units are being assembled at the Klärwerk Köhlbrandhöft, Hamburg, one for urine evaporation, and a steam stripping system. The processes are planed to be started in the middle of April.

To gain as much experience as possible in each very individual process, beforehand, experiments at laboratory scale were conducted, respectively foregoing experiments were re-evaluated.

Current State

Site description:

The large scale processes evaporation of yellow water, and steam stripping of ammonia water from yellow water are placed right next to the sewage sludge de-watering and drying unit (KETA) of the main wastewater treatment plant of Hamburg at Köhlbrandhöft. Infrastructure with water, energy, and steam is provided by the Hamburg wastewater facility, Hamburger Stadtentwässerung (HSE).

For the evaporation unit and for storage of tools and supply a standard container was set up. As stand for the steam stripping reactor a four story scaffolding was erected.

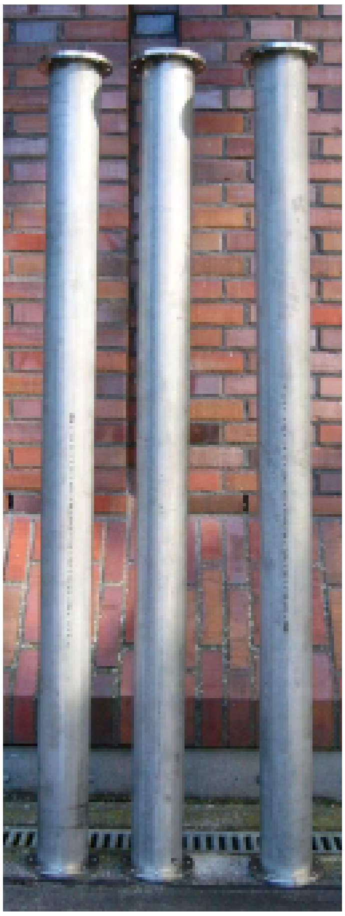
Three 1 m^3 big-packs are available at site and can be used for storage of untreated and treated urine.

Steam stripping unit:

The steal components for the steam stripping reactor were manufactured at the metal building shop at TUHH. The stripping tower, made of stainless steal, will be 5 m high, and can be segmented into 5 parts: 1x connecting piece for urine input and steam exhaust, 1x socket for depleted urine outlet and steam intake, and 3x reactor tubes.

The filling material for reaction surface extension is consisting in 15mm metal pall rings with a surface of 360 m^2/m^3, and a free volume of 95%.

Picture 1: connecting sockets and perforated plate



Picture 2: reactor tubes for steam stripping unit

For heat insulation mineral wool is used, protected by a cover of zinc plates.

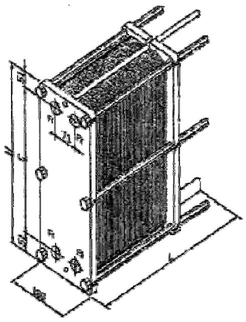
The stripping tower will be erected within the 4 story scaffolding.

Picture 3: 15 mm pall rings, filling for stripping unit

Heat exchange (he):

Because of the high salt concentration of urine and the possibility of precipitation at higher temperatures, a tube bundle heat exchanger is technically the best choice. Because of high expenditure in manufacturing tube bundle heat exchangers costs are too high for a demonstration project. Therefore a FeRo plate heat exchanging unit with 37 panels and a surface area of 2,94 m^2 will be used.

At an assumed temperature of 100°C from the depleted urine after steam stripping and a yielded final temperature of the depleted urine of 20°C untreated yellow water can be heated from 10°C starting temperature up to 95°C at the urine input into the stripping reactor. Thus, 10 kW of heat can be exchanged. At higher flow rates the heat transfer capacity of deployed heat exchange unit can be increase up to 30 kW.



Picture 4: FeRo plate heat exchanger

Energy, water, steam:

Electric energy and process water is provided by HSE. Steam is available at 6 bar and a temperature of 160°C. Measuring of the steam quantity will be conducted by volumetric measurement of the condensed off steam, and fraction comparison of the in- and outlet streams. Urine will be transported by a submersible slop pump.

Evaporation unit:

Because of shortage in manufacturing capacity and because of technical problems of the evaporation unit itself, this device could not be delivered, as of yet. The delivery date for a new evaporation unit is now scheduled at April 14th. The unit used in the beginning will be a Prowadest mini from KMU with a flow rate of 4 - 10 l/h and temperatures between 70 - 80°C at a pressure of approximately 300 mbar. The small unit will be used on a rental basis for 12 weeks.

Pre tests

Evaporation of yellow water:

B. Lindner investigated the potential of evaporation of yellow water for resource recovery in laboratory scale at TUHH in 2001.

At a complete evaporation of 1 l urine ~50 g of solid brown residue were obtained. Since the amount of total carbon is comparably high no crystal forming could be observed.

Picture 5: Concentrate and distillate from evaporation pre tests*

In an evaporation unit with a small downstream precipitation area 0.5 g of precipitate could be obtained within 5 h of evaporation of 1 l urine at an average temperature of 82°C and a pressure of approximately 970 mbar at an obtained concentration rate of 85 %.

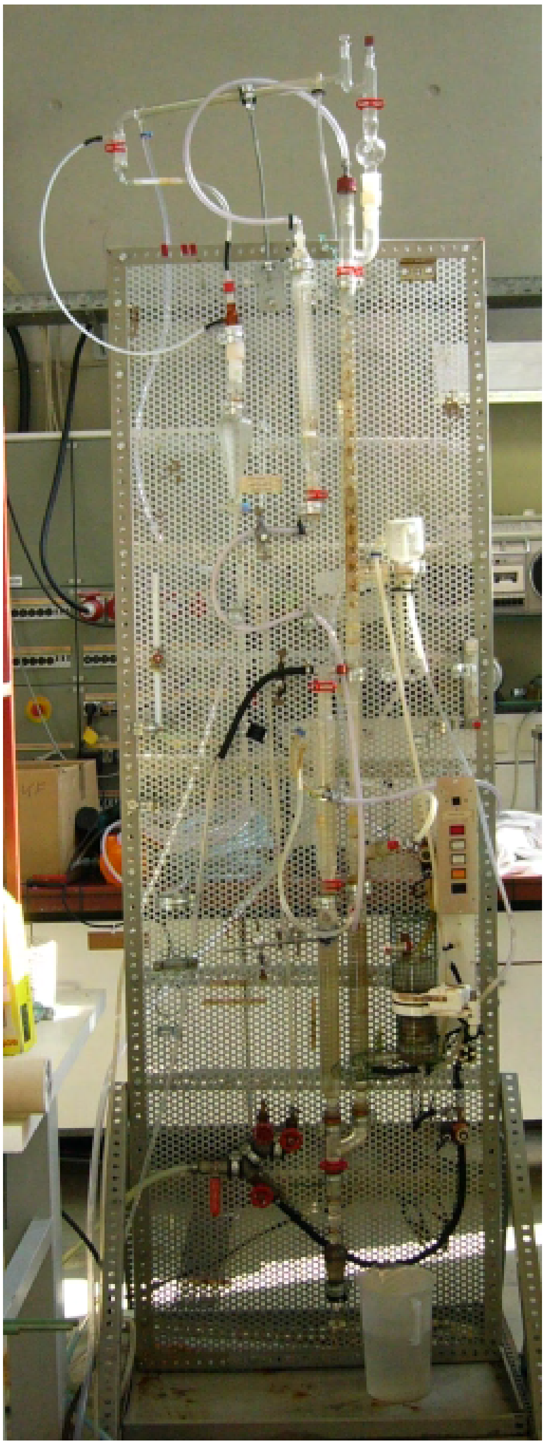
Compared to the untreated yellow water the distillate contained only 5% of the starting TN, 11% of P, and only 2% of the total organic fraction*.

Table 1: evaporation of yellow water, nutrient and carbon concentrations *

	TN [mg/l]	P [mg/l]	TC [mg/l]
starting sample	8.820	242	8.470
final concentrate	9.260	375	8.775
final distillate	490	48	200

The precipitate was not further analysed.

Aim of this thesis was not a maximum concentration rate, but to show the feasibility of the evaporation process on yellow water. With the appropriate techniques and adjustments, that are going to be applied in the current demonstration project, concentration- and precipitation rate will be optimised.



Picture 6: Steam stripping unit in laboratory scale

Ammonia stripping in laboratory scale:

A small steam stripping unit has been installed at TUHH and is being optimised towards ammonia extraction from yellow water. The operating data will be used at the large scale steam stripping process for progress enhancement.

Reactor volume of the small steam stripping unit is 2 l (h=1.5m, D=2.5cm, filled volume:2/3). Steam quantity can be adjusted between 0.2 and

* **Source:** B. Lindner (2001) "Bau und Inbetriebnahme einer Versuchsanlage zur Eindampfung von Gelbwasser als Technik zur direkten Wertstoffgewinnung in urbanen Gebieten", Diplomarbeit im Arbeitsbereich für kommunale und industrielle Abwasserwirtschaft, TUHH

0.9 kg/h. The volume of yellow water in the stripping reactor is 0.5 l.

During operation, the inflow of steam into the urine filled reactor caused a heavy foam production. Foam driven above the yellow water intake led to contamination of the condensed ammonia enriched steam. Thus no representative data could be collected, as of yet. In the small system no mechanical foam destruction device can be implemented. Thus a silicon based defoamer will be used, applied to the urine inlet and the upper part of the stripping unit.

Because of the larger cross section of the semi-technical stripping unit, the foam problematic might be reduced to some extend. But since substrate flow and steam volumes are also larger, additional foam destruction devices will be needed. Physical / mechanical solutions are favoured, to avoid addition of extra chemicals. Possibilities will be investigated throughout the running-time of the process.

Summery / Following tasks

The infrastructure for the semi-technical plants is prepared. Water, energy, and steam supply and the urine transport and holding capacities have been organised and are arranged.

The final set-up of the semi-technical plants is not completely finished, as of yet. This is mainly due to manufacturing/delivering problems. The evaporation unit could not be delivered until today. Manufacturing of the stripping reactor components took longer than estimated. To make use of the time of delay, a laboratory scale unit for a continuous ammonia stripping was build up, and is currently under investigation. Data from forgoing experiments regarding evaporation of yellow water were verified and re-evaluated.

However, the semi-technical stripping plant is ready for assembling. Offers for student work and masterthesis are published university-wide. First students are employed and will start their work by mid April.

At the project meeting in June '05 more detailed figures can be presented.

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Sanitation Concepts for Separate Treatment of Urine, Faeces and Greywater (SCST)

Task 8, Fertiliser usage

Intermediate Report 2005

Presented by: Dipl.- Ing. agr. A. Sasse, MSc NRM

Scientific Supervision: Prof. Dr. F. Ellmer

Intermediate Report 2005 SCST Task 8 – Fertiliser usage

Content:

Task 8 of the SCST Project is concerned with the fertilising effects of urine and faeces. Additionally, the acceptance of the application of these substances on agricultural sites is to be investigated. This report will present results from the first series of pot experiments with urine and inform about the current status of the field experiments.

Pot experiments 2004

Since May 2004, a series of pot experiments has been carried out to obtain information regarding the fertilising effects of urine. This was planned to give a first overview about what yield can be expected if Yellow Water (human urine and water) is used as fertiliser instead of conventional mineral fertiliser.

Yellow Water (urine and water) as collected at the sewage-works Stahnsdorf contains a distribution of nutrients in general suitable as fertiliser for many kinds of plants. The ratio of nitrogen : potassium : phosphorus is approximately 10:5:1. However, urine does not contain an optimum distribution of nutrients for all situations in agriculture as this is dependent on the soil nutrient status and also varies between the crops. It was decided these factors not to take into account to keep the experiment simple. To enable comparability, the conventional mineral fertiliser applied at the pot experiments contained the same amounts of total N, K and P as the Yellow Water. The yield limiting factor is nitrogen. However, while nitrogen in Yellow Water is mainly found in the form of ammonium, the mineral fertiliser contained both, ammonium and nitrate because it is used like this at practical conditions in conventional agriculture.

Fertiliser application was carried out in two spreadings, the first share was mixed into the soil during filling of the pots, the second halve was added during the main growing stage.

Each of the standardised (Mitscherlich) experimental pots contained 6.5 kg of soil from a silty sand site at Berlin/Dahlem representing a typical example of the light soils of Brandenburg. They were exposed to the weather but protected from birds.

All water used in the experiment was purified water do prevent additional nutrient intake from watering. During plant growth the soil moisture was kept between 60-80% water-capacity by daily watering.

Maize, spring wheat, oats and hemp were chosen for the pot experiment to cover a range of food, forage and non-food crops. The experiment was designed in 8 fertiliser treatments, 4 of urine and 4 of mineral fertiliser in steps of 0, 1, 2, 3 g total N per pot. Including 3 replications the total number of pots added up to 96. In the following, the results of each crop are presented.

Maize

In the beginning of June 2004, the pots were filled with soil and the fertiliser was added. Fife seeds of maize were sown and after establishment of the plants as necessary removed to reach the final number of 3 plants per pot. At the treatments with the highest dosage of Yellow Water the germination was observed 1 to 2 days later. However, no reduced or uneven germination could be observed at any of the variants. The second share of fertiliser was applied at the 23rd of July.

Figure 1 shows the plant development (height) during the growing period.

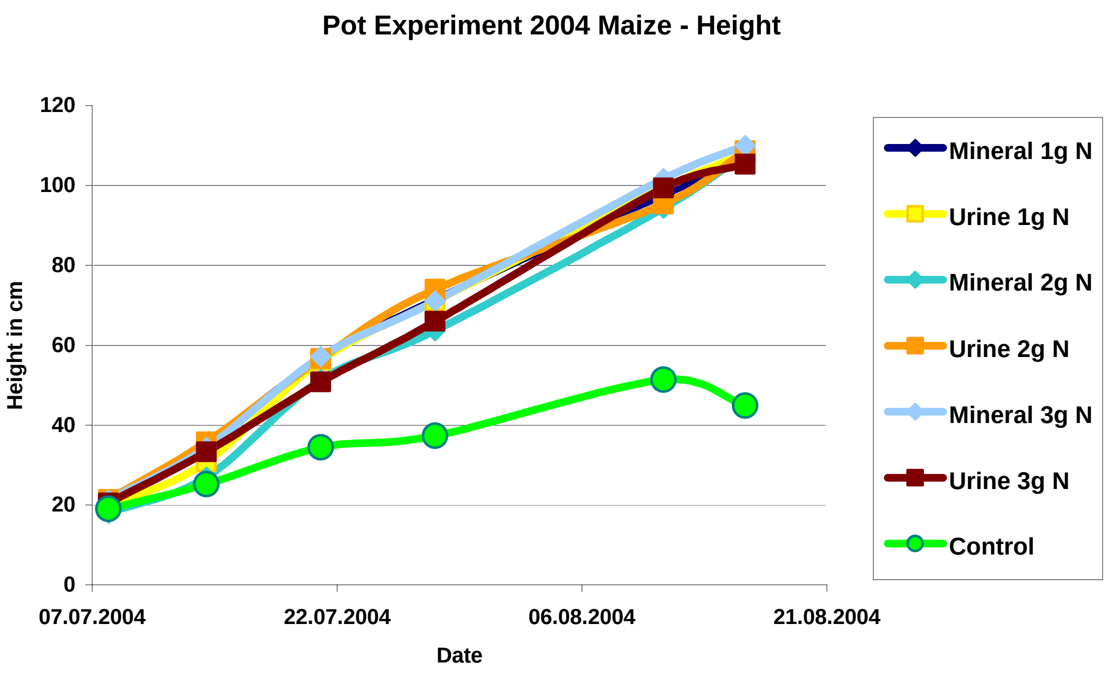


Figure 1: Height of maize during growing season

Apart from the zero-fertiliser treatment, the variants did not show significant differences in plant height at any time. A different development could be observed at the parameter plant colour. This can give evidence about the nutrient status of the plants. A higher number means darker colour and more chlorophyll per area unit. See the development of the leave colours as measured in different treatments at maize in figure 2.

As visible, the leave colour index was falling during the growing season. Obviously, the nutrient supply did not reach saturation, even at the highest nitrogen treatments. In tendency, the three Yellow Water treatments showed slightly less chlorophyll in the leaves as their corresponding mineral variants, a sign of less nitrogen in the plants.

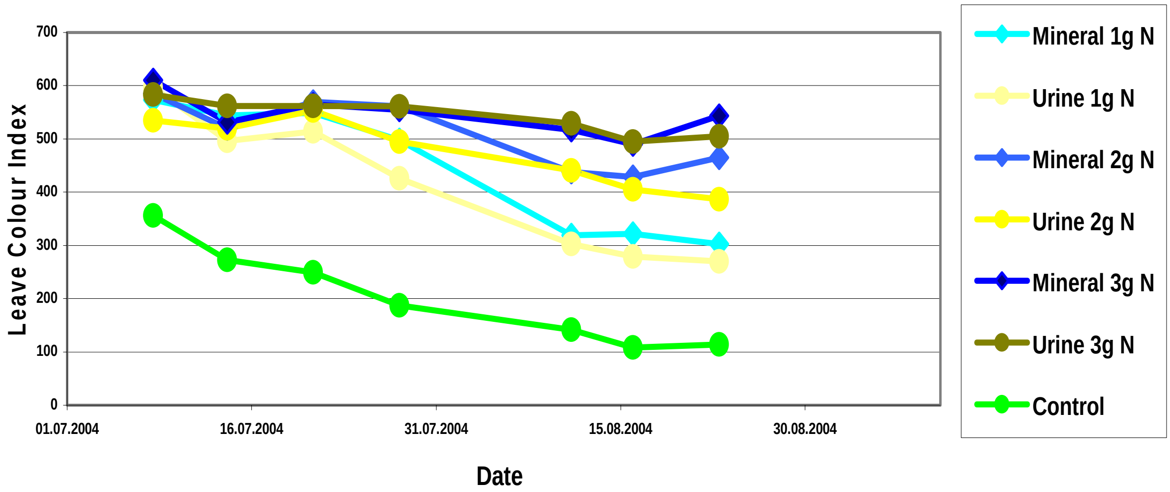


Figure 2: Leave colour of maize at the different treatments

A slight peek was evident after the second fertiliser application. The observed tendency was also clearly visible at the straw- and cob (spadix) yield. The urine treatments yielded only approx. 80-85% of the mineral fertilised variants, measured in Dry Matter. The difference in cob yield was observed to be higher than in straw. At the zero fertiliser treatment, the plants could uptake nutrients contained in the unfertilised soil only and therefore developed almost no maize cobs. See Table 1 and Figure 3 for yield results of maize cob and straw.

Table 1: Yield of Maize

Treatment	Dry Matter yield of straw in g/pot (Coeff. of variation)	Dry Matter yield of maize cob in g/pot (Coeff. of variation.)	Yield of straw + cob in % if Mineral 3g = 100%
Control	**21.1** **(11.7%)**	**4.9** **(10.0%)**	10.4%
Yellow Water 1g N	**86.6** **(13.8%)**	**35.3** **(7.6%)**	48.4%
Mineral 1g N	**100.0** **(0.3%)**	**51.0** **(3.8%)**	60.0%
Yellow Water 2g N	**109.1** **(12.7%)**	**63.7** **(26.1%)**	68.6%
Mineral 2g N	**120.2** **(3.3%)**	**92.3** **(2.7%)**	84,4%
Yellow Water 3g N	**126.1** **(8.9%)**	**77.3** **(18.0%)**	80.8%
Mineral 3g N	**129.7** **(4.2%)**	**122.0** **(12.8%)**	100%

Figure 3 presents the yield results in form of a graph. The difference in cob and straw yield is evenly evident in all tree dosages of nitrogen.

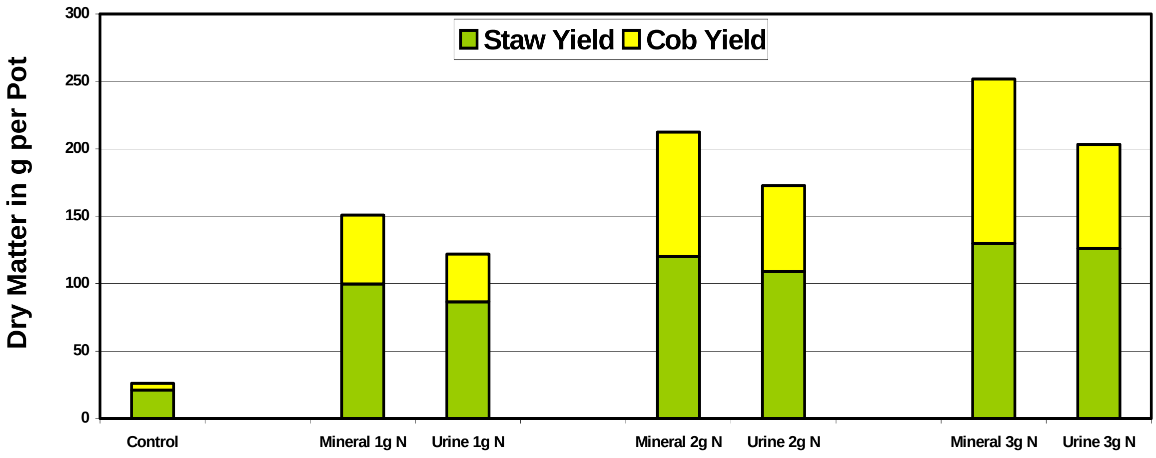


Figure 3: Yield of Maize

The application of 1g Nitrogen has the highest effect in terms of yield increase compared with the zero treatment. It is known, that yield increase due to fertiliser application does not raise linear but negative exponential. That explains why the surplus of yield per gram nitrogen decreases with increasing amounts of N.

Spring Wheat

Nine plants were established in each pot at the experiment with spring wheat. No differences in terms of germination time were observed between the treatments. The second fertiliser application followed also at the 23rd of July.

Apart from the non-fertilised control, the variants did not show significant differences in plant height during the growing period.

In terms of leave colour the following observation was made. As visible in Figure 4, the leave colour index was raising during the whole of the growing period. This can be taken as a sign for an almost continuing decrease of chlorophyll per area in the green plants. An exception was found at the 1g N urine treatment. Here, the colour index stays nearly at the same level with slight changes.

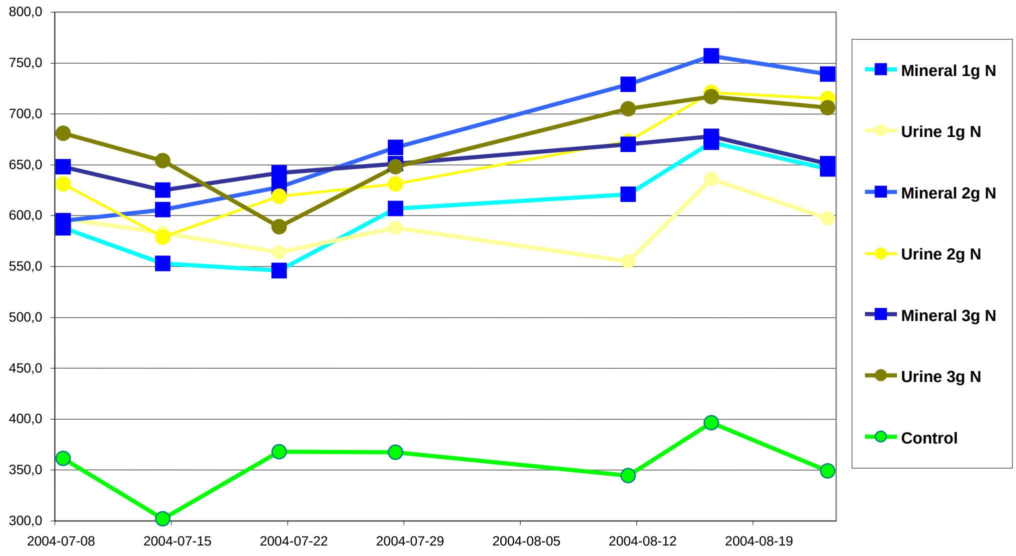


Figure 4: Leave Colour of Spring Wheat

Spring wheat did show the following results in terms of yield: Higher dosages of nitrogen did not automatically lead to increasing yield. In comparison to maize, the nutrient uptake and use per pot is lower in spring wheat due to morphological limitations. The potential yield is lower. As evident in Figure 5, the surplus of nutrients between the 2g and 3g variants could not be converted into a surplus of biomass anymore. Nutrient saturation was reached. In the case of the 3g N urine treatment, the higher amount of nutrients affected the plants even in a negative way. A slightly higher yield was obtained with only 2g nitrogen per pot from Yellow Water.

Table 2: Yield of Spring Wheat

Treatment	Dry Matter yield of straw in g/pot (Coeff. of variation)	Dry Matter yield of spike in g/pot (Coeff. of variation.)	Yield of straw + spike in % if Mineral 3g = 100%
Control	**8.7** **(3.0%)**	**6.7** **(7.4%)**	24.3%
Yellow Water 1g N	**20.9** **(3.9%)**	**32.1** **(4.3%)**	86.8%
Mineral 1g N	**22.7** **(3.8%)**	**30.8** **(6.4%)**	87.6%
Yellow Water 2g N	**23.7** **(6.6%)**	**38.1** **(26.0%)**	101.1%
Mineral 2g N	**25.2** **(5.1%)**	**35.5** **(10.7%)**	99.4%
Yellow Water 3g N	**21.2** **(3.4%)**	**24.3** **(21.2%)**	74.5%
Mineral 3g N	**25.8** **(5.0%)**	**35.3** **(34.3%)**	100%

Compared to maize, the yields did not follow a clear tendency. At the 1g treatments, Yellow Water showed a slightly lower yield in straw and ears. At the 2g treatments, the reverse was the case. The greatest difference could be observed at the 3g treatments. However, an explanation for this phenomenon cannot easily be found.

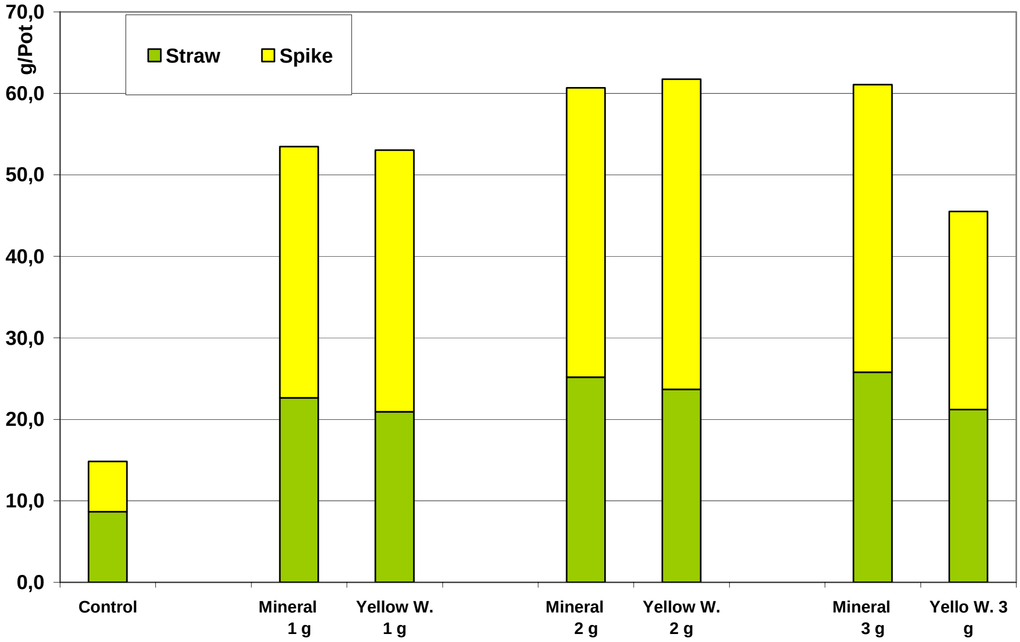


Figure 5: Yield of Spring Wheat

As visible in Figure 5, the difference in yield is greater in spikes (ears) than in straw. If only the straw yield would be taken into account, a clear tendency could be described: The straw yield of the Yellow Water fertilised treatments accounts for 82-94 % of the corresponding mineral variants.

Oats

Due to germination difficulties of Hemp, the pots intended to be used for it were planted with Oats. Despite not initially planned, the investigations at the 24 pots were carried out in the same way as at the other crops.

Table 3: Yield of Oats

Treatment	Dry Matter yield of straw in g/pot (Coeff. of variation)	Dry Matter yield of spike in g/pot (Coeff. of variation.)	Yield of straw + spike in % if Mineral 3g = 100%
Control	**8.2 (5.3%)**	**5.2 (20.6%)**	26.9%
Yellow Water 1g N	**22.9 (10.9%)**	**27.6 (24.9%)**	101.6%
Mineral 1g N	**26.7 (9.0%)**	**27.7 (10.1%)**	109.5%
Yellow Water 2g N	**25.1 (7.0%)**	**31.7 (20.9%)**	114.4%
Mineral 2g N	**28.5 (6.8%)**	**29.5 (26.9%)**	116.8%
Yellow Water 3g N	**25.1 (10.0%)**	**15.7 (38.6%)**	82.1%
Mineral 3g N	**26.6 (3.4%)**	**23.1 (55.4%)**	100%

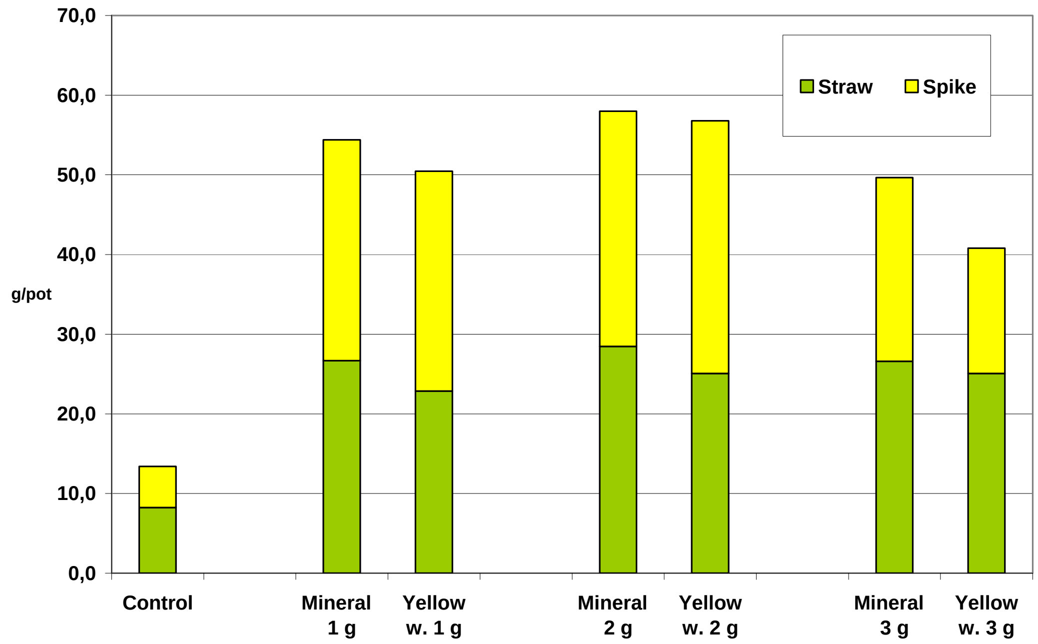


Figure 5: Yield of Oats

Similar to Spring Wheat, the straw yields did show a clear tendency of slightly lower values at the corresponding Yellow Water treatments compared to the mineral ones. In terms of spike yield this observation cannot be shared. (Figure 5 and Table 3) The 3g treatments show a strong decrease in yield compared to the 2g variants. This also suggests that nutrient saturation was reached and the nutrient supply tended to be toxic at the 3g treatments. However, other factors than the nutrient supply alone have to be considered because Oats as well as Spring Wheat did show the strongest decrease of yield at the 3g Yellow Water treatment. One possible explanation might be that nitrogen in Yellow Water exists mainly in the form of ammonium which leads, if fertilised, to a near-term but strong change of the pH-value in the soil. This might have an impact on the growth. Here, further investigations are necessary.

Hemp

As already mentioned, germination problems at the hemp were observed. Hemp did show a very low germination capacity when sown directly into the pots at all variants. Because of that, all plants needed to be cultivated in a greenhouse and were transplanted into the pots after two weeks which was in the beginning of July 2004. The plants of the 3g Yellow Water treatment could not cope with the amount of urine and died shortly after the first fertiliser dosage. Unfortunately, no final yield data could be received from the experiment as the plants were lost by theft. The cultivated variety was one with low THC-content which could obviously not bee seen at the first view.

During the winter 2004/2005 the experiment was repeated in the greenhouse. It did not quite show the same effects as the plants at the 3g Yellow Water treatment developed much better. Apart from the temperature, the conditions of the experiment were not changed. At the second experiment temperature varied between 10 and 20 degree Celsius while the first experiment was carried out at high summer temperatures of more than 30 degrees Celsius at daytime. The nutrient uptake might have been higher in the summer leading to lethal nutrient concentrations in the plants. Yield results from the second experiment are presented in Table 4 and Figure 6.

Table 4: Yield of Hemp

Treatment	Dry Matter yield per pot in g	In % if M 3g =100%
Control	7.8	15.3
Yellow Water 1g N	41.1	80.44
Mineral 1g N	42.6	83.31
Yellow Water 2g N	42.4	82.9
Mineral 2g N	55.8	109.3
Yellow Water 3g N	21.2	41.4
Mineral 3g N	51.1	100

The yield results of the second experiment with hemp draw a comparable picture to the results derived from the experiments with Spring Wheat and Oats. In any case, the yield derived from Yellow Water is lower than the corresponding mineral treatment. Apart from the unfertilised control, the lowest yield was reached in the 3g Yellow Water treatments. Possible reasons have been mentioned already.

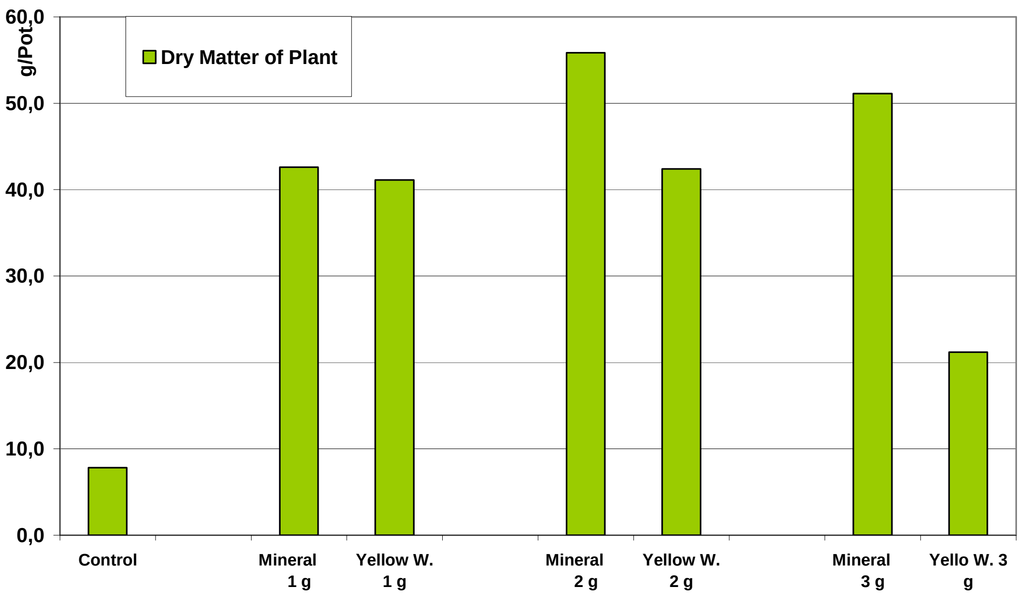


Figure 6: Yield of 2. Hemp Experiment

Conclusion

At the described experiments Yellow Water did show a fertilising effect on Maize, Spring Wheat, Oats and Hemp. Compared with mineral variants the effect could be found in the region of 50 to 90% if the same total amount of nutrients is applied. Lower fertilising effects have been observed at the 3g Yellow Water treatments at Spring Wheat, Oats and Hemp. At this variants the high urine concentration had obviously also a toxic effect. If the nutrient supply is not too high 80-95% of the nutrients of Yellow Water could be converted into yield compared with conventional mineral fertiliser. However, due to their controlled environment conditions pot experiments can only give guidelines of what yields can be expected at field conditions. Data which can be used to give final recommendations for the practical implementation of urine as fertiliser can only be obtained from field experiments.

Status field experiments

Fife field experiments have been established since August 2004 with oilseed rape and winter rye as well as since march 2005 with spring wheat, fibre flax and maize. The fields are located at the experimental field station of the Humboldt University of Berlin in Dahlem. Each of the fields covers an area of approximately 600 m². The winter crops were fertilised with Yellow Water and the spring crops with both, Yellow Water and faeces. Each field includes Yellow Water and mineral fertiliser treatments of 50kg, 100 kg and 150kg nitrogen / ha as well as an unfertilised control. With four replications the total number of parcels per crop adds up to 32. The plants developed well, however, until now off cause no data in terms of yield could be obtained.

The soil biological activity is considered to be an indicator for potential land management problems e.g. the impact of harmful substances. To test this, the population of earthworms has been assessed at 12 parcels in winter rye. Including two replications, 24 portions of soil (1/8 m², depth of 20) cm were taken off and searched for earthworms and their cocoons. The final results from that experiment will be obtained in autumn after a further replication.

The fertilising is accompanied by measurements of ammonia gas fluxes which are still continuing.

Pictures from the experiments

Picture 1: Pot experiments in August 2004

Picture 2: Second pot experiment with Hemp in the greenhouse

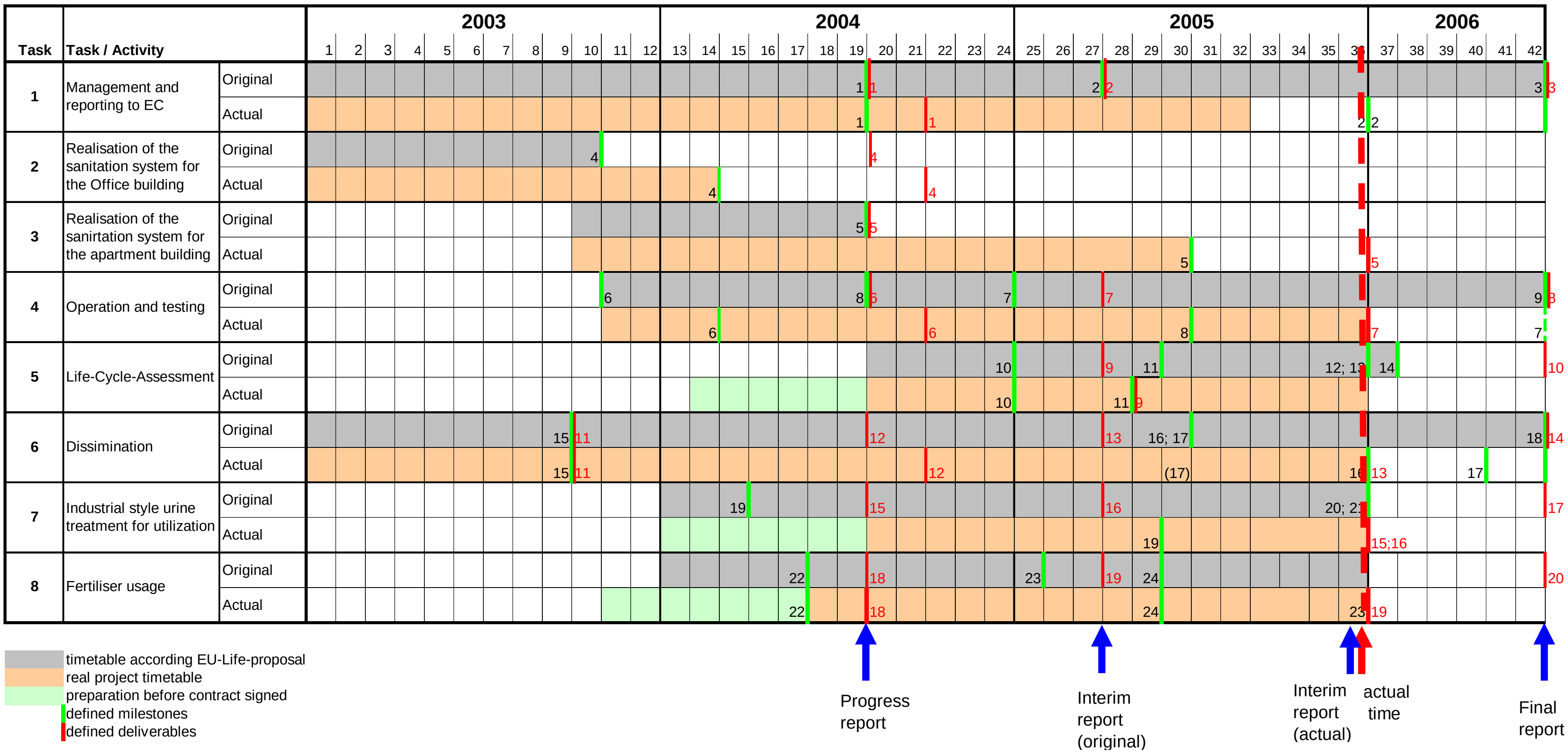
Picture 3: Pot experiment close to harvest in October 04

Picture 4: Experimental field with oilseed rape in September 04


Picture 5: Experimental Field with Spring Wheat in June 05


Picture 6: Searching for earthworms in May 2005

Annex 7.1 SCST-Demonstration project Gantt-Chart



Annex 7.1 SCST-Demonstration project Gantt-Chart

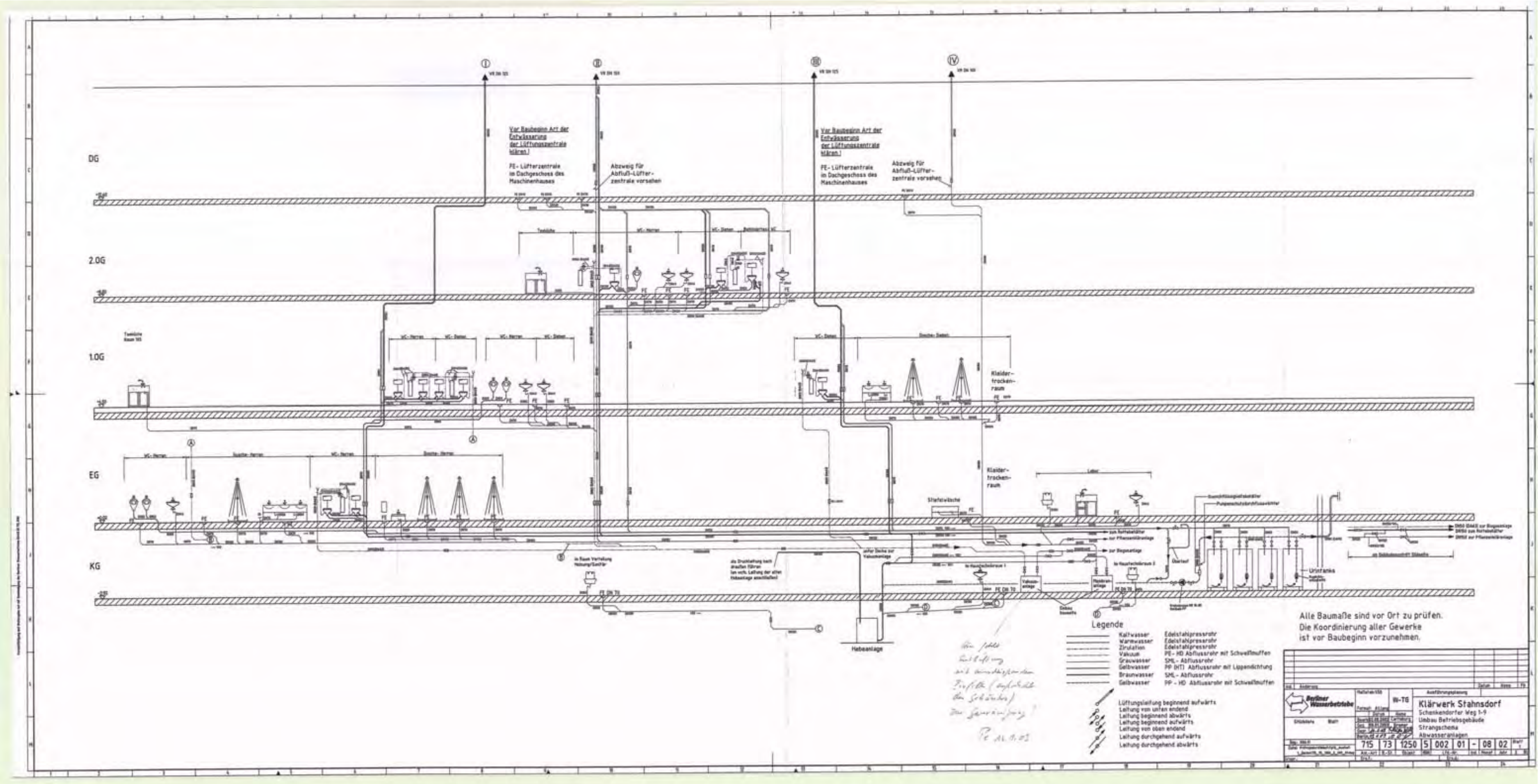
milestone No.	description
1	progress report
2	interim report
3	final report
4	complete installation of the equipment for the new sanitation concept with gravity-separartion-toilets
5	complete installation of the equipment for the new sanitation concept with vacuum-separation-toilets
6	start up of the new sanitation concept with gravity-separation-toilets
7	end of testing of the new sanitation concept with gravity-separation-toilets
8	start up of the new sanitation concept with vacuum-separation-toilets
9	end of testing of the new sanitation concept with vacuum-separation-toilets
10	collection of construction phase data completed
11	material- and energy-flux-analysis of SCST and conventional system completed
12	impact assessment of LCA completed
13	sensitivity analysis completed
14	decision support method for choice of optimal wastewater system completed
15	installation of an internet page, installation of links to the SCST-page
16	1st CD-ROM with description of the demonstration project, first results and presentation is available
17	realisation of a project workshop
18	2nd CD-ROM with description of the demonstration project, results and presentation including workshop is available
19	start up of production unit on a semi-technical scale
20	end of the opertaion of the semi-tachnical production unit
21	results of the evaluation of the experiments
22	fertiliser experiment 1 started
23	attitude study 1 finished
24	fertilser experiment 2 started

Annex 7.1 SCST-Demonstration project Gantt-Chart

deliverables No.	description
1	progress report
2	interim report
3	final report
4	Project plans for the office building, evidence of the office building sanitation system due to invoice of sanitation and construction enterprises and photos of the sanitation system of the office building (part of the progress report from Task 1)
5	Project plans for the apartment building, evidence of the apartment building sanitation system due to invoice of sanitation and construction enterprises and photos of the sanitation system of the apartment building (part of the progress report from Task 1)
6	First important results about the different investigation phases with the gravity separation toilets (part of the progress report from Task 1)
7	New important results about the different investigation phases with the gravity and vacuum separation toilets (part of the interim report from Task 1)
8	Important results about the different investigation phases with the gravity and vacuum separation toilets including operation concepts (part of the final report from Task 1)
9	Literature survey, material flow analysis and LCA of construction phase. Comparison with conventional system (part of the interim report from Task 1)
10	Integrated LCA of construction and operation of SCST and conventional system. Identification of relevant aspects for ecological assessment and transfer into a generally applicable decision support method (part of the final report from Task 1)
11	Information about the web address
12	Report about all dissemination activities like presentations and publications of the demonstration project (part of the progress report from Task 1)
13	Report about all dissemination activities like presentations and publications of the demonstration project including the 1st CD-ROM (part of the interim report from Task 1)
14	Report about all dissemination activities like presentations and publications of the demonstration project including the 2nd CD-ROM (part of the final report from Task 1)
15	Report including the first qualitative and quantitative figures about the produced fertilisers (part of the progress report from Task 1)
16	Report including the most qualitative and quantitative figures about the produced fertilisers (part of the Interim report from Task 1)
17	Report including models for a specific industry and knowledge about feasible scales and process combinations (part of the final report from Task 1)
18	Report including the first documentation about the effect on corn yield due to different fertilisers (part of the progress report from Task 1)
19	Report including the documentation about the effect on corn yield due to different fertilisers from the first year (part of the interim report from Task 1)
20	Report including fertilising recommendations and information which enables constructive handling of obstacles related to the acceptance in the agricultural sector and among consumers to fertilisation with urine and faeces derived products (part of the final report from Task 1)

Annex 7.1 SCST-Demonstration project Gantt-Chart

Annex 7.2 **Project drawings sanitation system of the office building**



Line scheme of the sanitation system inside the office building

Annex 7.2 Project drawings sanitation system of the office building

DRAWING LISTING OF THE SANITATION FACILITIES INSIDE THE OFFICE BUILDING

1 Wastewater treatment plant Stahnsdorf, SCST-project,
Floor plan of the office building basement
No. 715 73 1250 001 01-08 02

2 Wastewater treatment plant Stahnsdorf, SCST-project,
Floor plan of the office building ground floor
No. 715 73 1250 001 02-06 02

3 Wastewater treatment plant Stahnsdorf, SCST-project,
Floor plan of the office building first floor
No. 715 73 1250 001 03-06 02

4 Wastewater treatment plant Stahnsdorf, SCST-project,
Floor plan of the office building second floor
No. 715 73 1250 001 04-06 02

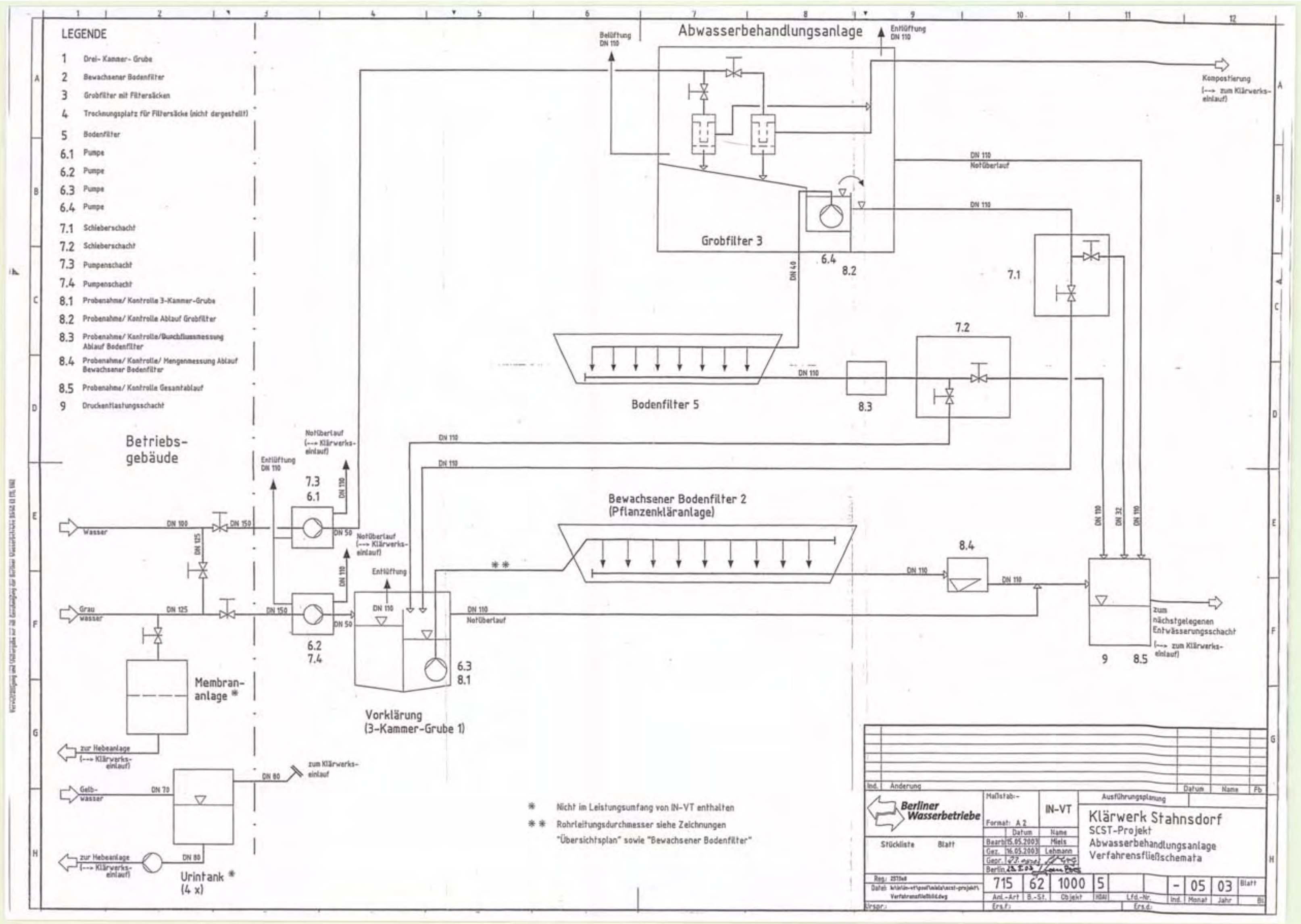
5 Wastewater treatment plant Stahnsdorf, SCST-project,
Floor plan of the office building attic floor
No. 715 73 1250 002 02-08 02

6 Wastewater treatment plant Stahnsdorf, SCST-project,
Line scheme of the sanitation system of the office building
No. 715 73 1250 002 01-08 02

7 Wastewater treatment plant Stahnsdorf, SCST-project,
Line scheme of the drinking water system of the office building
No. 715 73 1250 001 05-06 02

8 Wastewater treatment plant Stahnsdorf, SCST-project,
Urine tank plant
No. 715 73 1250 001 06-09 02

Annex 7.2 Project drawings of the office building sanitation system



Flow charts of the outside treatment units

Annex 7.2 Project drawings of the office building sanitation system

DRAWING LISTING OF THE OUTSIDE TREATMENT UNITS FOR THE OFFICE BUILDING

1 Wastewater treatment plant Stahnsdorf, SCST-project,
Wastewater treatment units, *overview site plan*
Nr. 715 62 1810 5 001 01

2 Wastewater treatment plant Stahnsdorf, SCST-project,
Wastewater treatment units, *basic flowsheet*
Nr. 715 62 1810 5 001 09

3 Wastewater treatment plant Stahnsdorf, SCST-project,
Wastewater treatment units, *unit operation flowsheet*
Nr. 715 62 1810 5 001 03

4 Wastewater treatment plant Stahnsdorf, SCST-project,
Wastewater treatment units, *site plan*
Nr. 715 62 1810 5 001 02

5 Wastewater treatment plant Stahnsdorf, SCST-project,
Wastewater treatment units, *longitudinal section*
Nr. 715 62 1810 5 001 04

6 Wastewater treatment plant Stahnsdorf, SCST-project,
Wastewater treatment units, *septic tank*
Nr. 715 62 1810 5 001 05

7 Wastewater treatment plant Stahnsdorf, SCST-project,
Wastewater treatment units, *constructed wetland*
Nr. 715 62 1810 5 001 06

8 Wastewater treatment plant Stahnsdorf, SCST-project,
Wastewater treatment units, *compost separator*
Nr. 715 62 1810 5 001 07

9 Wastewater treatment plant Stahnsdorf, SCST-project,
Wastewater treatment units, *soil filter*
Nr. 715 62 1810 5 001 08

Annex 7.3 Project drawings of the apartment building sanitation system

DRAWING LISTING OF THE SANITATION FACILITIES INSIDE THE APARTMENT BUILDING

1 Wastewater treatment plant Stahnsdorf, SCST-project,
Floor plan of the basement north wing of the apartment house
No. 880 72 0000 027 05

2 Wastewater treatment plant Stahnsdorf, SCST-project,
Floor plan of flat G ground floor of the apartment house
No. 880 72 0000 027 06

3 Wastewater treatment plant Stahnsdorf, SCST-project,
Floor plan of flat F first floor of the apartment house
No. 880 72 0000 027 07

4 Wastewater treatment plant Stahnsdorf, SCST-project,
Floor plan of flat E ground floor of the apartment house
No. 880 72 0000 027 08

5 Wastewater treatment plant Stahnsdorf, SCST-project,
Floor plan of flat first floor of the apartment house
No. 880 72 0000 027 09

6 Wastewater treatment plant Stahnsdorf, SCST-project,
Floor plan of the basement south wing of the apartment house
No. 880 72 0000 027 10

7 Wastewater treatment plant Stahnsdorf, SCST-project,
Floor plan of flat I ground floor of the apartment house
No. 880 72 0000 027 11

8 Wastewater treatment plant Stahnsdorf, SCST-project,
Floor plan of flat H first floor of the apartment house
No. 880 72 0000 027 12

9 Wastewater treatment plant Stahnsdorf, SCST-project,
Floor plan of flat K ground floor of the apartment house
No. 880 72 0000 027 13

10 Wastewater treatment plant Stahnsdorf, SCST-project,
Floor plan of flat J first floor of the apartment house
No. 880 72 0000 027 14

11 Wastewater treatment plant Stahnsdorf, SCST-project,
Floor plan of flat M basement of the apartment house
No. 880 72 0000 027 15

12 Wastewater treatment plant Stahnsdorf, SCST-project,
Floor plan of flat L first floor of the apartment house
No. 880 72 0000 027 16

Annex 7.3 Project drawings of the apartment building sanitation system

13 Wastewater treatment plant Stahnsdorf, SCST-project,
Line scheme of flats I/H the apartment house
No. 880 72 0000 027 17

14 Wastewater treatment plant Stahnsdorf, SCST-project,
Line scheme of flats K/J the apartment house
No. 880 72 0000 027 18

15 Wastewater treatment plant Stahnsdorf, SCST-project,
Line scheme of flats M/L the apartment house
No. 880 72 0000 027 19

16 Wastewater treatment plant Stahnsdorf, SCST-project,
Line scheme of flats G/F the apartment house
No. 880 72 0000 027 20

17 Wastewater treatment plant Stahnsdorf, SCST-project,
Line scheme of flats E the apartment house
No. 880 72 0000 027 21

EU-Demonstration project

Sanitation Concepts for Separate Treatment of Urine, Faeces and Grey water (SCST) – First results

Reporting period
11 March 2004 to 31 July 2005

written by

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December 2005

This demonstration project is being co-financed in the framework of the LIFE programme of the European Commission (LIFE03 ENV/D/000025)

1 Introduction

Within the SCST-Project (Sanitation Concepts for Separate Treatment of Urine, Faeces and Grey water) the demonstration of different sanitation concepts in the buildings of the WWTP Stahnsdorf as alternatives to conventional sanitation systems is intended. In these new sanitation concepts gravity as well as vacuum separation toilets and waterless urinals are in use. The different flows separated at their source are treated according their composition and volume and led back into the water and nutrient cycle as far as possible. For a better understanding the different flows are described in **Tab. 1.1** very briefly:

Tab. 1.1: Description of the different volumes

	Description	Source	Volume	Organic load (BOD, COD)	Nutrients (N,P,K)
grey water	Wastewater without faeces and urine	Shower, Washing basins	+	o	-
brown water	Faeces with flushing water	Separation toilets	-	+	o
yellow water	Urine	Separation toilets and waterless urinals	-	-	+
Explanation: + much	o medium	- little			

With the experience from this demonstration project the knowledge of new sanitation concepts should be enhanced significantly. Experiences regarding design, installation, operation, costs and user acceptance should be collected. Apart from functionality and reliability of the demonstration plant, cleaning efficiency of the connected treatment units is also of great interest.

This project is supported by the European Union (LIFE03 ENV/D/000025).

2 Materials and Methods

2.1 General Concepts

The new sanitation concepts have been realised in existing buildings (office building and apartment house) on the area of the Stahnsdorf WWTP (**Fig. 2.1.1**) owned and operated by the Berliner Wasserbetriebe. The general process scheme used in the EU-proposal can be seen in **Fig. 2.1.2**.

The main sanitation facilities in the office building are gravity separation toilets (Roediger, 2001) and waterless urinals from different suppliers. The faeces and flushing water (brown water) are discharged by gravity and drained in a compost separator (in the following the unit is named faeces separator). The faeces will be treated afterwards by composting. The filtrate from the faeces separator flows through a soil filter and will be mixed up with the pre settled grey water. Grey water is settled in a septic tank before treated in a constructed wetland. In parallel to the constructed wetland a membrane bioreactor is also be tested for grey water treatment. Urine flows into storage tanks. Different methods will be tested for handling and treatment of urine before using it as fertiliser. The methods are storage, vacuum evaporation, steam stripping, precipitation, ozonation, UV-irradiation and different combinations of these processes.

Fig. 2.1.1: Aerial view of WWTP Stahnsdorf and SCST-project site

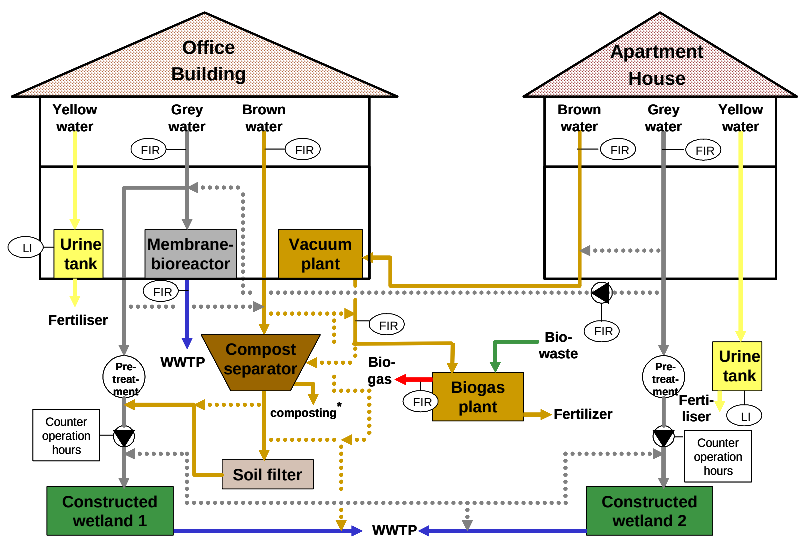


Fig. 2.1.2: New sanitation concepts with *gravity* separation toilets in the office building and with *vacuum* separation toilets in the apartment house of the WWTP Stahnsdorf

For the new sanitation concept for the apartment house vacuum separation toilets were taken into consid-eration. Here urine and grey water are discharged and transported by gravity, while faeces are transported by a vacuum sewer system. Urine will be treated as mentioned above. Due to the low dilution faeces will be digested together with bio-waste. Digested sludge is also a fertiliser in general, e.g. for farmlands. Biogas can be used either in gas cookers or in a combined heat and power unit (CHPU). This topic will not be tested in this project. Grey water passes like in the case of the office building through a sedimentation tank before its treatment in a constructed wetland. Since dish washing powders have a high content of phosphate (often more than 30 %) and dishwashing machines are more and more common, for both concepts a phosphate precipitation could also be necessary during grey water treatment. After the treatment grey water can be used e.g. for irrigation in general. In this project the effluent of the membrane bioreactor will be investigated with respect to the different options of re-use as water with a lower quality than drinking water.

These two sanitation concepts are technical options belonging to the new approach, others are possible, e.g. composting of the faeces together with bio-waste if a production of biogas doesn't be suitable. The type of grey water treatment has also to be adapted to the local conditions. For large settlements an activated sludge tank or a technical bio-film system etc. could be a more appropriate solution than a constructed wetland. The size of an activated sludge tank for grey water treatment could be however much smaller than for municipal wastewater treatment due to the much lower COD, nitrogen and suspended solids loads (Otterpohl 2001).

As mentioned above vacuum separation toilets have been considered initially for the apartment house in which only 10 flats instead of 15 will be integrated in the new sanitation concept. Meanwhile, since vacuum separation toilets are still not available on the market, the concept has been changed: the longer experienced gravity separation toilets will be used instead. Until now only vacuum separation toilets are available from the company Roediger, which are modified gravity separation toilets. At the moment these toilets are on the prototype level for the demonstration of the feasibility. This fact was the deciding factor for the changing of the concept: the vacuum separation toilets will be installed in the office building and the flats in the apartment house will be equipped with the gravity separation toilets. For the office building this is possible since a vacuum system is also installed in addition to the gravity system in this building. To change the concept only gravity separation toilets have to be replaced against vacuum separation toilets. For the operation of these two sanitation concepts different variants have been foreseen for which additional pipes were necessary (see **Fig. 2.1.2**).

2.2 Variants

The variants (V) including the main interests which were chosen in the EU-proposal are shown below.

V1 (With soil filter): Effectiveness of source separation (nutrient in urine); Composition of the different flows (effectiveness of source separation); Effectiveness of faeces separator (quality of raw material for composting); Quality of compost; Effectiveness of pathogens reduction of soil filter; Effectiveness of grey water treatment in constructed wetland.

V2 (Without soil filter): Effectiveness of constructed wetland compared to V1.(Remark: the words "soil filter" in front of "compared to V1" as written in the EU-proposal had to be deleted since it does not make any sense.)

V3 (Grey- and brown water mixture and with soil filter): Common treatment of the mixture grey water and brown water in faeces separator/soil filter.

V4 (Grey- and brown water mixture and without soil filter): Effectiveness of constructed wetland compared to V2.

V5 (With membrane biology): Effectiveness of grey water treatment in membrane biology with the purpose of water reuse.

V6 (With digester): Effectiveness of the digestion of brown water collected and transported by vacuum in a digester together with bio waste; Digester performance: organic matter reduction, gas production, pathogen reduction, impact of bio waste reduction; Quality of liquid fertiliser; operation experience with vacuum transport systems.

V7 (Membrane biology with grey water from apartments): Effectiveness of digestion like V6; Effectiveness of grey water treatment of the apartments in the membrane biology.

V8 (Faeces from office building via vacuum and composting): Impact of vacuum collection and transport of brown water on the process in the faeces separator.

2.3 Tested variants until July 2005

A general timetable of the different operation conditions is given in **Fig. 2.3.2**. Details are described below.

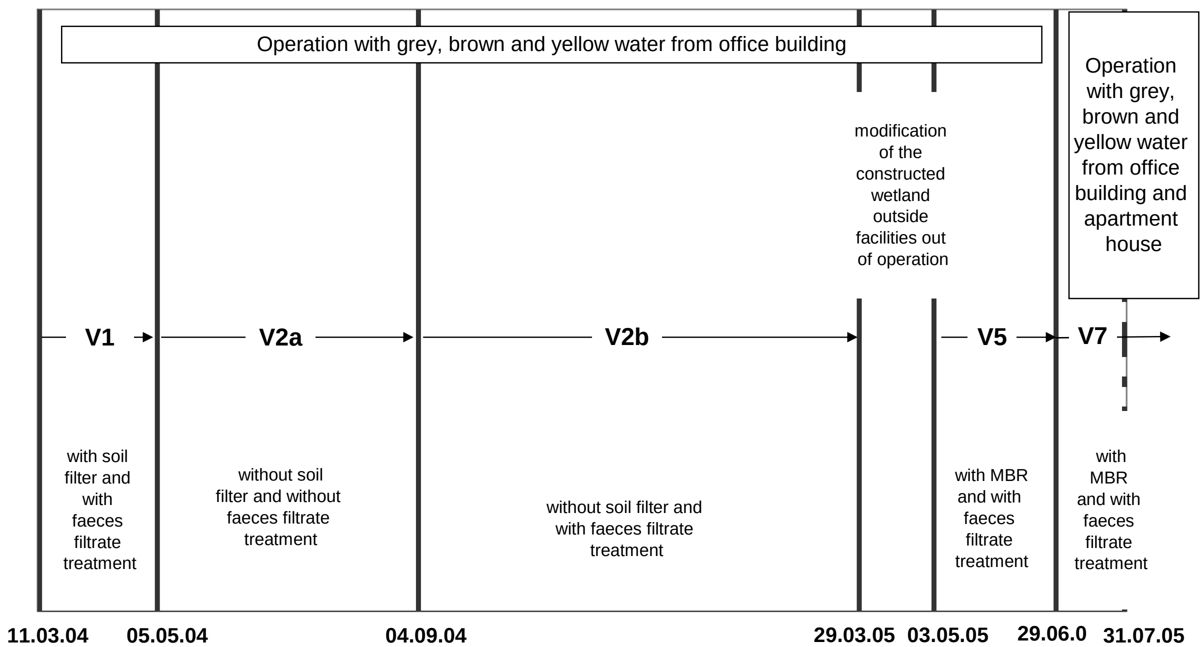


Fig. 2.3.2: Tested variants (V)

The operation of nine gravity separation toilets and one vacuum separation toilet started in October and December 2003, the operation of the treatment started in March 2004 with the first variant:

Variant V1.

The flow scheme of this variant is shown in **Fig. 2.3.3**.

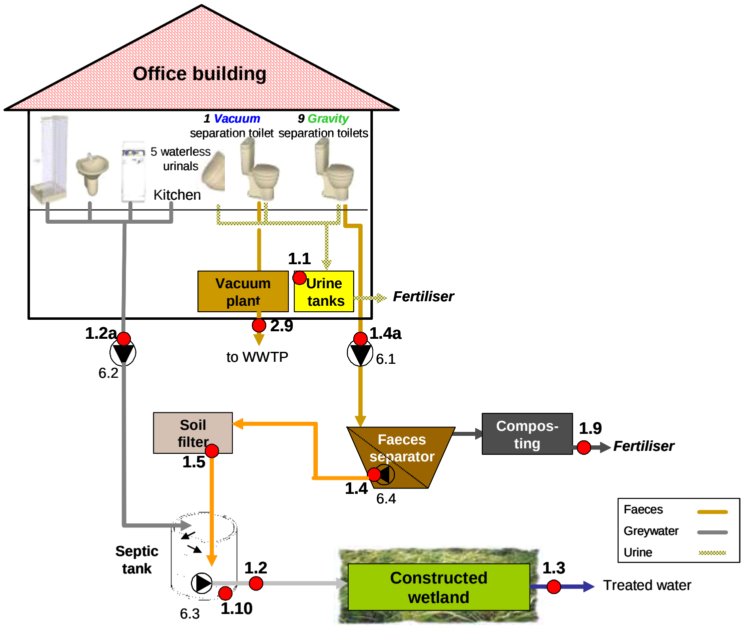


Fig. 2.3.3: Flow scheme of *Variant V1* (with soil filter)

This variant has been operated from 11 March until 4 May 2004.

The grey water from showers, wash basins, kitchen including dish washing machines and from the laboratory of the Stahnsdorf WWTP was discharging by gravity into a pit outside of the office building. From this pit it was pumped by means of a cutting pump (6.2) into the first chamber of the two-chamber septic tank (see 2.4.9). The pre-settled grey water was pumped (6.3) to the constructed wetland (see 2.4.10). The biologically treated grey water flew into an effluent pit and at least into the influent of the Stahnsdorf WWTP since no permission for discharging into the receiving water was applied.

The urine from nine gravity separation toilets and one vacuum separation toilet as well from the five waterless urinals flow by gravity into the urine tanks (see 2.4.4) where it has been stored without pH-adjusting.

The brown water from the vacuum separation toilet was sucked by a vacuum plant (see 2.4.3) which is installed in the cellar rooms of the office building. From this vacuum plant the brown water was pumped into the WWTP until a biogas plant is available for its treatment (Probably starting in January 2006). It has to be mention that this first vacuum separation toilet, which is an altered gravity separation toilet (see 2.4.1), has been installed in December 2003 just for testing purposes.

The brown water including flush water from the nine gravity separation toilets and also the flush water from flushing the toilet bowls after urinating have been discharged by gravity into the pit in front of the office building. From this pit the brown water was pumped by means of a cutting pump (6.1) into the faeces separator (see 2.4.6) for dewatering and storage. The filtrate was pumped to the soil filter (see 2.4.8) for removing particles and pathogenic germs before it flows by gravity to the pump chamber of the septic tank where it was mixed up with the pre-settled grey water.

The main interest of investigations for this variant is mentioned in the description of V1 in chapter 2.2.

Because of the high concentration of suspended solids (SS approx. 300 mg/l) in the brown water the operation of the soil filter became very difficult. After a few weeks it was blocked and was taken out of operation on 4 May 2004. With this day the *Variant V2* started. This variant had to be divided into sub-variants V2a and V2b which were not mentioned in the EU-Proposal. The reason for this was the installation of the equipments at different times.

Variant V2a

The flow scheme of this variant is shown in **Fig. 2.3.4**.

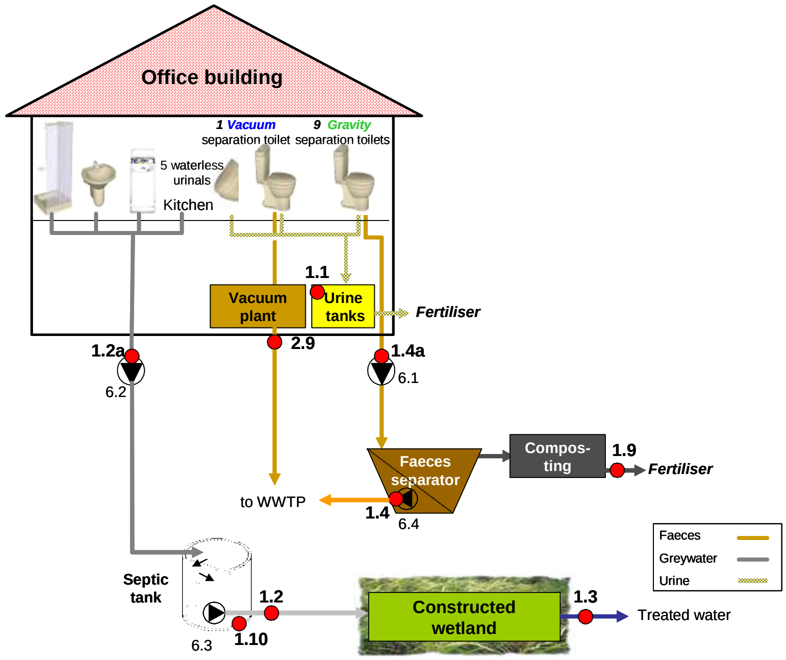


Fig. 2.3.4: Flow scheme of *Variant V2a* (without soil filter and no treatment of faecal filtrate)

This variant has been operated from 5 May 2004 until 3 September 2004. The difference to *Variant V1* was the missing treatment of the filtrate of the faeces separator by the shutdown of the soil filter. Instead the filtrate was discharged by gravity to the Stahnsdorf WWTP.

The main interest of investigations for this variant was to compare the effectiveness of the constructed wetland with its effectiveness during *Variant V1*.

After the test of *Variant V2a* the

Variant V2b,

shown in **Fig. 2.3.5**, was started.

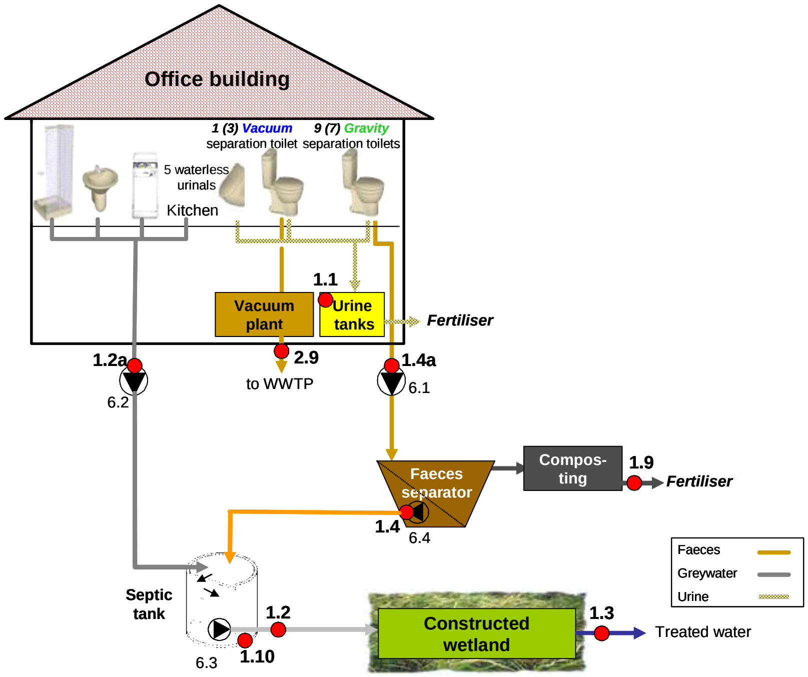


Fig. 2.3.5: Flow scheme of *Variant V2b* (without soil filter, but treatment of faecal filtrate)

The operation of this variant was from 4 September 2004 until 29 March 2005. The main topic of this variant was the investigation concerning the efficiency of the constructed wetland for pre-treated grey water including faeces filtrate. The pre-treatment of the faeces filtrate changed from filtration (*Variant V1*) to the removal of suspended solids by sedimentation in the first chamber of the septic tank.

In contrast to *Variant V2a* the faeces filtrate have been pumped since 15 September onward instead discharged by gravity. For this operation mode the change of the pipes of this pump 6.4 was necessary. The main reason for using the pump was to receive a proper mixture of the faeces filtrate in the suction well where samples are taken by an automatic sampler. The mixture is realised due to on and off switches of the pump depending on the filtrate level in the suction well.

During the operation of this variant two more gravity separation toilets were exchanged against vacuum separation toilets in December 2004. From this time until the end of operation of this variant in March 2005 only the faeces from 7 gravity separation toilets could be collected in the faeces separator and thus a little less faeces filtrate were mixed up with the grey water.

The operation of this variant showed that the distribution on the surface of the constructed wetland could be optimized. An improvement of this distribution system of the constructed wetland (see 2.4.10) was made from 30 March until 2 May 2005. In this period all outside facilities (constructed wetland, septic tank, faeces separator) were out of operation. After this changing works and installation of the membrane bio-reactor the operation of *Variant* V5 has been started. *Variant V3* and *Variant V4* are still not tested.

Variant V5

The *Variant V5* (**Fig. 2.3.6**.) was in operation from 3 Mai until 28 June 2005. This variant differed from *Variant V2b* mainly due to the additional operation of the membrane bio-reactor and the operation of nine vacuum separation toilets and the gravity separation toilet left-over. Since the gravity separation toilet was less frequented nearly no faecal filtrate was mixed up with the greywater. After some start-up works the operation of the membrane bio-reactor started on 25 May 2005.

The main interest of this variant was to receive a stable operation process with the membrane bio-reactor and to investigate the quality of the treated greywater only from the office building.

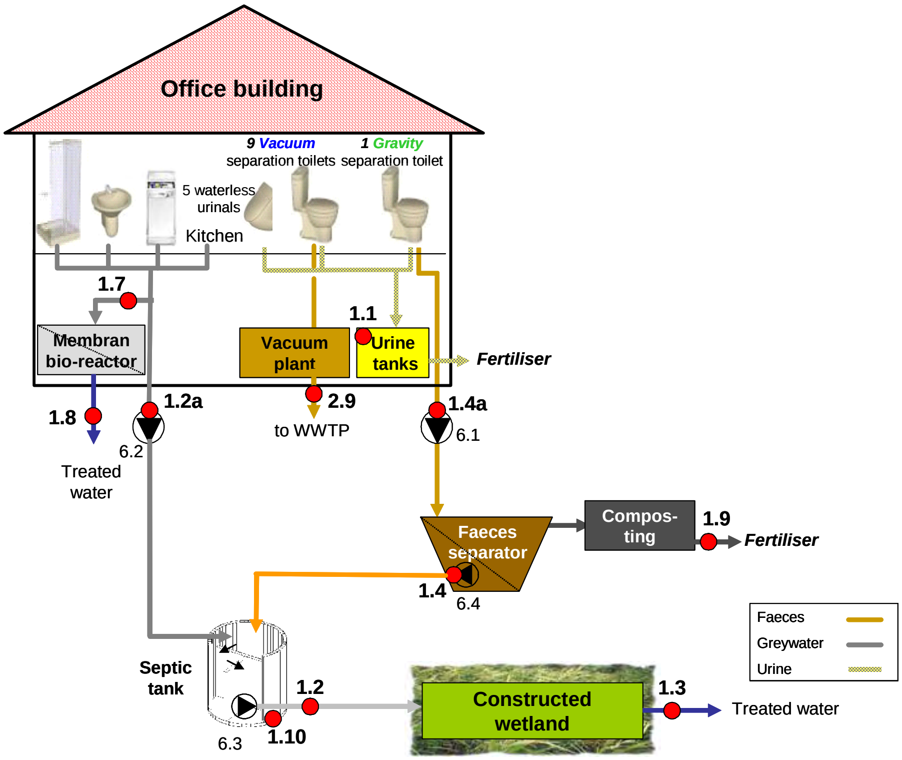


Fig. 2.3.6: Flow scheme of *Variant V5* (<u>without</u> soil filter, but treatment of faecal filtrate and operation of membrane bio-reactor)

From the end of June it was possible to treat also greywater with the membrane bio-reactor from the apartment house since pipes and connections of the pumps for grey and brownwater was finished (pumps for yellowwater are not yet installed). That means

Variant V7,

which is shown in **Fig. 2.3.7**, could be started at 29 June 2005.

In addition the gravity separation toilets are installed in ten flats of the apartment house; six in the left wing of the building and four in the right one. The greywater from here is discharged by gravity in pits outside of the apartment house similar to office building described for *Variant V1*. From this pits it is pumped (B1 and B2) into the office building and it is mixed up with the greywater from there. Then the greywater is pumped like in *Variant 1.* The greywater for the membrane bio-reactor was retained from the greywater pipe after mixing both greywater flows.

The brownwater flows also by gravity into pits outside of the apartment house. From this pits it was pumped (A1 and A2) direct to the faeces separator for dewatering and collecting the faeces. The filtrate was pumped (6.4) to the first chamber of the septic tank.

In this *Variant V7* changing's were made compared to the *Variant V7* described in the EU-proposal (see 2.2). At first the *Variant 7* works without the digester for faeces and bio-waste treatment and furthermore the greywater is a mixture discharged from the office building as well as from the apartment house. The results from the operation of the membrane bio-reactor are also reliable if greywater from office building is included in the greywater from the apartment house. The main volume of greywater is coming from the apartment house.

Variant V7 will be operated until the digestion plant is ready for operation, scheduled for January 2006. Then *Variant V6* will follow, which is scheduled for January 2006. Testing the effectiveness and quality of the mixture of both greywater flows is the main interest of *Variant V7*.

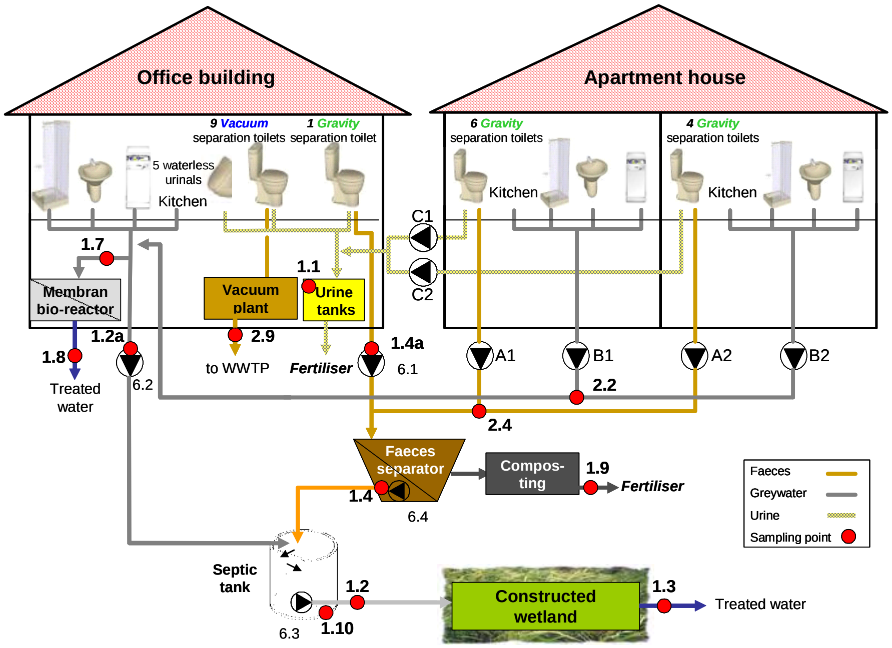


Fig. 2.3.7: Flow scheme of *Variant V7* (without soil filter, but treatment of faecal filtrate, operation of membrane bio-reactor including greywater from apartment house)

In this interim report the operation of *Variant V7* only until 31 July 2005 will be reported, the following phases are part of the final report.

2.4 Facilities

2.4.1 Toilets and urinals

Gravity separation toilets

The gravity separation toilet, which is in use for this project is the No Mix-Toilet delivered by the Roediger company (Roediger 2001). At the moment this toilet model is the only one available on the market without dilution of the urine by flushing water. This circumstance was a prerequisite for integration of the separation toilets in the project. The function of this toilet is described in **Fig. 2.4.1**. The volume of flushing water for faeces is 6 L/flush in the case of the office building as well as in the apartment house. For flushing the urine area 1 l/flush is used in the office building and 3 l/flush in the apartment house due to different flushing equipment.

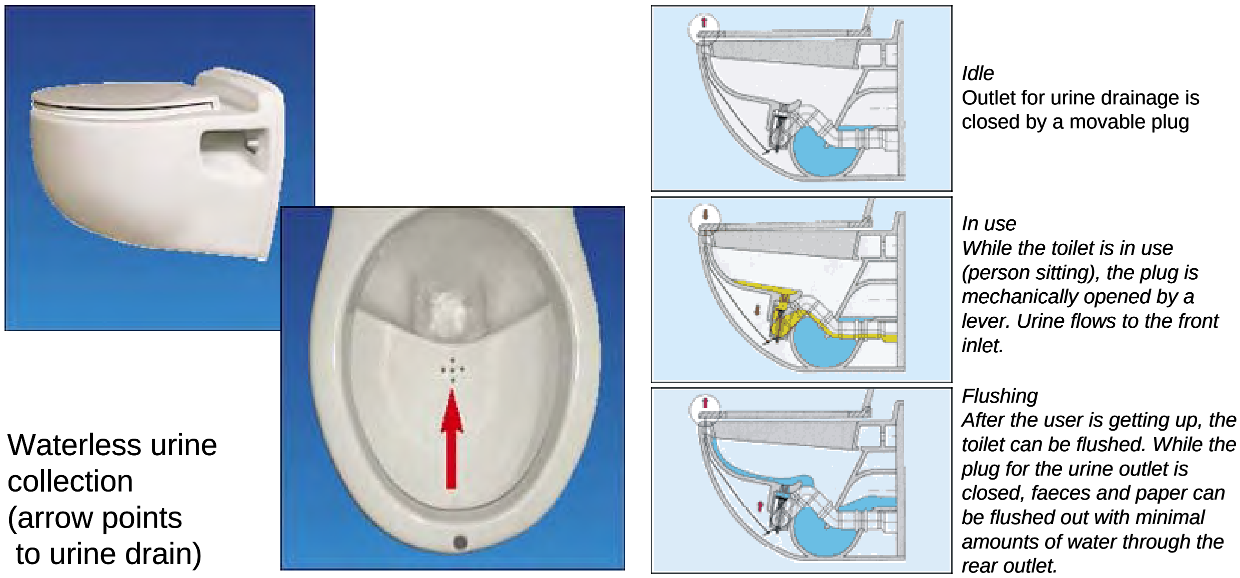


Fig. 2.4.1: Gravity separation toilet (Roediger-No Mix Toilet; Roediger 2001)

Vacuum separation toilets

Until today a vacuum separation toilet is not available on the market. Therefore a prototype by modification of gravity No Mix-Toilet was prepared for the use in vacuum system by the company Roediger (**Fig. 2.4.2**).

Fig. 2.4.2: Vacuum separation toilet

In general the function of this toilet is similar to the gravity separation toilets. Only the faeces outlet is connected to the vacuum system and the faeces including flushing water are sucked off. The vacuum equipment is the same like for the Roediger vacuum toilets (Roediger 2001). The amount of flushing water is always the same for flushing the faeces as well as for the urine area because the same flushing system is used for both. The amount of flushing water can be adjusted up to about 3 L/flush. In the office building different flushing volumes are chosen for the different toilets:

- Seven toilets adjusted for 1 L/flush,
- One for 0.7 L/flush (women dressing room, first floor) and
- One for 2 L/flush (men’s toilet, second floor).

Since the amount of flushing water is low a flushing water tube made of polyethylene with a diameter of 8 mm is installed around beneath the ceramic edge inside of the toilet bowl. This tube has small wholes in a distance of about 20 mm. Only with this flushing system toilet paper could not be flushed from front to the back faeces effluent. This situation became better when additional wholes have been realised in front of the flushing tube but it is still not satisfying. Here a further development by the producer becomes necessary in the future.

For reducing the flushing noise and saving of energy for vacuum production interim brownwater storage tanks with a volume of approx. 8 L each are installed near the toilets. Two toilets as a maximum are connected to one of these tanks, which are always emptied automatically when they are filled. So a water flush of approx. 8 L will be transported in the vacuum pipes at once.

Waterless urinals

Three different waterless urinals are in operation in the office building; two produced by the company Urimat (Urimat, 2005), two by the company Ernst (Ernst 2005) and one by the company Duravit (Duravit 2005) (**Fig. 2.4.3**).

Ernst Urimat Duravit

Fig. 2.4.3: Waterless urinals

For odour-preventing caused by the pipe system different systems of siphons are in use. Ernst and Urimat urinals are equipped with a removable siphon. Urinals from Ernst as well as from Duravit are using sealing liquids, which are floating on the urine during their lower density and cover the surface. The Urimat urinal uses a physical system (membrane, float, electromagnet) for the seal.

2.4.2 Pipes

The used pipes for grey, brown and yellowwater is listed in **Tab. 2.4.1**.

Tab. 2.4.1: Pipes for grey, brown and yellowwater

			grey water	brown water	brown water	yellow water
				gravity separation toilets	vacuum separation toilets	
material		inside buildings	SML-pipe (cast iron)	SML-pipe (cast iron)	PE-HD-pipe (polyethylene)	HAT-pipe/PPs (polypropylene)
material		pressure lines outside buildings	PE-HD-pipe (polyethylene)	PE-HD-pipe (polyethylene)	-	PE-HD-pipe (polyethylene)
nominal internal diameter	mm	inside buildings	50 to 150, mainly 100	100 to 150, mainly 100	40 and 50, mainly 50	50 and 70, mainly 70
nominal internal diameter	mm	pressure lines outside buildings	50	50	-	40

The main pipes for yellow-water have a nominal internal diameter of 70 mm, only the connection pipes to the toilets and urinals are built with a diameter of 50 mm. This decision is based on experiments from different projects in Scandinavia, which were visited during the pre-study of this project. For checking if precipitant products are accumulating in the yellowwater pipes acrylic glass pipes with a length of 0.5 m each are horizontally installed in the two yellowwater pipes just before they are going into the urine tanks.

2.4.3 Vacuum plant

The vacuum plant (**Fig. 2.4.4**), which is used in this project, is the smallest unit, which is available from the company Roediger (Roediger 2001). It is installed in the cellar of the office building and can serve at least 40 toilets. The vacuum (0.6 bar) is produced by two redundant vacuum pumps, which are installed on top of the unit. For the discharge of brownwater from the vacuum tank two redundant pressure pumps are installed behind the small storage tank of the unit.

Fig. 2.4.4: Vacuum plant

2.4.4 Urine Tanks

For storage urine four tanks with double walls are installed in the cellar of the office building (**Fig. 2.4.5**), each with a volume of 1,000 L. The outer tank is made by galvanised steel plate and the inner tank by polyethylene.

Fig. 2.4.5: Urine tanks

2.4.5 Membrane bio-reactor

The membrane bio-reactor pilot plant (MBR) consists of a rectangular biological reactor with a working volume of 35 – 60 L (**Fig. 2.4.6**). A module from the company A3 GmbH (A3 GmbH 2003) made of 18 plane polyphenol resin membranes (total surface area of 2.59 m²) with a pore size of 0.4 µm was immersed into the reactor (**Fig. 2.4.7**). The flat sheet membranes had an orientation parallel to the filtration. The flow scheme of the membrane bio-reactor is shown in **Fig. 2.4.8**.

The module was continuously aerated at a rate of 2.6 m^3/h by an air blower located at the bottom of the reactor. This system provided both aeration to the biomass and scour to the membrane surface.

Fig. 2.4.6: Membrane bio-reactor

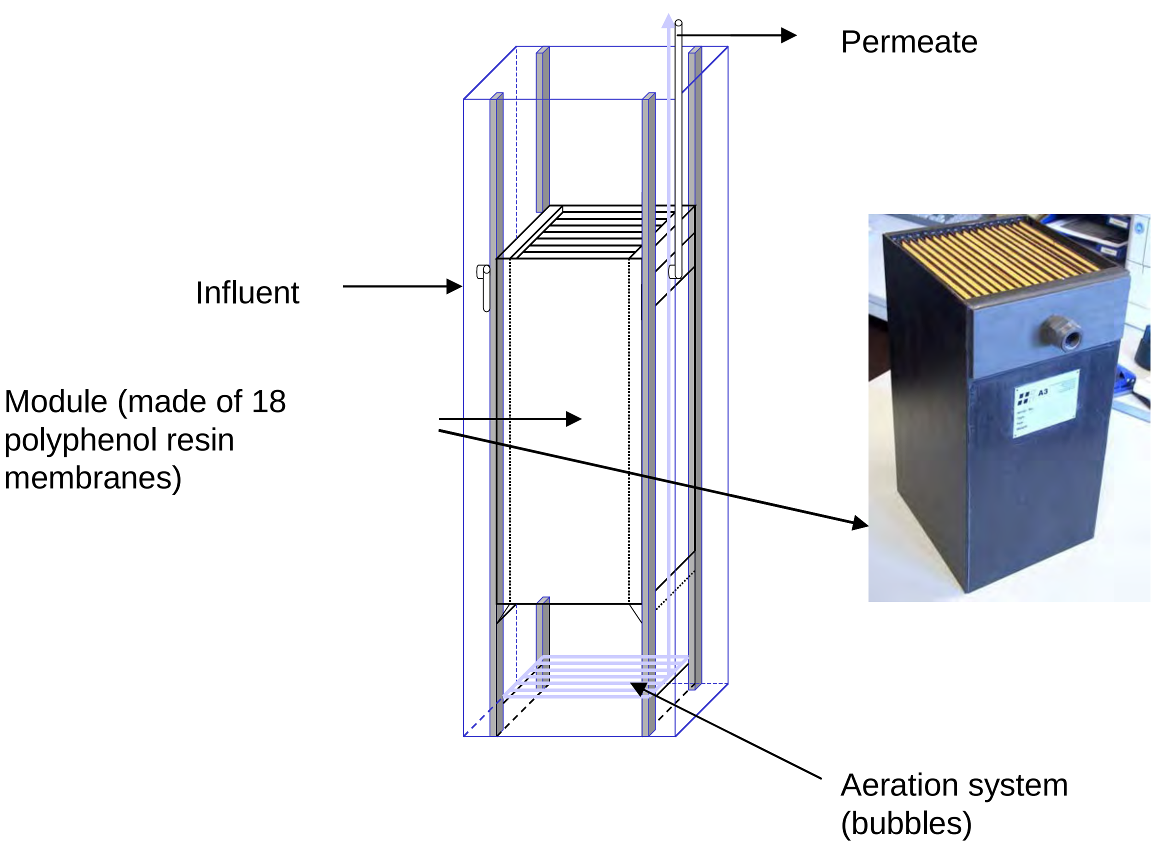


Fig. 2.4.7: Membrane bio-reactor module

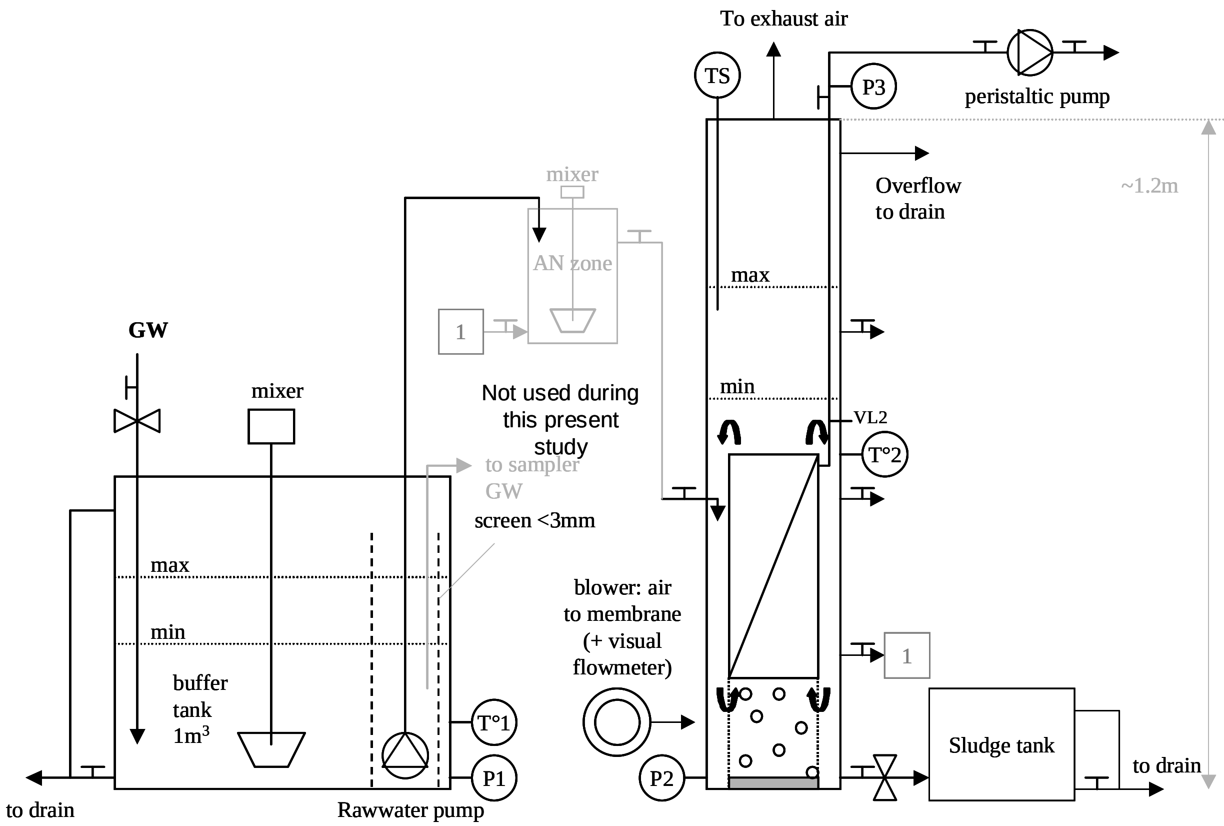


Fig. 2.4.8: Flow scheme of the membrane bio-reactor

The feed system was composed of two agitated buffer tanks of 500 L each and a peristaltic pump. The Hydraulic Retention Time (HRT) in those tanks was adjustable between 6 and 24 hours. Raw greywater was passed trough a filtration stage (strainer with slit size of 1 mm) and then pumped straight to the bio-reactor.

The permeate was removed using a peristaltic pump. This pump operated on an adjustable time basis (for example 15 min ON / 5 min OFF) in order to minimise fouling on the membrane surface. The HRT (1 - 5 hours) in the reactor was adjusted by changing the permeate flow and the reactor volume. The solid retention time (SRT) in the MBR reactor was controlled by regular extraction of sludge with a pump set by a timer. The sludge was gathered in a tank. SRT in the bioreactor was adjusted by changing the pump flow manually.

Two pressure transducers controlled the levels in the buffer tank and the reactor. A third was used to measure the relaxation (P_R) and filtration (P_F) pressures and to calculate the transmembrane pressure (TMP).

The reactor was equipped with sensors for suspended solids, temperature and dissolved oxygen (DO). The pH in the buffer tank and in the reactor was measured manually with a pH-meter. The standard buffer solutions of pH values 4 and 7 were used to calibrate the instrument.

The anaerobic tank for pre-denitrification and biological phosphorus removal indicated on the flow scheme was not used during this present study.

The pilot plant was connected to a computer, which commanded pumps and levels in the tanks (analogical values). It recorded the parameters (numerical values) too: levels in reactor and buffer tank, flow of pumps, pressures, and biological parameters. They were recorded every 30 seconds during the week and every minute during the week-end.

2.4.6 Faeces separator

The dewatering of faeces takes place in filter bags (faeces separator), which are shown in **Fig. 2.4.9**.

Fig. 2.4.9: Fugafil-Saran Filter bag (PE 1200/500) for faeces dewatering

The filter bags are from the company Fugafil-Saran GmbH (Fugafil-Saran 2005). Two different types are in use: until 10 May 2005 the polyethylene filter bag PE 1200/500 with a pore size of 1.2 mm and since 11 May 2005 the polypropylene filter bag PP 1500/500 FLH with a pore size of 1.4 mm. Both filter bags have a diameter of 600 mm and a height of 800 mm.

The filter bags are installed in a pit of concrete (**Fig. 2.4.10**)

Fig. 2.4.10: Faeces dewatering facility

By the upgrade to four filter bags two filters each can be used in parallel. Since July 2005 this became necessary due to the higher hydraulic loading by the connection of the apartment house to the system. By the start of the operation about 10 litres of bark mulch was added to each empty filter bag. This improves the backing of faeces during start up of the filter bags. The filled filter bags can be removed with a crane (**Fig. 2.4.11**). The filtrate can be discharged with a pump to different directions like described above (see 2.3).

Fig. 2.4.11: Faeces dewatering facility including crane

2.4.7 Compost technique

For composting the thickened faeces the filled filter bags stay in the faeces dewatering pit for post-self dewatering for one up to two weeks. The filter-bags with the dewatered faeces are removed with the crane and transported in waterproof bags to the research camp of the Humboldt University in Berlin-Dahlem were fertiliser experiments take place (Task 8 of the project). In the first two bags, which have been filled in parallel since March 2004, 1,000 worms *Eisenia fetida* from the company Regenwurmfarm Tacke GmbH (Tacke 2005) have been added into each bag on 4 October 2004. Both bags were covered by a conventional compost hood (**Fig. 2.4.12**) and stored in a room, which is tempered by about 20 ^{o}C. After composting until April 2005 the worms have been removed. These worms have been used for the next two parallel filled bags, which were transported in April 2005 to the Humboldt University.

Fig. 2.4.12: Faeces for composting in a compost hood

2.4.8 Soil filter

The soil filter (**Fig. 2.4.13**) was foreseen for the remove of pathogen germs from the faecal filtrate before mixing it with pre-settled greywater in the pump chamber of the septic tank.

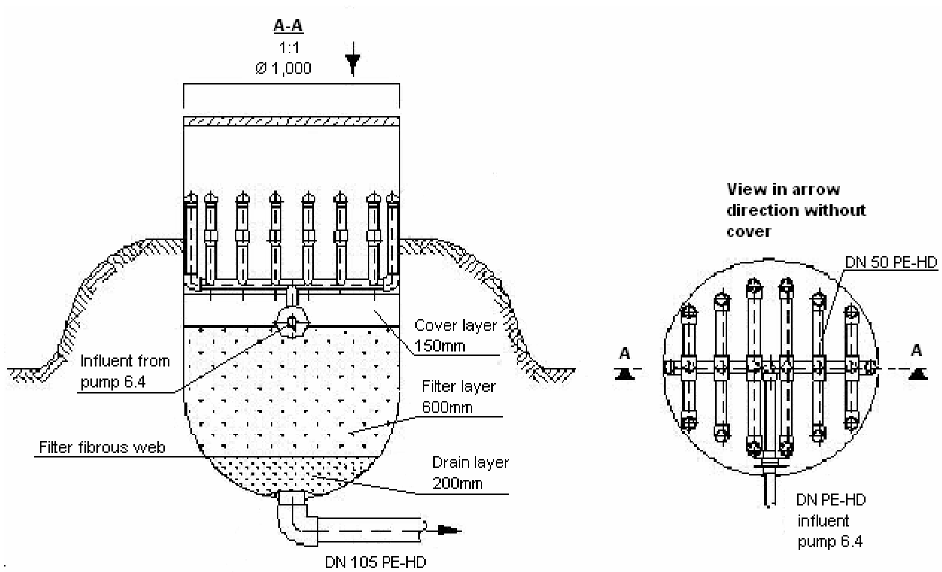


Fig. 2.4.13: Soil filter

Design data of the soil filter and the build up of the filter are given in **Tab. 2.4.2** and **Tab. 2.4.3**, respectively.

Tab. 2.4.2: Soil filter, design parameter

filter load	q_A	$m^3/(m^2\ h)$	0.2
daily flow of faeces filtrate	Q_d	m^3/d	0.685
filter area selected	A	m^2	0.8

Tab. 2.4.3: Soil filter, filter layer

	heights (cm)	material	graining
cover layer	15	gravel	8/16
filter layer	60	sand	0/4
filter fibrous	-	-	-
drain layer	20	gravel	8/16
geo fibrous	-	-	-

The filter was designed for a filter load of 0.2 $m^3/(m^2.h)$ to realise a slow sand filtration process. The inlet distribution is made by pipes, which have been installed in the cover layer. These pipes have wholes of 10 mm with a distance of 10 cm located in the bottom side. Since this filter was blocked after about five weeks of operation the distribution system have been removed from filter layer and fixed about 10 cm above it. But this could not prevent blocking of the soil filter why the operation was stopped on 4 May 2005 (see *Variant V1*, chapter 2.3).

For taking representative samples from the effluent of the soil filter with an automatic sampler a control pit is installed.

2.4.9 Septic tank

The septic tank for greywater and faecal filtrate pre-treatment is shown in **Fig. 2.4.14** and design data are given in **Tab. 2.4.4**.

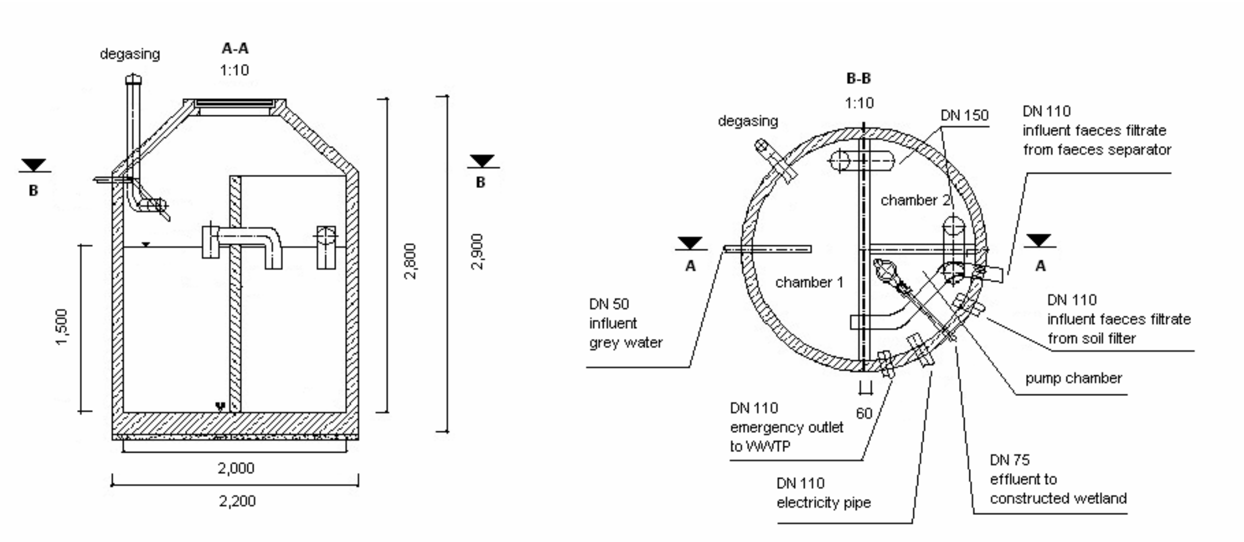


Fig. 2.4.14: Septic tank

Tab. 2.4.4: Septic tank, design data

inflow	Q_{10}	m^3/h	0.458
total working capacity chamber 1	V_1	m^3	2.27
total working capacity chamber 2	V_2	m^3	1.09
volume reduction for solids storage	-	%	50
retention time by 50 % volume reduction	t	h	3.7

This septic tank is a two chamber tank. Greywater and faeces filtrate are pumped in chamber 1 first and flows via submersed overflows in chamber 2 and in the pump sump from where it is pumped to the constructed wetland. The delivery of the pumps is 4.91 L/s.

2.4.10 Constructed wetland

A general view of the constructed wetland is shown in **Fig. 2.4.15**.

Fig. 2.4.15: Constructed wetland

The type of this treatment plant is an intermittent loaded vertical flown constructed wetland. The design data and data of the different layers are given in **Tab. 2.4.5** and **Tab. 2.4.6**.

Tab. 2.4.5: Constructed wetland, design data

inflow	Q_d	L/d	4.580
max. inflow	$Q_{d,max}$	L/d	5.265
population equivalents	E	-	58
spec. inflow	$Q_{d,spec.}$	L/(E d)	80
spec. BOD-load	$B_{d,BOD}$	g/(E d)	30
spec. area	$A_{spec.}$	m^2/E	2
surface flow rate	q_A	L/(m^2 d)	40
area	A	m^2	116
length	L	m	14.5
width	B	m	8.0

Tab. 2.4.6: Constructed wetland, layer data (from top to bottom)

	description	layer height	material	graining
1	plants	5 plants/m^2	reed	-
2	upper layer	10 (20)* cm	gravel	0/16 (16/32)*
3	filter layer mixed up with waterwok iron sludge (2.2 m^3)	80 (70)* cm	sand	0/4
4	geo fibrous	-	-	-
5	drainige layer	15 cm	gravel	8/16
6	pond foil	0.015 cm	polyethylen	-
7	geo fibrous	-	-	-

* since changing works in April 2005

The cross section of this constructed wetland is shown in **Fig. 2.4.16** and the distribution system in **Fig. 2.4.17**.

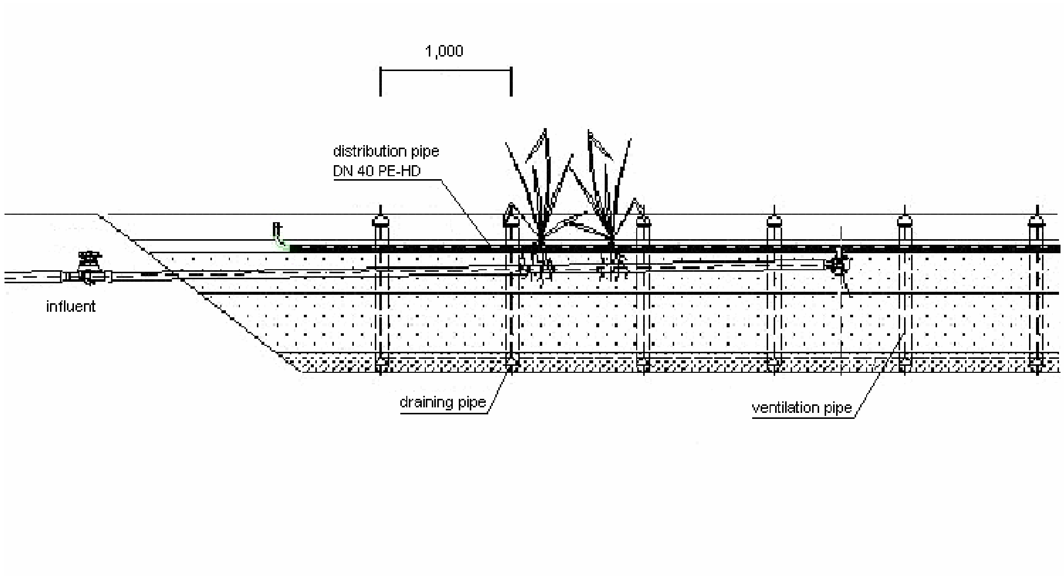


Fig. 2.4.16: Constructed wetland, cross section

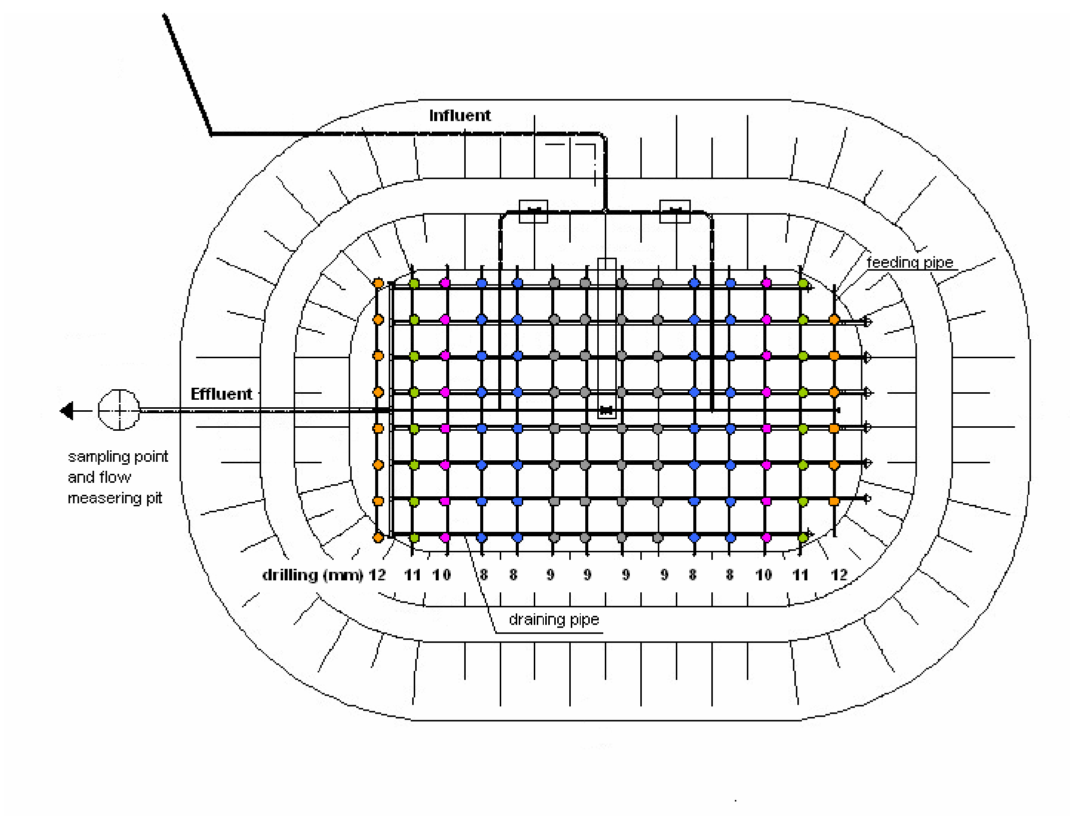


Fig. 2.4.17: Constructed wetland, distribution system

The pre-settled water from the septic tank is pumped in intervals with 4.91 L/s (see 2.4.9) through a pipe, which is divided into two inlet pipes at the top of the constructed wetland. Each of the two inlet pipes finish in the main feeding pipe, on which the distribution grid of fourteen distribution pipes is connected (**Fig. 2.4.16** and Fig. **2.4.17**). Each of the distribution pipes is equipped with holes at the bottom side in a distance of 1m with different diameters (8 – 12 mm) (**Fig. 2.4.17**). The treated water discharges by eight drainage pipes at the bottom of the wetland, which are connected to central effluent pipe. After volume measuring by tip water meter and sampling in the effluent pit the treated water is discharging to the WWTP Stahnsdorf. By the installation of two inlet pipes and the possibilities of shut-off the pipes by valves only half of the total area can be loaded with wastewater.

After one year of operation it became obvious that the distribution of the influent was not satisfying because the reed plant have grown with different heights and density. Instead with a top layer with a coarse diameter of 8/16 mm (height 10 cm) the upper layer was constructed with the small coarse of 0/4 mm. So the roots of the plants have been grown into the distribution system by entering the holes and have clogged it. So the result of the inflow distribution was not satisfying. For the optimisation reed and upper layer have been removed in April 2005 and tests of influent distribution were undertaken (**Fig. 2.4.18**).

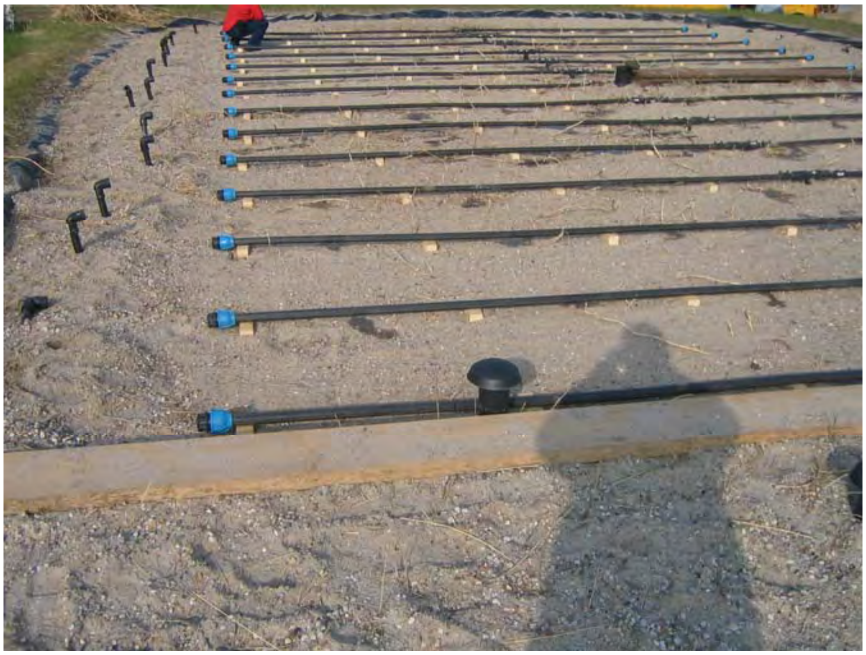


Fig. 2.4.18: Constructed wetland, distribution system

Based on these tests the 8 mm holes of the distribution pipes have been extended to 9 mm and the 10 mm holes to 11 mm. Furthermore the upper layer was replaced by another gravel layer of (16/32) and the distribution pipes have been covered 5 cm with this gravel. After that changing the constructed wetland was planted again with reed.

The growth of the reed plants became more regular and this was seen as a sign for a much better distribution of the water. The growth heights become similar for the whole area of the constructed wetland.

2.5 Volume measurement, sampling and analytic

2.5.1 Volume measurement

For measurement of the volumes different equipments listed in **Tab. 2.5.1** are installed. The positions of the pumps and of the tip water meter can be seen in **Fig. 2.3.7**.

Tab. 2.5.1: Volume measurement

facility	counter for operation time	volume meter	level meter	magnetic inductive flow meter	volume calculated by means of counter figures and pump diagram	volume calculated by means of counter figures and measured flow	volume derived from counter figures, volume and level meter, magnetic indutive flow meter
basement of office building: influent drinking water counter		x					x
ground floor of office building: drinking water counter for flushing of 2 toilets (men)		x					x
first floor of office building: drinking water counter for flushing of 1 toilet (women dressing room)		x					x
first floor of office building: drinking water counter for flushing of 4 toilets (2 women and 2 men toilets)		x					x
second floor of office building: drinking water counter for flushing of 2 toilets (1 women and 1 handicapped toilet)		x					x
second floor of office building: drinking water counter for flushing of 1 toilet (men)		x					x
pump 6.1	x				x		
pump 6.2	x				x		
pump 6.3	x					x	
pump 6.4	x				x		
pump A1	x				x		
pump A2	x				x		
pump B1	x				x		
pump B2	x				x		
pump C1	x				x		
pump C2	x				x		
effluent constructed wetland: tip water meter	x					x	
urine tank 1			x				x
urine tank 2			x				x
urine tank 3			x				x
urine tank 4			x				x
influent membrane bio-reactor				x			x

2.5.2 Sampling

Samples were taken at different points (**Fig. 2.3.7**). Sampling points and the method of sampling are listed in **Tab. 2.5.2**.

Tab. 2.5.2: Sampling points and methods

sample point	sampling method
1.1 urine tank	grab sample after mixing the tank content
1.2a grey water pit	daily grab samples from Monday to Friday which are mixed to a composite sample before analysing
1.2 pump chamber of septic tank	24-hour composite sample taken by a automatic sampler (grab sample for bacteriological parameters according German guideline DIN 38402 A14)
1.3 effluent pit of the constructed wetland	24-hour composite sample taken by a automatic sampler (grab sample for bacteriological parameters according German guideline DIN 38402 A14)
1.4a brown water pit	daily grab samples from Monday to Friday which are mixed to a composite sample before analysing
1.4 pumping pit of faecal filtrate	24-hour composite sample taken by a automatic sampler
1.5 effluent pit of the soil filter	24-hour composite sample taken by a automatic sampler
1.7 influent storage tank for membrane bio-reactor	24-hour composite sample taken by a automatic sampler
1.8 effluent of membrane bio-reactor	24-hour composite sample taken by a automatic sampler
membrane bio-reactor	grab sample
1.9 compost	composite sample from each finished compost
A1 brown water pit	daily grab samples from Monday to Friday which are mixed to a composite sample together with the samples from sampling point A2 before analysing
A2 brown water pit	daily grab samples from Monday to Friday which are mixed to a composite sample together with the samples from sampling point A1 before analysing
B1 grey water pit	daily grab samples from Monday to Friday which are mixed to a composite sample together with the samples from sampling point B2 before analysing
B2 grey water pit	daily grab samples from Monday to Friday which are mixed to a composite sample together with the samples from sampling point B1 before analysing

2.5.3 Analytic

The laboratories of the Berliner Wasserbetriebe (BWB) mainly carried out the analytic of the samples. Some analytic, mainly in relation to bacteriological parameters, was done by the laboratory Labor 28 (Labor 28 2005). The analytic in relation to pharmaceuticals in urine was undertaken by the laboratory IWW (Universität Duisburg 2005). All analysing methods are listed in Tab. 2.5.3.

For analysing the pharmaceutical parameters IWW used their own developed methods. The physical and chemical parameters are mainly measured and analysed in the BWB-laboratory of the Waßmannsdorf-WWTP laboratory. Some are measured and analysed in the Stahnsdorf-WWTP laboratory and in the central BWB-laboratory in Berlin-Jungfernheide.

Tab. 2.5.3: Analysing methods

parameter	unit	method used in central BWB laboratory	method used in WWTP-Stahnsdorf laboratory
temperature (T)	°C		pH-Meter WTW pH 196
pH		DIN 38404-C05	pH-Meter WTW pH 196
dissolved oxygen (DO)	mg/L		amperometric with WTW Oxi 196 (Unit: mg/l) / Hach LDO HQ10
conductivity	µS/cm	DIN EN 2788-C08	conduct meter WTW LF 196
suspended solids (SS)	mg/L	DIN EN 872	gravimetric Process
dry residue (DR)	g/L	DIN EN 12879	
TOC	mg/L	DIN EN 1484-H03	
volatile solids (VS)	%/(g/kg)	DIN 38409 - H02	
COD	mg/L	38409-H41/Dr. Lange	Dr. Lange
BOD_5	mg/L	DIN EN 1899-1	
N-total	mg/L	DIN 38409 - H12	Dr. Lange
NH_4-N	mg/L	DIN EN ISO 11732/ Dr. Lange	Dr. Lange
NO_2-N	mg/L	DIN EN 26777-D10/ Dr. Lange	Dr. Lange
NO_3-N	mg/L	DIN EN ISO 10304-2	Dr. Lange
org. N	mg/L	DIN EN 25663 - H11	
PT (P-total)	mg/L	DIN EN 1189-D11- 6/Dr. Lange	Dr. Lange
PO_4-Pf (dissolved otho-phosphate)	mg/L	DIN EN 1189-D11- 3/ Dr. Lange	Dr. Lange
volatile fatty acid	mg/L	DIN 38414-S19	
K	mg/L	DIN EN 11885-E22 ICP	
Ca	mg/L	DIN EN 11885-E22 ICP	
Mg	mg/L	DIN EN 11885-E22 ICP	
Cd	µg/L	DIN EN 11885-E22 ICP	
Cr	µg/L	DIN EN 11885-E22 ICP	
Cu	µg/L	DIN EN 11885-E22 ICP	
Hg	µg/L	DIN EN 1483-E12 AAS	
Ni	µg/L	DIN EN 11885-E22 ICP	
Pb	µg/L	DIN EN 11885-E22 ICP	
Zn	µg/L	DIN EN 11885-E22 ICP	
Cl	mg/L	Dr. Lange	
SO4	mg/L	Dr. Lange	
AOX	µg/L	DIN EN 1485	
faecal coliform germs	mpn/100 mL	MPN-method (MPN = most probable number)	
coliphage	pfu/100 mL	Berliner Wasserbetriebe laboratory house method	
intestinal entero cocci	mpn/100 mL	ISO 7899-2	

3 Results and discussion

3.1 Toilets and urinals

3.1.1 Gravity separation toilet

The gravity separation toilets (see 2.4.1) used in the office building, for which 6 L flushing water per flush are adjusted, are applicable in general for separate discharge of urine and faeces.

Unfortunately it was not tested during the operation if the urine valve was full open during the use of the toilets. These toilets have been replaced by vacuum separation toilets in April 2005 (see 2.1) and stored. Since these toilets were only rough cleaned before storage it is possible to test all to see if the urine valve is able to open and if the valve and effluent pipeline are covered by precipitant products. Until now only one toilet has been checked. The valve of this toilet opens complete and only few precipitant products on the surface of the valve and pipeline could be found. The other toilets will be checked later on and the results will be reported in the final report. During the whole time of 1 ½ years of operation no serious technical problem occurred with these toilets in the office building. In opposite of these few problems occurred with the gravity separation toilets in the apartment house which are installed since April 2005 (see 2.1). When the new installed toilets have been checked the urine valve did not open properly during operation by three of ten toilets. These toilets have to be replaced.

In general the experience with the operation of these toilets showed a potential of optimization. (see also 3.1.4). The demands of optimization have to be fulfilled in future projects. The proposals for the improvement are as follows:

a) Change of flushing: the flushing system distributes the water in the front as well as in the back part of the toilet bowl. The relation of this flushing distribution has to be changed. The changing has to achieve a flushing of the front part of the bowl with approx. 90 % of the total flushing water. Only with this amount of water a proper transport of toilet paper and possible faeces with one flush will be achieved. Both flush possibilities (low flush with approx. 3 L and high flush with approx. 6 L) have to fulfil these criteria. Otherwise flushing water will be wasted.
b) The removal of the siphon for the urine effluent has to be much easier. The best solution should be the removal from the top known from waterless urinals.
c) The position of the urine overflow losses from the upper space of the valve into the faeces outlet has to be higher. This would better prevent urine, which can flow into the faeces effluent if urine is piling up for any case.
d) The small overflow weir from the front bowl towards the back faeces outlet has to heighten. If the urine volume is high urine can flow over the porcelain weir into the faeces effluent. More holes in the bowl for the urine effluent would prevent this urine (nutrient) loss. This solution could be realised easier by the installation of a removable urine siphon with a metal cover.
e) The adjustment of the smaller flush volume for urine flushing (low volume) should be made easier.
f) The prerequisite of urine separation for this type of toilet is the use in sitting position, because the urine valve opens only by the body weight of the sitting person (approx. 10 – 15 kg). Otherwise urine would be discharged into the faecal outlet.
   This system will not work under specific conditions:
   - Many persons don't want to sit during the use of – mainly public – toilets due to the concern of hygienic infection mainly women have a very high sensitivity to this matter.
   - Many men don't sit for urinating, especially if a urinal is not available.

   In both cases the separation of the urine would not take place. This is a main disadvantage for the implementation of the type of separation toilet especially in public areas.
   The change of the valve opening system could be a possibility of optimisation. Another solution could be the connection of the urine valve with the toilet-lid:
   - toilet-lid in upright position: urine valve is open and flush water is blocked
   - toilet-lid in a non-upright position: urine valve is close and flushing is possible.

   For the use of a toilet-brush for cleaning with flush water the toilet lid has to be moved from upright position and fixed by the user manually.

The disadvantage of this valve control system is the opening of the urine valve in the upright lid position. By pouring of cleaning water into the toilet a part of this water could flow into the urine effluent and would dilute the urine.
The installation of an infrared-sensor could be an alternative to the mechanical solution.
These arguments show that finding a solution, which fits all requirements is very difficult.
In general mechanically or electronically solutions are possible but mechanically solutions should be favoured to prevent additional electricity installation.

g) The inner surface of the toilet should be smoother for better cleaning of e.g. iron-manganese sediments from flushing water.

3.1.2 Vacuum separation toilet

Before discussing the experience with the vacuum separation toilet in detail it has to be stated that the vacuum separation toilet is a new development of toilet. Due to the low number of implemented toilets in the project no company could be found, which agreed in a totally new toilet development from the scratch. Therefore existing gravity separation toilets were re-constructed to vacuum separation toilet. For this the flush outlets of the toilet was equipped with a vacuum valve, furthermore the volume of the toilets siphon was reduced by a flexible mass. The flush system was adapted to the vacuum mechanism. So the toilets must be seen more as a prototype for testing purposes than a readily developed type of toilet, which could be introduced to the market immediately.

Vacuum separation toilets (see 2.4.1) are in operation in the office building (see 2.1). The first toilet has been installed in the ladies dressing room in December 2003 for testing. The amount of flushing water is adjusted of 0.7 L per flush. For the most uses the flushing result won't be satisfied, therefore the use of the toilet-brush in parallel is necessary. But for the regular user is this flushing water volume too little (see also 3.1.4) especially since too little water is coming from front to flush toilet paper and as the case may be faeces to the back faeces effluent. Until now there has been no problem with the vacuum suction system but in this toilet a problem occurred with the flushing water valve, which is also controlled by vacuum. This valve did not close after two times use. That means water was flowing over the toilet bowl. This valve has been replaced. But these situations showed one disadvantage of the vacuum toilet since the effluent valve is closed after using. Anyway, the staff of the WWTP Stahnsdorf agreed to replace two more gravity separation toilets by vacuum separation toilets in December 2004 in the second floor were the most persons are working. One has been installed in the men and one in the ladies restroom. The flushing water is adjusted of

- 2 L per flush in the men restroom and
- 1 L per flush in the ladies restroom.

The greater flush volume for the toilet in the men restroom is necessary since the tube for faeces effluent to the vacuum valve had to be realised longer due to construction reasons compared to the toilet in the ladies restroom. These toilets are accepted in general but the flushing results are not really satisfying and the flushing noise is more disturbing for the most users (see also 3.1.4). Independent of these facts, again the staff accepted to replace six more gravity separation toilets by vacuum separation toilets in the first floor and in the ground floor in April 2005. The flushing water of these toilets is always 1 L per flush. These toilets are also accepted in general but in relation to flushing and flushing noise is the same true like before. With all these additional vacuum separation toilets did not appear the problem with the flushing valve like mentioned above. But one toilet in the first floor has been blocked in the faeces effluent. The reason was the green hand drying paper, which is normally used for hand drying and not for toilet purposes.

It is obvious that these vacuum separation toilets, which are altered gravity separation toilets, have to be improved for using it in another projects. Very important is to improve the flushing system but also the most items, which are mentioned above for the gravity separation toilet.

3.1.3 Waterless urinals

Duravit urinal

One Duravit urinal (see 2.4.1) is installed in the men's restroom in the second floor. This is used by at least four men daily from Monday to Friday. According to the maintenance description from the Duravit company the siphon should be cleaned once a week with water to prevent clogging by precipitant products. Avoiding a dilution of the urine the siphon cleaning proposed in the manual has never been executed since starting the urinals operation in October 2003. Only the sealing liquid for the siphon from Duravit is refilled every month and the urinal is cleaned within the regular cleaning intervals once a day with the recommended cleaning liquid. This cleaning liquid is sprayed on the surface and dried with paper. Until now no clogging of the siphon or other problems occurred. .

Ernst urinal

Two Ernst urinals (see 2.4.1) are installed; one in the ground and one in the first floor. The urinal in the ground floor is mainly used by shift workers of the WWTP and the urinal in the first floor by staff from the engineering department as well as visitors. These urinals are maintained twice a year by the company Renschler which is authorised by the company Ernst. This maintenance frequency is necessary for the office building otherwise the siphons will be clogged. The sealing liquid for the siphon from Ernst is refilled every two weeks and the urinal is cleaned once a day with the recommended cleaning liquid.

Urimat urinal

One Urimat urinal (see 2.4.1) has always been installed in the men's restrooms like the Ernst urinals. Since smell prevention is realised with a membrane, which is closing, and opening with an electric magnet no sealing liquid is necessary. These urinals are also cleaned once a day with cleaning liquid from the company Urimat. For preventing clogging in the siphon its exchange every three months is necessary. The opening of the urine outlet is controlled by an infrared sensor, which is installed in the front of the urinal bowl. This urinal is positioned beside a toilet and each user of the toilet crosses the area of the infra-red-sensor. The producer was not able to give recommendations for the decrease of the sensor sensitivity. Due to the high number of openings – released by persons, who mainly used the toilet and not the urinal – a strong ammonia smell occurred in the restroom.

Comparison of the three urinals

The following comparison will take in account only the experience from the daily use but not the costs, because economic calculations depend very strong on the frequency of the use of the urinals.

It can be concluded that all three urinals are not working without any odour. The smell is always increasing during the day until the cleaning. The daily cleaning is necessary. But also water flushed urinals are not working odourless. The Duravit urinal has had the slightest maintenance expenditure. No cleaning of the siphon was necessary for an operation time of 1 ½ year. The Ernst urinals have to be maintained from a company twice a year. The Urimat urinals should be maintained about four times a year also from a company in the case of the Stahnsdorf office building.

3.1.4 User survey

3.1.4.1 Questionnaire

The acceptance of separation toilets and waterless urinals by the users is the prerequisite for the implementation of new sanitation concepts. For receiving the opinion from the users questionnaires (**Fig. 3.1.4.1**) are available in each restroom of the office building.

New sanitation concepts for separate discharge and treatment of urine (yellow water), faeces (brown water) und grey water

Demonstration project Stahnsdorf

Here is something different!!

Save water – reduce water pollution-
nutrients recovery and energy production

You just have used a new developed separation toilet or a waterless urinal:

We care about your opinion…

1. Have you seen such a toilet or urinal before?	yes ○	no ○
2. Were you reserved?	yes ○	no ○
3. Were you scared?	yes ○	no ○
4. What kind of toilet did you use?	○ gravity separation toilet	○ vacuum separation toilet

5. Please give your personal assessment compared to a conventional toilet**:**	better	no difference	worse
design	○	○	○
flushing	○	○	○
seating comfort	○	○	○
hygienic feeling	○	○	○
flushing noise	○	○	○

6. How many times did you push the flushing button?			
• Brown water and yellow water	1time ○	2times ○	3times ○
• Just yellow water (**small** button)	1 time ○	2times ○	3times ○
• Just yellow water (**big** button)	1time ○	2times ○	3times ○

7. Could you imagine such a toilet at home?	yes ○	no ○

8. Assessment for urinal (just for men)

Used urinal: Ernst ○ Duravit ○ Urimat ○	better	no difference	worse
your feeling about the missing flush	○	○	○
hygienic feeling	○	○	○

9. Are the instructions comprehensible?	yes ○	no ○
10. Could you imagine such a urinal at home?	yes ○	no ○

Personal indications	Age	< 20	20 - 34	35 - 50	51 - 65	> 65
Female. ○	Male. ○	○	○	○	○	○

11. The back side is available for all your remarks and comments

Fig. 3.1.1: Questionnaire for separation toilets and urinals

Besides of the different questions on the questionnaire the question 10 is one important question to see if the users can imagine using such toilets and urinals at home.

3.1.4.2 Users of urinals and toilets and general results

The office building staff regularly uses the restrooms. These are four men and four women from the waste water management team and laboratory, respectively, and three persons from the engineering department. Furthermore the restrooms are used by the operators from the WWTP at the daily showering time and occasionally used by external persons during visits or meetings. Until the end of July 2005 61 answered questionnaires have been collected;

- 40 for the gravity separation toilets,
- 15 for the vacuum separation toilets and
- 6 direct for the waterless urinals.

On 15 questionnaires filled out for the separation toilets urinal-related questions were also answered. The fewer questionnaires for the vacuum separation toilets are due to the shorter operation time (see 3.1.2). The age and sex distribution of the users is shown **Fig. 3.1.2**.

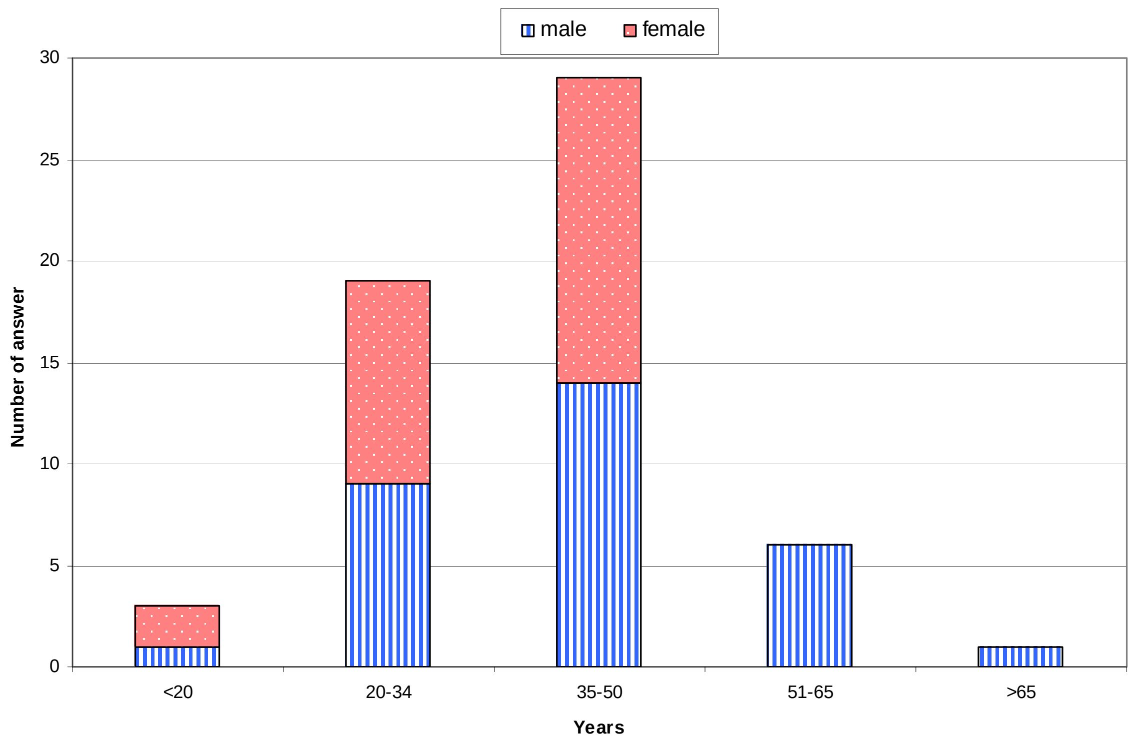


Fig. 3.1.2: Age and sex of the users

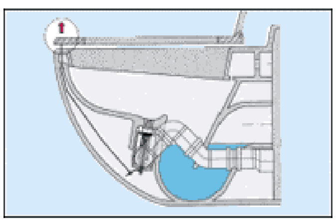
As the figure shows about half of the users who filled out the questionnaires are men and women, respectively. The most persons are between 35 and 50, followed by persons between 20 and 34.

One question on the questionnaire (question 9) asks for the comprehension of the instruction sheets, which are installed in each restroom (**Fig. 3.1.3** and **Fig. 3.1.4**)

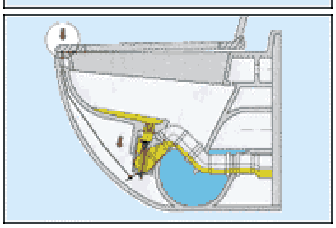
User advices

for the new developed gravity separation toilet (Roediger *No Mix Toilet*) for separate discharge of faeces and urine (without flushing)

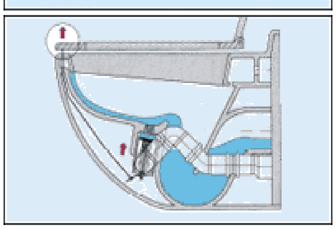
- **Please use it <u>only</u> sitting**
- **Please stay <u>before</u> flushing**



Idle
Outlet for ***urine*** drainage is closed by a moveable plug



In use
While the toilet is in use (person sitting), the plug is mechanically opened by a lever. ***urine*** flows to the front inlet.



Flushing
After the user is getting up, the toilet can be flushed. While the plug for the ***urine*** outlet is closed, faeces and paper can be flushed out with minimal amounts of water through the rear outlet.

KOMPETENZZENTRUM Wasser Berlin — Berliner Wasserbetriebe — VEOLIA Water

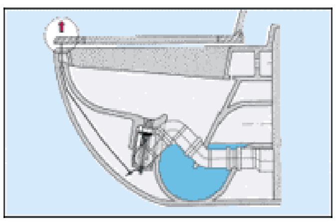
This demonstration project is supported by the European community with the LIFE programm.

Fig. 3.1.3: Instruction sheet for gravity separation toilet

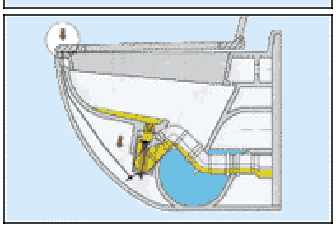
User advices

for the prototype ***vacuum*** separation toilet (Roediger) for separate discharge of ***faeces*** and ***urine***

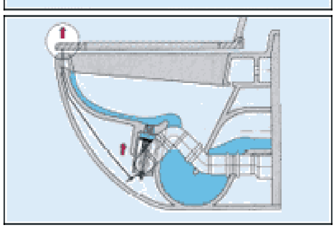
- **Please use it <u>only</u> sitting**
- **Please stay <u>before</u> flushing**



Idle
Outlet for ***urine*** drainage is closed by a moveable plug



In use
While the toilet is in use (person sitting), the plug is mechanically opened by a lever. ***urine*** flows to the front inlet.



Flushing
After the user is getting up, the valve for ***urine*** outlet is closed and the toilet can be flushed. By pushing the flushing button 2 L flushing water will flush the faeces and toilet paper in the back which are sucked away by vacuum.

This demonstration project is supported by the European community with the LIFE program.

Fig. 3.1.4: Instruction sheet for vacuum separation toilet

The results of the questionnaires are shown in **Tab. 3.1.1**.

Tab. 3.1.1: Answers to general questions of the questionnaire

no. on questionnaire	question		gravity separation toilet		vacuum separation toilet	
			yes	no	yes	no
1	Have you seen such a toilet or urinal before?	%	24	76	33	67
2	Were you resered?	%	9	91	33	67
3	Were you scared?	%	9	91	20	80
9	Are the instructions comprehensible?	%	95	5	100	0

The most users were crossing yes for both instructions. So the function and the use of the separation toilets are understood by the users.

Question 1 "*Have you seen such a toilet or urinal before?*" was answered *no* for both toilets by the majority of the users. Despite of this result the users were not particularly sceptical using the gravity separation toilets since 91 % affirmed that they were not reserved before using this type of toilet (question 2, "*Where you reserved*?"). The result from this question is different for the vacuum separation toilets were 33 % of the users were reserved. The most users were not scared using these toilets but for the vacuum separation toilet the number of it is smaller (question 3). These results show that the most of the users are open to use or at least to test new toilets.

3.1.4.3 Waterless urinal assessment

To assess the acceptance of the urinal by the male user's two questions were chosen: feeling about the missing flush and the hygienic feeling (question 8, **Fig. 3.1.1**). Since only a few of the 22 questionnaires concerning the used type of urinal were answered the results do not allow distinguishing between the three urinals. It appears that the users do not recognise the different types of urinals. The results to the above mentioned questions are shown in **Fig. 3.1.5**.

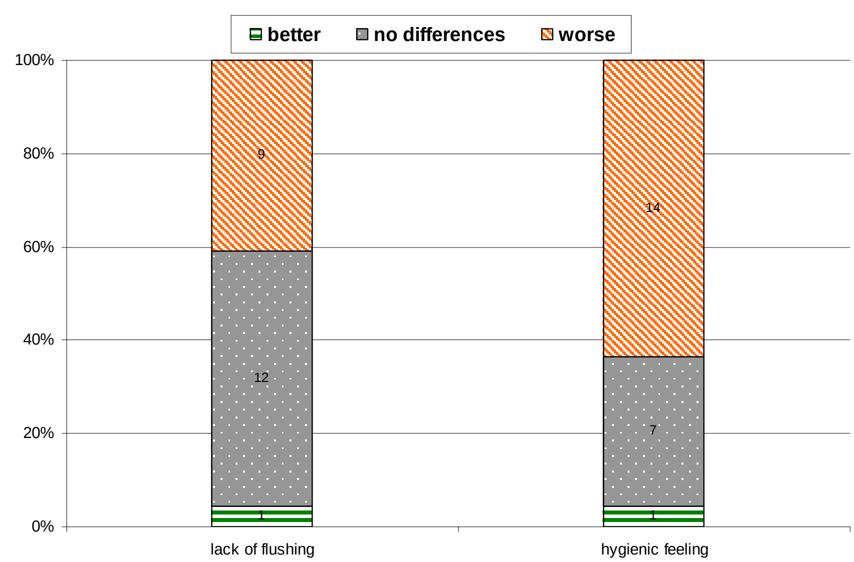


Fig. 3.1.5: Results from the urinal assessment

As the figure shows about 60 % of the users who used the questionnaires does not care about the missing flush. It seems that users accept waterless urinals in principle. But on the same time about 60 % have a worse hygienic feeling compared with conventional urinals. This shows that the quality of the urinals should be improved or the awareness of the users has to be increased by more information. The hygienic feeling could be improved, e.g. if the urinal surface would be made smoother to permit the urine to flow easily to the effluent without urine drops on the surface.

3.1.4.4 Gravity separation toilet assessment

In the following results from questions 5 and 6 of the questionnaire (**Fig. 3.1.1**) will be presented. The results from question 5 are evaluated in **Fig. 3.1.6**.

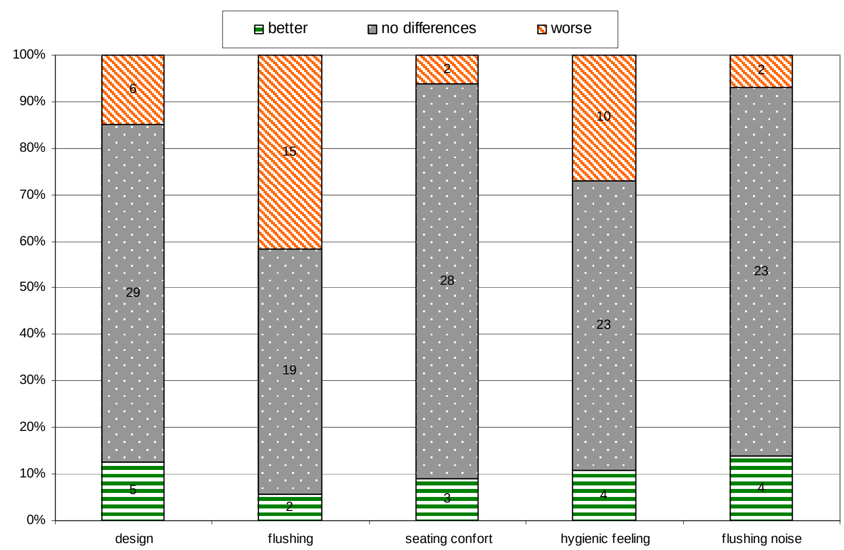


Fig. 3.1.6: Results from the gravity separation toilet assessment

This figure shows that the users who answered the questionnaire do not see a difference to the conventional toilets for the most parameters in general. In total about 70 % of the answers are *no differences* and *better*. That means a good acceptance for this type of toilet. Nevertheless two weakness are clearly observable; the flushing, with a dissatisfaction rate of 42% and the hygienic feeling which is considering by nearly one user over three as worse compared with conventional toilets. Probably those two parameters are linked. This shows clearly that the flushing system has to be improved as mentioned already in paragraph 3.1.1. This unsatisfied flush system is also underlined by the fact that 57 % of the users have pushed the flushing bottom more than ones.

The acceptance of this gravity separation toilet regarding the design and seating comfort is also important. In relation to the design only 12 people saw some negative differences to conventional toilets. Due to the very similar design to conventional toilets this is very obvious. For 91 % of the users the seating comfort is the same or even better in relation to the conventional toilets. Only few remarked on the questionnaire that the seating comfort is worse; here the user was not satisfied with the seating position.

3.1.4.5 Vacuum separation toilet assessment

Like for the gravity separation toilets above in the following results from questions 5 and 6 of the questionnaire (**Fig. 3.1.1**) related to the vacuum separation toilets will be presented. The results from question 5 are showed in **Fig. 3.1.7**.

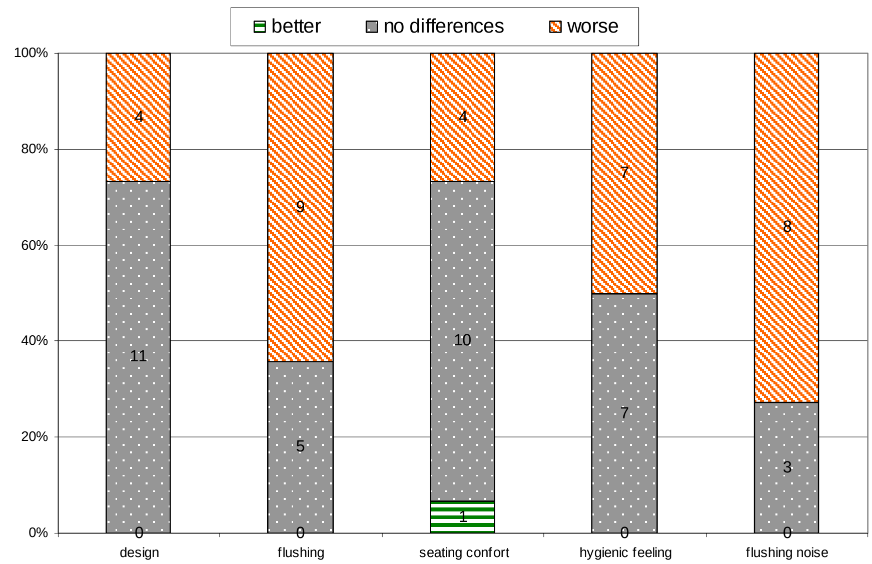


Fig. 3.1.7: Results from the vacuum separation toilet assessment

The results in relation to the design are comparable to the results from the gravity separation toilets. Because the vacuum separation toilets are altered gravity separation toilets (see 2.4.1) this doesn't surprise. The flushing of these toilets is worse compared with conventional toilets, which are already mentioned in paragraph 3.1.2. This is approved by 64 % of the users, which answered the questionnaire. For cleaning the toilet 33 % of the users pushed twice on the flushing bottom per use and 22 % even three times. Concerning the hygienic feeling, 50 % of the users consider that the hygienic feeling is worse compared to conventional toilets. This can be linked with the flushing problem. A further weak point for this vacuum separation toilet is the flushing noise. With every flush the vacuum valve opens and permits the faeces to be sucked off causing a clear sucking noise. The noise is worse compared to conventional toilets; this was answered by 73 % of the users.

These results in relation to flushing, flushing noise and hygienic feeling were expected since the used toilets are provisional vacuum separation toilets. These toilets have to be improved like mentioned already in paragraph 3.1.2.

3.1.4.6 Application potential for separation toilets and waterless urinals

To know if the users would like to use the separation toilets and waterless urinals at home questions 7 and 10 are asked on the questionnaire (**Fig. 3.1.1**). The answers are given in **Fig. 3.1.8**.

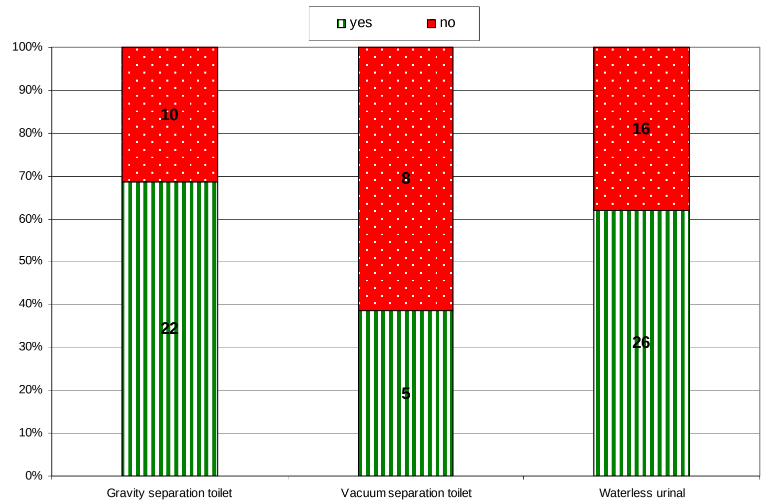


Fig. 3.1.8: Answers to question, "Could you imagine using such toilets/urinals at home?"

The answers are mainly positive for the gravity separation toilets; 69 % of the users who have answered the questionnaire would accept such toilet in their own home. The evaluation of the data showed women gave 75 % of the positive answers. Independent of the weaknesses described above, these persons could imagine the use of this type of toilet.

The results for the vacuum separation toilets show that only about 40 % of the users who filled in the questionnaire could accept such type of toilet at home. This is not surprising since the tested toilets are still provisional vacuum separation toilets.

The results concerning the urinal are mainly positive; 62 % of the persons who filled in the questionnaire would accept waterless urinals at home.

3.1.4.7 Conclusion for the user survey

The results from the user survey in relation to the different separation toilets and waterless urinals by means of a questionnaire show that these facilities are not declined in general. About 70 % of the users who answered the questionnaire could image using gravity separation toilets at home. Over 50 % would also accept waterless urinals at home but only 40 % can imagine using vacuum separation toilets at home. These are in general results, which are motivating for further improvements of the separation toilets and urinals. The results presented are from 61 answered questionnaires. It will be interesting to see the survey results at the end of this demonstration project when more answers will be available especially from the users of the apartment house.

3.2 Pipes

The different pipes for grey, brown and yellowwater installed in the frame of this demonstration project are mentioned in paragraph 2.4.2. The experiment with these pipes did not show any problems until now. Two acrylic glass pipes are installed in the yellowwater pipes for observation purposes. In one only very few and in the other one where the most toilets and urinals are connected the sediments have a heights of about 5 mm.

3.3 Vacuum plant

The vacuum plant (see 2.4.3) is now in operation since the first installation of the first vacuum toilet (see 3.1.2) in December 2003. No serious problems occurred until now. One imported prerequisite for a reliable operation is a regularly service. This service has to be done once a year for the plant in the office building. This service includes also the maintenance of different vacuum equipments from each vacuum separation toilet like cleaning of the one-way valves in the vacuum tubes near the interim storage tanks.

One serious problem occurred with a control valve from the interim storage tank of the first installed vacuum separation toilet very soon after start up of operation, which had to be exchanged.

3.4 Stored urine

Until now urine was collected only from office building since the urine pumps for pumping urine from apartment house were not installed until the end of July 2005. The urine from the office building flows into the urine tanks (see 2.4.4) by gravity. The filling characteristics of the four different urine tanks and the storage times of the urine are shown in **Fig. 3.4.1**.

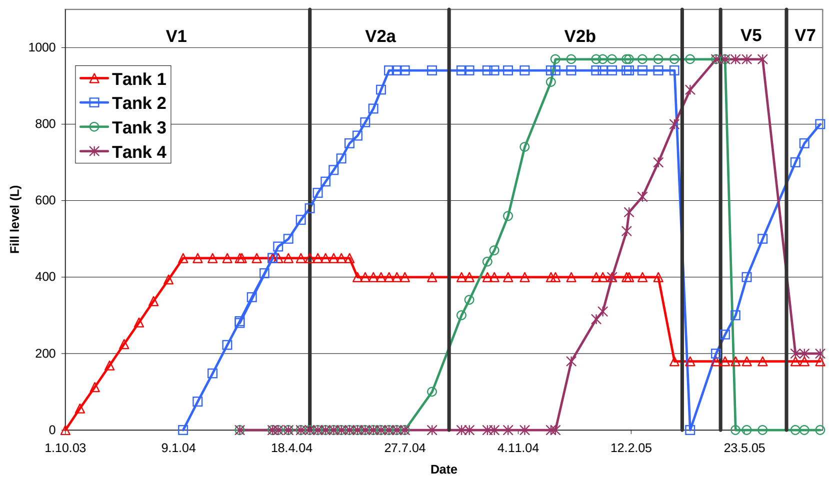


Fig. 3.4.1: Fill characteristic of the urine tanks and storage time of the urine from the office building

Tank 1 was closed after half filling. From time to time urine was taken out for different fertiliser experiments at the Humboldt University Berlin (see below).

The daily flow of urine from the office building is drawn in **Fig. 3.4.2**.

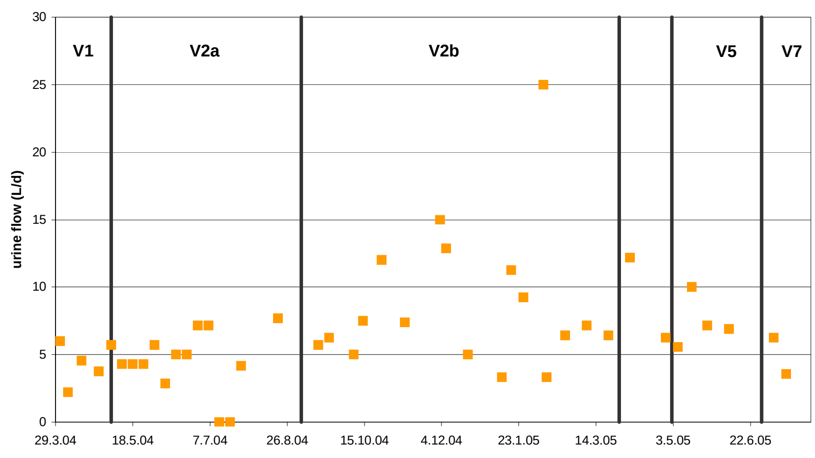


Fig. 3.4.2: Daily flow of urine from the office building

As this figures shows the average amount of urine from the office building is about 7 L/d. Until now this urine is only used for fertilising purposes from the Humboldt University Berlin in the framework of Task 8 "*Fertiliser usage*" of this Demonstration project. In future this urine will also be used for the investigations at the Technical University Hamburg-Harburg who is carrying out Task 7 "*Industrial style urine treatment for utilization*". Up to the present urine from waterless urinals from the city Hamburg is used for these investigations.
The concentrations of the analysed parameters from the urine of the different tanks and from literature are listed in **Tab. 3.4.1**.

Tab. 3.4.1: Concentration of chemical parameters of the urine from office building (grab samples) and from literature

parameter	unit	office building stored urine tank 1	office building stored urine tank 1	office building stored urine tank 1	office building stored urine tank 2	office building stored urine tank 3	office building stored urine tank 4	literature[1] fresh urine mean values
sample day		1 Apr 04	6 July 04	10 Feb 05	10 Feb 05	10 Feb 05	10 June 05	-
filling time	months	3	3	3	6	5	5	-
storage time	months	3	9	13	7	2	1	-
pH	-	8.6	8.5	8.6	8.7	8.8	9	6.2
conductivity	µS/cm	40,880	38,400	41,600	37,400	35,800	37,300	-
SS	mg/L	225	200	85	114	670		-
COD	mg/L	7,520	5,560	2,850	8,250	8,610	7,600	10,000
TOC	mg/L	2,590	2,080	1,055	3,326	3,312	-	-
Norg	mg N/L	-	-	-	320	190	210	-
NH_4-N	mg N/L	4,280	4,050	3,950	3,410	3,380	3,900	-
NO_2-N	mg N/L	< 0.05	< 0.05	0.6	0.5	0.5	-	-
NO_3-N	mg N/L	< 0.3	< 0.3	< 0.3	0.7	< 0.3	-	-
N-total	mg N/L	-	-	-	3,741	3,571	4,110	9,200
P-total	mg P/L	380	370	396	426	441	370	740
Cl^-	mg/L	4,820	4,310	514	521	513	-	3,800
Ca^{2+}	mg/L			6.2	9.9	45	-	190
K^+	mg/L	2,000	2,300	2,000	2,000	2,100	-	2,200
Mg^{2+}	mg/L	-	-	1.2	1.5	14	-	100
Cd^{2+}	µg/L	-	-	< 3	< 3	< 3	-	-
Cr^{3+}	µg/L	-	-	< 5	< 5	< 5	-	-
Cu^{2+}	µg/L	-	-	3,400	2,100	2,000	-	-
Hg^{2+}	µg/L	-	-	< 0.2	< 0.2	< 0.2	-	-
Ni^{2+}	µg/L	-	-	< 10	< 10	< 10	-	-
Pb^{2+}	µg/L	-	-	37	< 15	< 15	-	-
Zn^{2+}	µg/L	-	-	2,200	780	960	-	-

[1] (Udert et al. 2004)

For analysing the urine grab samples have been taken from the tanks. Before taking the samples the urine was mixed with a barrel pump. In this table it is distinguished between filling time of the tanks and storage time of the urine. In the storage time no fresh urine was added to the tanks. From the first two samples from tank 1 not all parameters were analysed for different reasons. The same is true for the sample from tank 4. The literature data are average values from different sources (Udert et al. 2004).

The comparison of the values from urine of the office building with the literature values show in general that the urine from the office building is less concentrated, e.g. the concentration of N-total is hardly half as high as the mean value from literature. One reason for this may be that the users in the office building went already to the toilets before they use the toilets and urinals in the office building and dispense less concentrated urine. In relation to heavy metals Cu and Zn are mainly detected. These metals are probably originated mainly from the drinking water pipes.

Besides of chemical parameters the urine from the different tanks are also analysed in relation to micropollutants at IWW-laboratory (Universität Duisburg 2005). The results are listed in **Tab. 3.4.2**

Tab. 3.4.2: Concentration of micropollutants of the urine from office building (grab samples)

urine tank		1	1	2	3	4
sample day		22 Apr 04	29 Okt 04	15 March 05	15 March 05	10 June 05
filling time	month	3	3	6	5	5
storage time	month	2.5	6.5	8	3	1
lipid reduction						
Clofibrinsäure	µg/l	3.7	< 1	< 1	< 1	< 1
Bezafibrat	µg/l	485	2,200	2.7	< 1	1,029
Fenofibrat	µg/l	< 1	< 1	< 1	< 1	< 1
analgetika/antiphlogistika						
Diclofenac	µg/l	8.2	13	33.8	33.7	8.5
Fenoprofen	µg/l	1.6	< 1	< 1	< 1	< 1
Ibuprofen	µg/l	570	600	370	436	263
Indometacin	µg/l	< 1	< 1	< 1	< 1	< 1
Phenactecin	µg/l	< 1	< 1	< 1	< 1	< 1
Phenazon	µg/l	< 3	< 3	15.5	< 3	< 3
Ketoprofen	µg/l		42	3.2	1.8	< 1
antiepileptika and blood circulation increasing substances						
Carbamazepin	µg/l	< 1	< 1	1.5	1.4	7.9
Pentoxyfyllin	µg/l	< 1	< 1	< 1	< 1	< 1
natural und synthetic hormons						
3-Hydroxyestra-1,3,5(10)-trien-17-on	µg/l	< 10	< 10	< 10	< 10	< 10
17a-Ethinyl-1,3,5(10)estratrien-3,17ß-diol	ng/l			< 50	< 50	< 50
17 α-Ethinylestradiol	µg/l	< 50	< 50			
β-Sitosterol	µg/l	2.5	< 2.0	< 1	< 1	5

The results in this table represent only urine from users of the office building and are not representative for a huge population. The kind of the analysed micropollutants is chosen based on experiments on other places.

As the table shows the concentration of the most micropollutants are below the detection value (<). The increased storage time from 2.5 up to 6.5 months of the urine from tank 1 did not induce to significant lower concentrations. The significant higher concentration for Benzafibrat may be caused from the analysing procedure. The constellation for urine collecting makes it difficult to investigate how the concentrations of micropollutants change from fresh to stored urine since stored urine is always mixed by fresh urine during the filling time of the tanks (see also **Fig. 3.4.1**). In future samples will be taken for micropollutant analysis immediately after the tank is closed and one more after a storage time of some months before emptying the tank.

3.5 Treatment facilities

3.5.1 General

The following presentation of the results and discussion will not be divided into the different tested variants but into the different facilities. Due to this procedure the explanation of the processes and the treatment stages will be more understandable.

3.5.2 Faeces separator

The main objective of the faeces separator (see 2.4.6) is the collection, dewatering and thickening of the solid faeces as a preparation step for the following composting process. The volume of the treated brownwater during the different variants (see 2.3) is shown in **Fig. 3.5.2.1**.

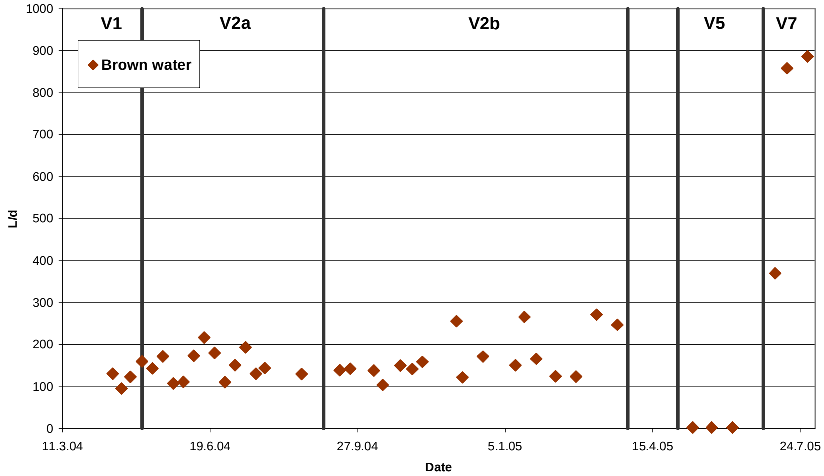


Fig. 3.5.2.1: Brownwater flow during the different variants

The brownwater for *Variants V1* to *V5* was only originated from the gravity separation toilets of the office building and starting with Variant *V7* mainly from the gravity separation toilets of the apartment house. After the installation of the vacuum separation toilets only one gravity separation toilet from the office building is still connected to the faeces separator (see 2.3, *Variant V5*) but this one left is less frequented. This was the only gravity separation toilet, which was connected to the faeces separator during *Variant V5*. Therefore the flow into the faces separator is nearly zero during this phase. With the connection of the toilets of the apartment house the brownwater flow increased significantly from the former 150 L/d (V2b) to 900 L/d (V7). This is comprehensible since the number of connected people increased from about 10 in office building up to about 25 people in the apartment house. Furthermore the toilets in the apartment house are more frequently in use especially during the week-end.

The increased brownwater volume obliged to change the operational mode of the faeces separator. Instead of two filter bags four filter bags are in use. The pore size of these filter bags is 1.4 mm. The kind of these filter bags are already installed since 10 May 2005. Before this time the pore size was 1.2 mm (see 2.4.6). Two of them are alternatively used always in parallel for three to four days. This prevents in general an overflow of the filter bags.

The efficiency of the faeces separator in relation to suspended solids (SS) is demonstrated in **Fig. 3.5.2.2**.

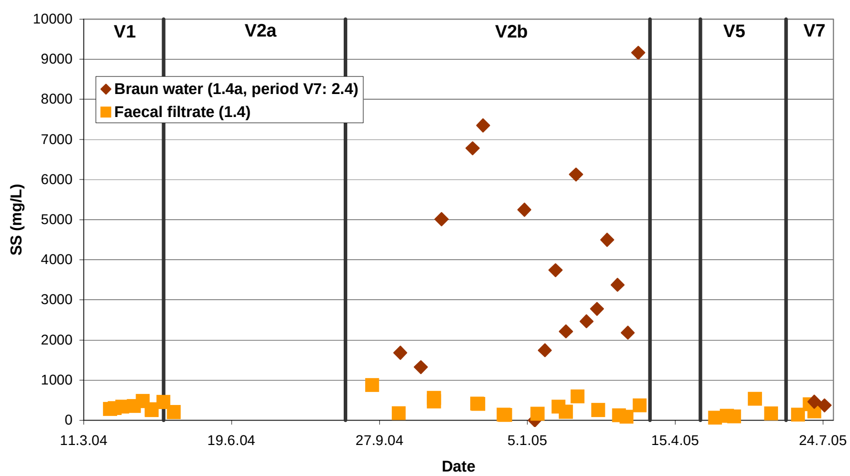


Fig. 3.5.2.2: SS concentrations of brownwater in the infl. and effl. of the faeces separator during the different variants (24 h-composite samples)(1.4, 1.4a and 2.4 are samplings points, see **Fig. 2.3.7**)

During *Variant V2a* no samples have been taken from brownwater since it was diverted to the WWTP in this time (see 2.3). Sampling of the influent was started with *Variant V2b*. No influent sampling was undertaken during *Variant V5* since brownwater from only one gravity separation toilet was pumped to the separator.

As the results for *Variant V2b* in this figure shows the SS influent concentration varied in a wide range from 1,000 up to 9,000 mg/L. The most probably reason for this variation maybe the kind of sampling (see 2.5.2). Since no reliable automatic sampler is available for taking a representative sample of the inhomogeneous brownwater samples had to be taken manually. These samples have been grab samples which are taken once a day always from Monday to Friday. These grab samples were mixed to a one week composite sample. The same kind of sampling is also used for brownwater sampling from the apartment house (*Variant V7*). The first two values of the SS influent concentration cannot be accepted as a realistic value, but are a hint for the concentration range expected in future. The SS effluent concentration of the separator was mainly below 500 mg/L. The level of the effluent concentration did not change with the change of the filter bags with a larger pore size. The mean values of SS and other parameters for *Variant V2b*, which had the longest operation time and for which influent and effluent values are available, are listed in **Tab. 3.5.2.1**.

Tab. 3.5.2.1: Efficiency of faeces separator; influent (sampling point 1.4a) and effluent (sampling point 1.4) concentration and elimination of different parameters (24 h-composite samples, mean values) from brownwater

		Variant V2b (4.9.04 - 29.3.05)			
		influent (1.4a)	effluent (1.4)	elimination	elimination (%)
Qd	L/d	169	169		
Temperature	°C	-	7		
SS	mg/L	4104	331	3774	92
COD	mg/L	4774	1007	3766	79
BOD	mg/L	1565	354	1212	77
Norg	mg N/L	133	45	88	66
NH_4-N	mg N/L	23	26	-2	-9
N-total	mg N/L	156	70	86	55
P-total	mg P/L	40	20	20	50
SS	g/d	692	56	637	92
COD	g/d	805	170	635	79
BOD	g/d	264	60	204	77
Norg	g N/d	22	8	15	66
NH_4-N	g N/d	4	4	0	-9
N-total	g N/d	26	12	15	55
P-total	g P/d	7	3	3	50

The influent and effluent flow of 169 L/d is assumed to be the same since the volume of the solids in the brownwater is negligible in comparison with the liquid one. The function of the faeces separator is the elimination of unsolved substances from the brownwater. In opposite to separation technologies like sedimentation a collection of dry material is wanted. It is expected that dissolved substances will pass the separator; in parallel a small part may be adsorbed by the organic solids. As the figures show fare the highest amount of SS (92 %) has been remained in the filter bags. But the SS effluent concentration with 331 mg/L is still very high. The nitrogen parameters show that in the influent most of it has been organic nitrogen. In total 55 % of nitrogen could be retained in the faeces separator. Nearly the same percentage (50 %) could be retained from phosphorous.

The figures in this table show in general that an efficiency of solid separation of more than 90 % occurs. Due to the high influent concentration a concentration of more than 300 mg/L of solid matter remains in the effluent. This could be achieved by a smaller pore size, which is unfortunately connected with a significant smaller filtration rate of the separator. A significant increase of the separation efficiency will only be expected with other separation systems. Besides of better separation efficiency for larger units the bag filtration system is not recommended. Here a separation facility, which works continuously, has to be implemented. Therefore the filter bags used in the project can also be applied in small units for small or low house numbers.

3.5.3 Compost technique

As described in paragraph 2.4.7 dewatered faeces have been brought twice to the experiment field of the Humboldt University Berlin for composting until now. But in **Tab. 3.5.3.1** only dates from the first delivered dewatered faeces are mentioned. The composting process of the second delivered faeces is still continuing.

Tab. 3.5.3.1: Dates from the first faeces compost

fill time of filter bags (11.3.04 - 20.9.04)	month	≈ 6
composting time (20.9.04 - 26.4.05)	month	≈ 7
composting temperature	^oC	≈ 20
compost mass	kg	≈ 60
dried solid content	%	40.6
dried solids (DS)	kg	≈ 25
org. dried solid content	%	79.9
N total	%	2,73
N Kjeldahl	mg/kg DS	13,600
P total	mg/kg DS	3,400
Potassium (K)	mg/kg DS	2,800
Calcium (Ca)	mg/kg DS	23,000
Cadmium (Cd)	mg/kg DS	1.5
Chrome (Cr)	mg/kg DS	25
Copper (Cu)	mg/kg DS	210
Magnesium (Mg)	mg/kg DS	1,500
Nickel (Ni)	mg/kg DS	22
Lead (Pb)	mg/kg DS	30
Zink (Zn)	mg/kg DS	720
Mercury (Hg)	mg/kg DS	0.44
colony count at 22°C	cfu/1mL	3,300,000
colony count at 36°C	cfu/1mL	3,700,000
E-coli	cfu/g	11,000
coliform germs	cfu/g	340,000
Clostridium perfringens	cfu/g	0
Salmonellen	1/g	positiv

The remained dried solids of the composted faeces which were collected for about 6 months and have been composted by a composting temperature of around 20 ^oC for about 7 months was approx. 25 kg. Unfortunately it is not possible to compare this mass with the initial mass since it was not measured. The results from the analysis of this compost should give just a first overview of the composition of the first faeces compost. More will be discussed in the final report when more compost is produced.

3.5.4 Soil filter

The soil filter (see 2.4.8) was used at the beginning of the project in order to treat the filtrate from the faeces separator. It was expected to remove already pathogen germs before treatment with the constructed wetland together with pre-settled greywater. But after about five weeks of operation clogging and blockages occurred in the soil filter. The reason of this had been a higher loading of the faeces filtrate with solids as expected. Due this fact the operation of this soil filter was stopped on 5 May 2005. This operation period is described as *Variant V1* (see also 2.3).

In order to follow the performances of the soil filter two measurement points were taken into account, point 1.4 (effluent of the faeces separator and influent of the soil filter) and point 1.5 (effluent of the soil filter).
The **Fig. 3.5.4.1** shows the influent and effluent concentration of the suspended solid for the period of *Variant V1*.

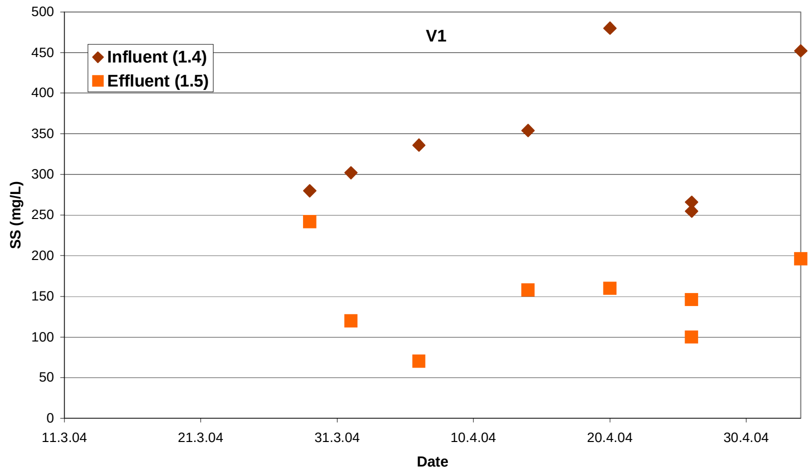


Fig. 3.5.4.1: Influent and effluent SS-concentration of the soil filter (24 h composite sample)

As the figures show the influent concentration fluctuated from 250 to 500 mg/L and in the effluent from 70 to 250 mg/L.

In **Tab. 3.5.4.1** mean values of different parameters from the soil filter are presented.

Tab. 3.5.4.1: Influent and effluent concentrations of different parameters from the soil filter (mean value)

		Variant V1 (11.3.05 - 5.5.04)			
		influent (1.4)	effluent (1.5)	elimination	elimination (%)
Q_d	L/d	144	144		
q_A	m³/(m².h)	0,0075	0,0075		
Temperature	°C	16	13	3	16
pH		7,5	7,3	0,2	3
Conductivity	µs/cm	1478	1582	-104	-7
O_2	mg/L	1,0	1,8	-0,8	-75
SS	mg/L	341	149	192	56
COD	mg/L	910	534	376	41
N org	mg/L	40	22	18	45
NH_4-N	mg/L	27,7	30,1	-2,3	-8
NO_3-N	mg/L	1,8	1,0	0,8	44
NO_2-N	mg/L	0,3	0,1	0,2	74
PT	mg/L	15,7	10,2	5,5	35
PO_4-Pf	mg/L	12,1	9,1	3,0	24
TOC	mg/L	141	138	3	2
BOD	mg/L	360	70	290	81
SS	g/d	49	22	28	56
COD	g/d	131	77	54	41
N org	g/d	6	3	3	45
NH_4-N	g/d	4,0	4,3	0	-8
NO_3-N	g/d	0,25	0,14	0,11	44
NO_2-N	g/d	0,04	0,01	0,03	74
PT	g/d	2,26	1,47	0,8	35
PO_4-Pf	g/d	1,75	1,32	0,4	24
TOC	g/d	20,3	19,9	0,4	2
BOD	g/d	51,9	10,1	42	81

The flow is assumed to be the same for the influent and effluent and is listed as the average value during the period.

The flow through the soil filter during *Variant V1* was 144 L/d, which is below the designed flow rate of 685 L/d (see table **Tab. 2.4.2**). The soil filter was designed in order to treat the entire faeces filtrate of the faeces separator coming from the apartment house and the office building. During *Variant V1* only the office building was connected with the facilities.

As the tables shows 56 % of SS could be removed. Other substances, which are connected to the SS, are also partly removed, e.g. the elimination rate of COD was 41 %. Since the operation of this soil filter was not satisfying from start on no bacteriological parameters have been analysed.

Until now this soil filter was not operated again. A reliable operation of it can only be expected if the SS-concentration in the faeces filtrate would be far below 50 mg/L. But this gaol can not be achieved with the used faeces filter bags (see 2.4.6).

3.5.5 Septic tank

The septic tank is the pre-treatment step before the constructed wetland. The treatment process is mainly sedimentation. The volume treated during *Variant V1 to V7* is drawn in **Fig. 3.5.5.1**.

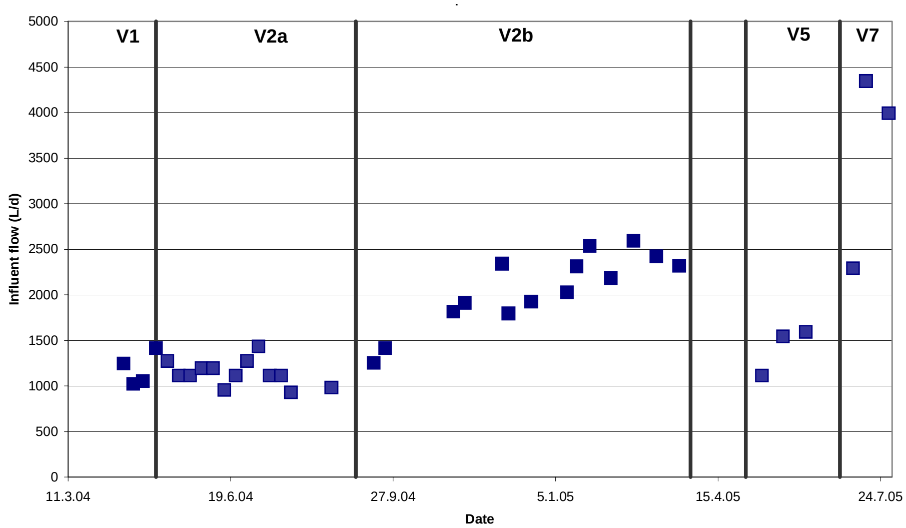


Fig. 3.5.5.1: Influent flow of septic tank

During *Variant V1* the flow consisted of greywater from the office building and of faecal filtrate from the effluent of the soil filter. In the period of *Variant V2a* it was only greywater from office building. For *Variant V2b* the influent consisted of greywater from the office building and of faecal filtrate from the faecal separator. In the time of *Variant V5* the influent was practically only greywater from the office building since in that time only one gravity separation toilet was connected to the faeces separator, which was very few used. During *Variant V7* the influent existed from greywater from office building and from the apartment house as well from faeces filtrate from faeces separator which was fed practically only from brownwater of the apartment house (see also 2.3). As **Fig. 3.5.5.1** shows the flow increased from about 1,300 L/d in *Variant V1* up to about 4,500 L/d in *Variant V7*. The most time these flows have been below the design flow of 4,580 L/d. The retention time of the different flows in the septic tank is visualised in **Fig. 3.5.5.2**.

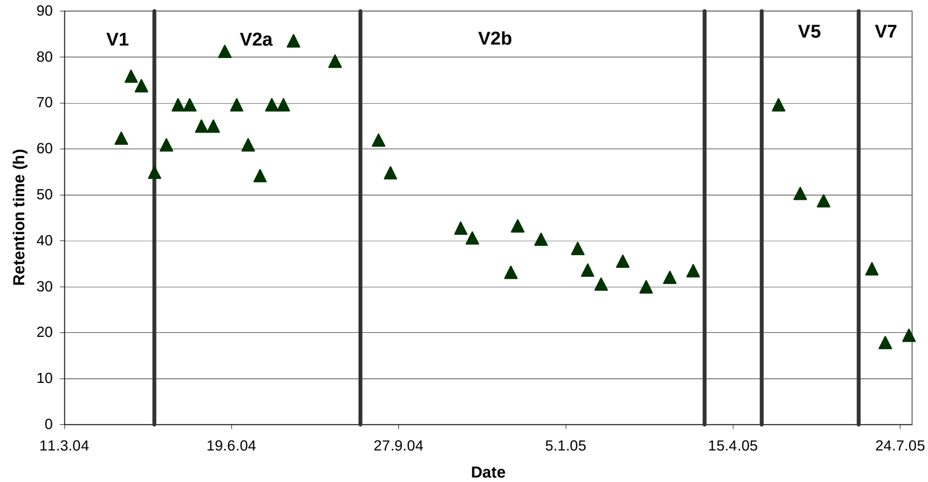


Fig. 3.5.5.2: Retention time of the flow in the septic tank

The retention time during the most variants has been very high due to the low flows. The designed retention time is 3.7 h for the operation situation when the septic tank is half filled with sludge (see 2.4.9). At the end of April 2005 it was checked if much solids are on the bottom of the septic tank. The result was that no significant solids layer could be found. This was proved when the septic tank was cleaned on 2 May 2005. Only about 4 kg solids could be measured. This is the reason why the retention time in **Fig. 3.5.5.2** was calculated with the whole useful volume of the two chambers of the septic tank. As a consequence of the very less solids in the septic tank the retention time for further operation will be about 10 hours since the flow is now nearly equal to the designed flow (see flow from *Variant V7* in **Fig. 3.5.5.1**).

The quality in relation to SS in the effluent of the septic tank is demonstrated in **Fig. 3.5.5.1**.

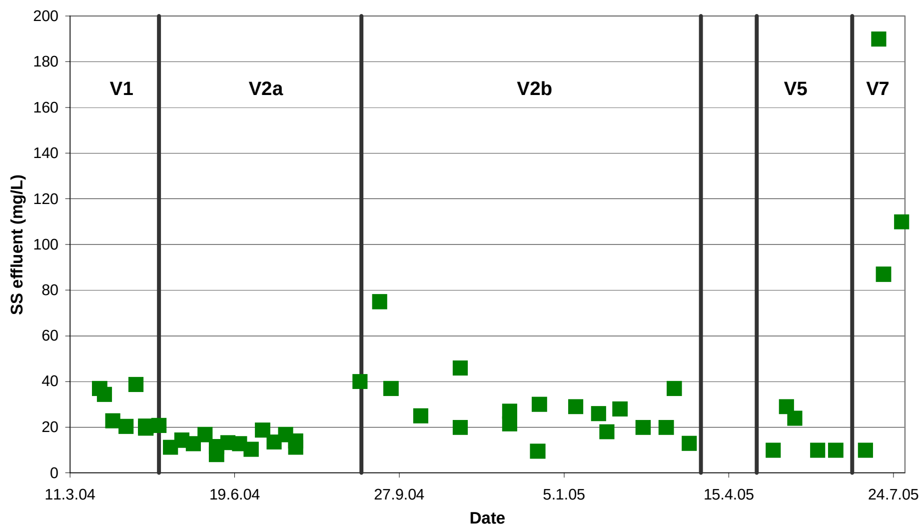


Fig. 3.5.5.3: SS-concentration in the effluent of the septic tank (24 h-composite sample)

Unfortunately it can not be showed for the first three variants how much the SS-influent concentration was since analysing of greywater was started first at the end of *Variant V2b*. Until the time of Variant V5 the SS-concentration was mainly below 40 mg/L. This concentration is below the concentration of 100 mg/l (or 5 g SS/(m^2 d)) where silting of the constructed wetland favoured may occur (Winter and Goetz, 2004).

As described above the analysing of greywater was first started at the end of *Variant V2b*. For that reason mean influent and effluent values could only be calculated for *Variant V5* (the time of *Variant V7* is to short for mean values) which are listed in **Tab. 3.5.5.1**.

Tab. 3.5.5.1: Influent and effluent concentrations as well elimination efficiency of the septic tank during *Variant V5*

Variant V5 (3.5. - 29.6.2005)					
		influent	effluent	elimination	elimination (%)
		grey water (1.2a)	(1.2)		
Q_d	L/d	1419	1419	-	-
retention time	h	56	-	-	-
temperature	°C	-	17	-	-
SS	mg/L	58	17	-	-
COD	mg O_2/L	189	101	-	-
BOD	mg O_2/L	72	47	-	-
NH_4-N	mg N/L	0.43	5.23	-	-
Norg	mg N/L	8.3	2.6	-	-
N total	mg N/L	9.0	8.1	-	-
NO_3-N	mg N/L	0.27	0.24	-	-
NO_2-N	mg N/L	0.04	0.02	-	-
P-total	mg P/L	2.0	2.0	-	-
PO_4-P_f	mg P/L	1.0	1.6	-	-
SS	g/d	82	24	59	71
COD	g O_2/d	268	144	124	46
BOD	g O_2/d	102	67	35	34
NH_4-N	g N/d	0.60	7.42	-6.8	-1131
Norg	g N/d	11.7	3.7	8.0	68
N total	g N/d	12.8	11.5	1.3	10
NO_3-N	g N/d	0.38	0.34	0.04	10
NO_2-N	g N/d	0.06	0.03	0.03	49
P-total	g P/d	2.9	2.8	0.1	4
PO_4-P_f	g P/d	1.5	2.3	-0.8	-56

During this period the inflow was practically only greywater (see above). As the influent concentrations show the values are very low since the greywater was mainly from the showers and the hand wash basins of the office building. About 70 % of the SS could be removed. Due to the sludge collected at the bottom and the long retention time anaerobic conditions occur very rapidly. Therefore organic nitrogen transferred to ammonium and phosphorus was released which increased the NH_4-N- and PO_4-P_f-concentrations in the effluent.

3.5.6 Constructed wetland

The efficiency of the treatment of the different wastewater flows in the constructed wetland will be assessed by using the concentration lines as well as the mean values of loadings in the table which is presented at the end of this paragraph (**Tab. 3.5.6.1**). In this table all removal rates are calculated on the base of loads, detailed information are given below by description of the calculations concerning the nitrogen removal. The constructed wetland was operated over a period of 1.25 years in the different conditions. All concentrations given in the discussions below are mean value from of each variant listed in **Tab. 3.5.6.1**. The variation of the concentrations can be seen in the graphs.

The hydraulic load in the influent and effluent of the constructed wetland for all variants is presented in **Fig. 3.5.6.1**.

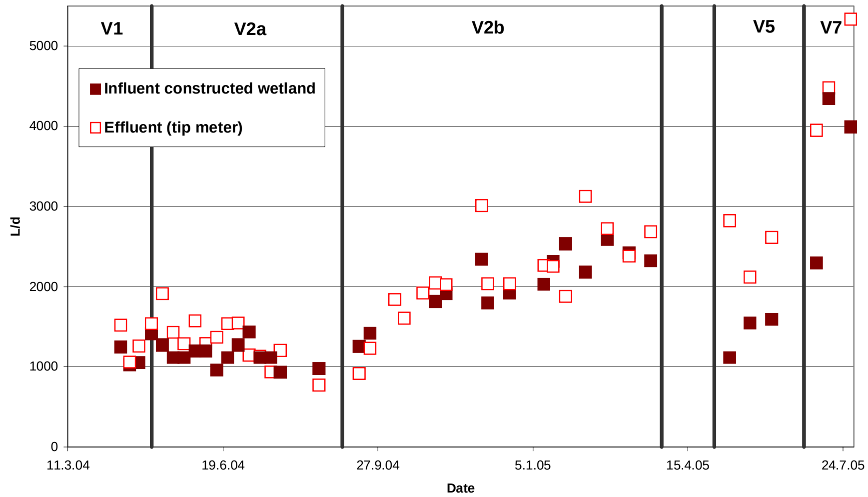


Fig. 3.5.6.1: Influent and effluent flow of the constructed wetland

This figure shows an increase of the volume during *Variant V2b* and again during *Variant V7*. The first increase is due more users in the office building and the second increase due to the connection of the flats from apartment house to the treatment facilities. Higher flows in the effluent are mostly caused by storm weather. The higher effluent flow during *Variant V5* is mainly due to the fact that the retrofitted layer in April 2005 (see 2.4.10) was irrigated with industrial wastewater (which is micro filtered effluent from the WWTP Stahnsdorf) for better growth of the plants. Some higher effluent flows during *Variant V1* and *V2*a may also be caused by problems of volume measuring in that time. The values of the flows during *Variant V7* are too less yet for a reliable interpretation.

The temperature lines (**Fig. 3.5.6.2**) show the seasonal changing of the climate. During the summertime the temperature of the wastewater increases up to 19 ^{o}C, the effluent of the constructed wetland has the same temperature. During the winter the temperature of the wastewater goes down to less than 10 ^{o}C, the effluent of the wetland cools down to less than 5 ^{o}C due to the long residential time.

This temperature variation influences also the biological activity of the micro organisms, living on the surface of the filter grains.

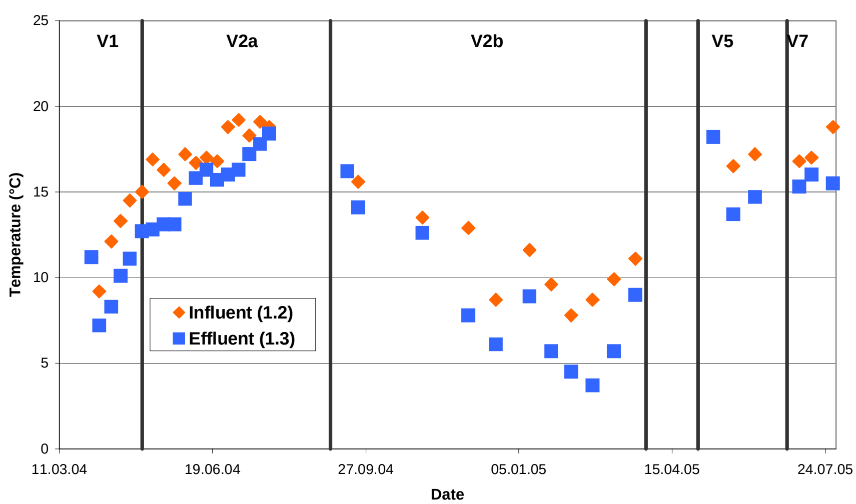


Fig. 3.5.6.2: Temperature of the influent and effluent of the constructed wetland

The COD as a parameter for the organic pollution can be seen in the **Fig. 3.5.6.3**. From *Variant V1* to *V 5* the greywater consisted mainly of the water from shower, hand wash basin and dishwashers from the office building. Only the greywater without faecal filtrate after sedimentation has had a low mean concentration of 73 mg/L (*V2a*). This concentration increases by adding the filtrate of the soil filter to 98 mg/L (*V1*). If the brownwater is treated only by a faces separator, the concentration hits a range of 101 – 136 mg/L (*V2b* and *V5*). Compared to greywater from households the concentrations are very low and are far away from the concentrations used for dimensioning the constructed wetland. Only after the connection of the apartment house to the system with its greywater from households (kitchen, bathrooms, washing machine etc.) a higher concentration level appeared. A concentration over 300 mg/L was measured but the operation time of *Variant V7* was too short for an interpretation.

The constructed wetland was significantly under loaded in the first phases of the project, therefore the low COD effluent values 30 mg/L don't surprise. Due to the low loading of the constructed wetland a dependence of the temperature can not be recognized. Also in times of low temperature like the second half of *Variant V2b* the effluent values are not higher than before.

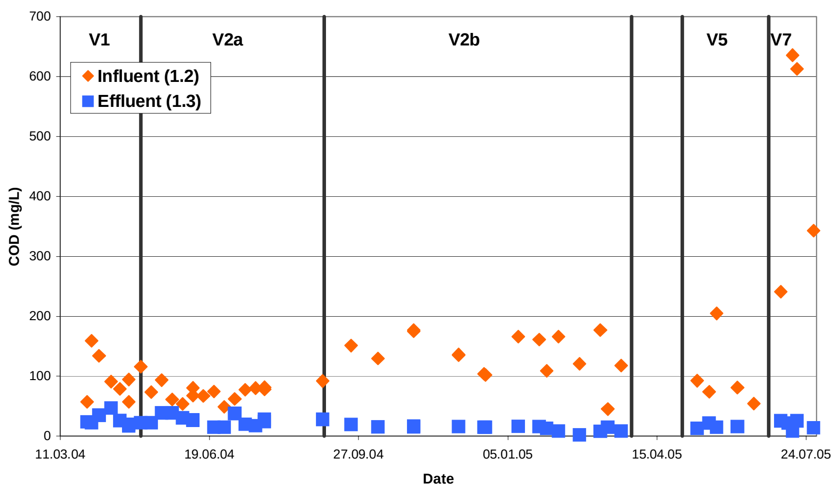


Fig. 3.5.6.3: COD of the influent and effluent of the constructed wetland (24 h composite sample)

Also the higher loading (*V7*) doesn't result in higher effluent values. This shows on the one hand the low loading on the other hand the dynamic behaviour of the wetland during higher loadings. This time of higher loading is too short for an assessment.
The BOD_5-values are less than the COD-values, but show the same behaviour (**Fig. 3.5.6.4**).

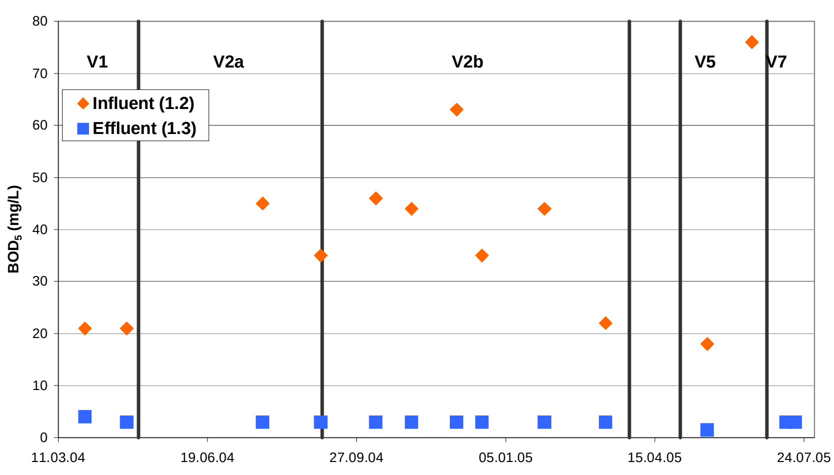


Fig. 3.5.6.4: BOD_5 of the influent and effluent of the constructed wetland (24 h composite sample)

The influent and effluent nitrogen concentrations of the constructed wetland are shown in **Fig. 3.5.6.5**.

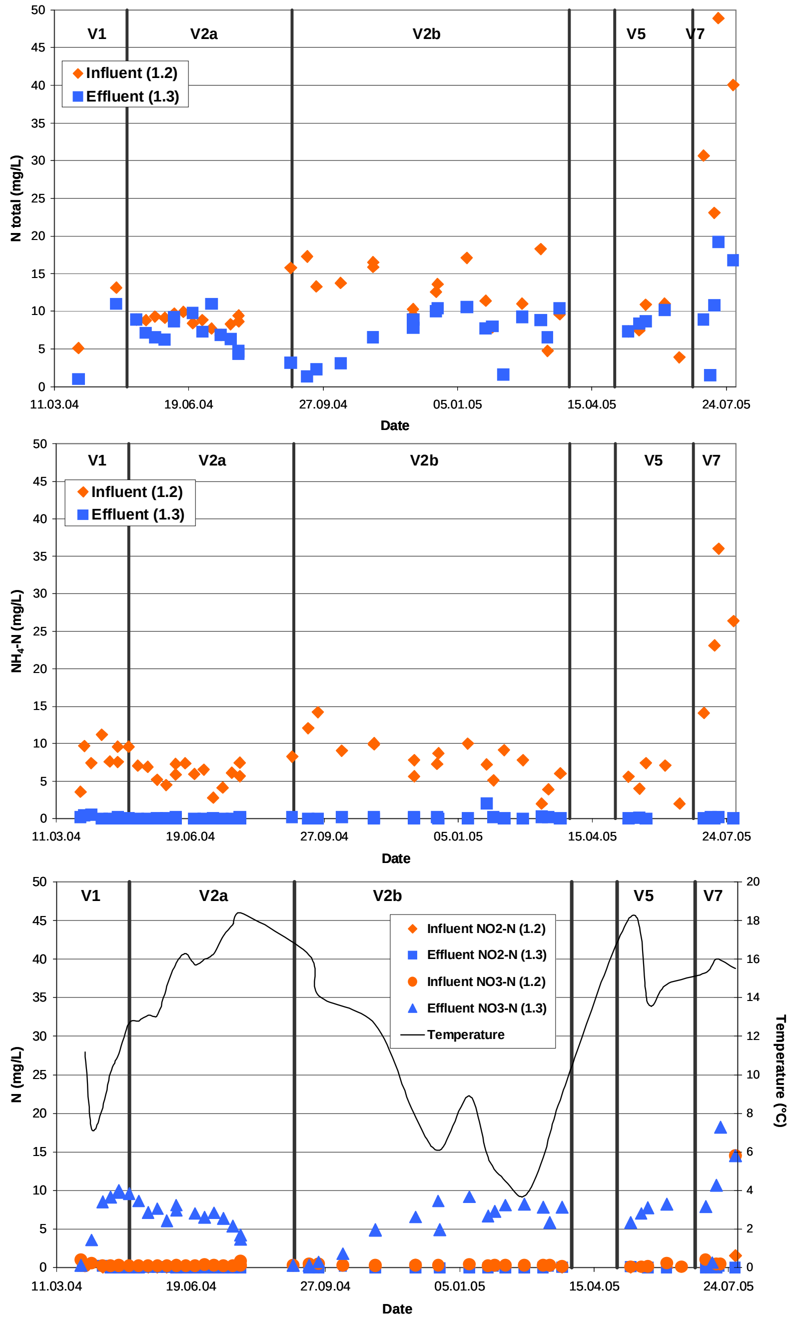


Fig. 3.5.6.5: Nitrogen parameters of the influent and effluent of the constructed wetland (24 h composite sample) (above: N-total; middle: NH_4-N; below: NO_2 and NO_3)

Compared to conventional wastewater the nitrogen concentrations in the influent of the constructed wetland during *Variant V1* to *V5* are much lower due to the urine separation. The concentration has been below 20 mg/L, the corresponding ammonia concentration is less than 15 mg/L. These values show a leakage of nitrogen in the separation system, which may be caused by a lower urine separation rate of the toilets than assumed. During *Variant V7* the concentrations increased but additional values are necessary.

Ammonia is nitrified during the whole operation time with a nitrification rate mostly of approx. 90 % (see **Tab. 3.5.6.1**) – also during winter time with a temperature below 15 °C. Most of the total nitrogen in the effluent of the constructed wetland is caused by nitrate as a product of the nitrification process. Although there is an aerobic environment in the constructed wetland a denitrification takes place. Due to the mainly aerobic conditions in the filter the denitrification of the oxidised nitrogen occurs only in part. In *Variant V7* the nitrogen concentration in the influent increased significantly up to 40 – 50 mg/L, but could be nitrified completely. The reason for this high influent concentration is still not found. Due to the higher organic loading (COD, BOD_5) the denitrification rate became higher and the nitrate concentration increases only up to 15 mg/L. During the first two phases the constructed wetland was able to bind the phosphorus on the ferric particles of the filter material. The increase of the effluent concentration starting in *Variant V2b* shows the beginning of the decrease of binding capacity (**Fig. 3.5.6.6**).

The phosphorus concentration in the influent varies from 1 – 8 mg/L with mean values of 1.9 to 3.2 mg/L during the different variants. This concentration is much higher than expected. The reason for the high values during *Variant V1 to V5* can be seen in the use of the dishwasher, which detergents contain a high concentration of phosphates. This higher concentration can be bound by the constructed wetland and the effluent concentration level seems to be constant.

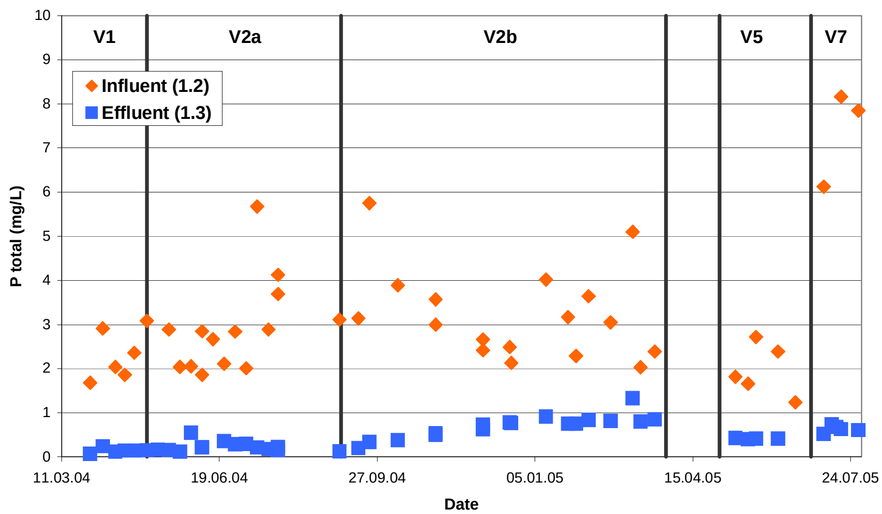


Fig. 3.5.6.6: Total phosphorus concentration of the influent and effluent of the constructed wetland (24 h composite sample)

The mean values of concentrations, loads and the volumetric load for the different variants are listed in the **Tab. 3.5.6.1**.

Tab. 3.5.6.1: Influent and effluent data of the constructed wetland (24 h composite sample, mean value)

Parameter	Symbol	Unit	Design value	V1	V2a	V2b	V5	V7
Flowrates								
Influent	Q_0	L/d	4.580	1.185	1.172	2.062	1.419	3.544
Effluent	Q_e	L/d		1.399	1.318	2.117	2.518	4.590
Hydraulic load	$B_{A,Q}$	mm/d	40	10	10	18	12	31
Temperature								
Influent	T_0	°C		12,6	17,6	10,9	17,3	17,5
Effluent	T_e	°C		10,1	15,6	7,8	15,5	15,6
COD								
Influent conc.	COD_0	mg/L		98	73	136	101	458
Effluent conc.	COD_e	mg/L		27	25	13	17	19
Load influent	$BCOD_0$	g/d		116	86	280	143	1.623
Load effluent	$BCOD_e$	g/d		38	33	28	43	87
Load Removal rate	η_{COD}	%		67	61	90	70	95
Specific load	$B_{A,COD}$	g/(m².d)	20	1,0	0,7	2,4	1,2	14
BOD_5								
Influent conc.	BOD_0	mg/L		21	40	42	47	-
Effluent conc.	BOD_e	mg/L		4	3	3	2	3
Load influent	$BBOD_0$	g/d		25	47	87	67	-
Load effluent	$BBOD_e$	g/d		6	4	6	5	14
Load Removal rate	η_{BOD}	%		78	92	93	92	-
Specific load	$B_{A,BOD}$	g/(m².d)	10	0	0	1	1	-
Total Nitrogen								
Influent conc.	$N_{tot,0}$	mgN/L			9,3	13	8,1	36
Effluent conc.	$N_{tot,e}$	mgN/L			6,7	7,1	8,6	12
Load influent	$BN_{tot,0}$	gN/d			11	27	11	128
Load effluent	$BN_{tot,e}$	gN/d			8,8	15	22	55
Load Removal rate	η_{Ntot}	%			19	44	-	57
Specific load	$B_{A,N}$	gN/(m².d)			0	0	0	1
Ammonia								
Influent conc.	NH_4N_0	mgN/L		8,3	6,1	8,0	5,2	25,0
Effluent conc.	NH_4N_e	mgN/L		0,2	0,0	0,2	0,0	0,1
Load influent	BNH_4N_0	gN/d			7,1	16	7,4	89
Load effluent	BNH_4N_e	gN/d			0,0	0,4	0,1	0,5
Org. Nitrogen								
Influent conc.	$N_{org,0}$	mgN/L			2,9	4,8	2,6	4,2
Effluent conc.	$N_{org,e}$	mgN/L			1,0	1,4	0,9	0,9
Load influent	$BN_{org,0}$	gN/d			3,4	10	3,7	15
Load effluent	$BN_{org,e}$	gN/d			1,3	3,0	2,3	4,1
Nitrate								
Influent conc.	NO_3N_0	mgN/L		0,4	0,3	0,3	0,2	4,1
Effluent conc.	NO_3N_e	mgN/L		7,3	5,7	5,5	7,2	10,4
Load influent	BNO_3N_0	gN/d		0,5	0,4	0,6	0,3	15
Load effluent	BNO_3N_e	gN/d		10	8	12	18	48
Nitrogen removal								
Nitrified Nitrogen	B_N	gN/d			9,6	23	9,2	123
Nitrification rate	η_N	%			88	87	80	96
Denitrified Nitrogen	B_{DN}	gN/d			2,1	11,8	-	75
Denitrification rate	η_{DN}	%			22	50	-	61
Total Phosphorus								
Influent conc.	$P_{tot,0}$	mgP/L		2,0	2,9	3,2	1,9	5,5
Effluent conc.	$P_{tot,e}$	mgP/L		0,1	0,2	0,7	0,4	0,6
Load influent	$BP_{tot,0}$	gP/d		2,4	3,4	6,6	2,7	19
Load effluent	$BP_{tot,e}$	gP/d		0,2	0,3	1,5	1,0	2,8
Load Removal rate	η_{Ptot}	%		92	92	78	63	86
Volumetric load	$B_{A,P}$	gP/(m².d)		0,02	0,03	0,06	0,02	0,20

For the assessment of the nitrogen removal of the constructed wetland the values are calculated as follows:

Nitrified Nitrogen	BN_N	=	$BN_{tot,0} - BN_{org,e} - BNH_4N_e$	$[g/d]$
Denitrified Nitrogen	BN_{DN}	=	$BN_N - BNO_3N_e$	$[g/d]$
Nitrification rate	η_N	=	$\dfrac{BN_N}{BN_{tot,0}}$	[%]
Denitrification rate	η_{DN}	=	$\dfrac{BN_{DN}}{BN_N}$	[%]

During the most time the constructed wetland has been operated far away from the design criteria, so the plant was under loaded most of the time. Only after the connection of the apartment house with the beginning of *Variant V7* the concentrations increased to a level known for greywater. Therefore the continuation of this *Variant V7* will give loadings, which can be used for the assessment of the constructed wetland.

Besides of the physical/chemical parameters it is also important to know how the effluent quality of the constructed wetland is in relation to bacteriological parameters. Results for total and faecal coliforms are given in **Fig. 3.5.6.7** and **Fig. 3.5.6.8**.

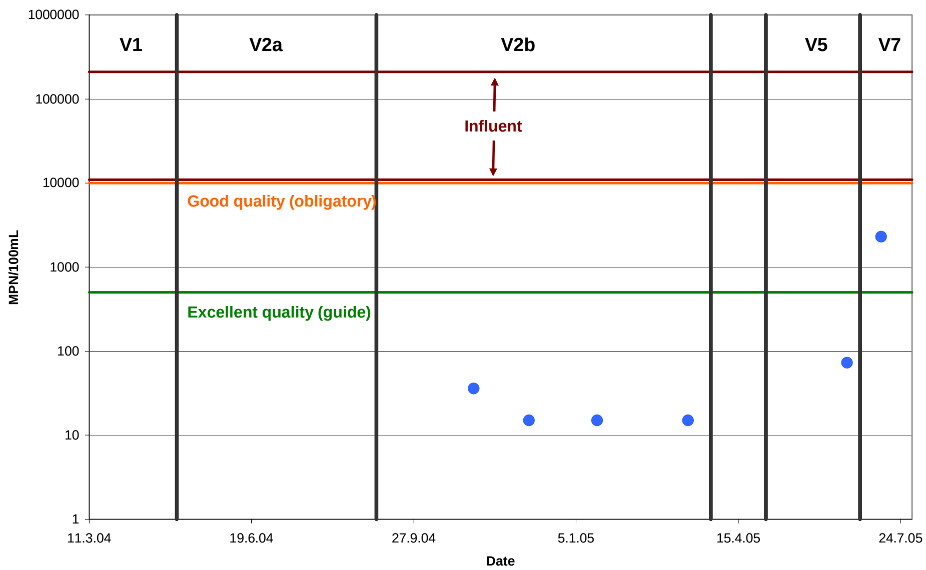


Fig. 3.5.6.7: Total coliforms in the influent and effluent of the constructed wetland

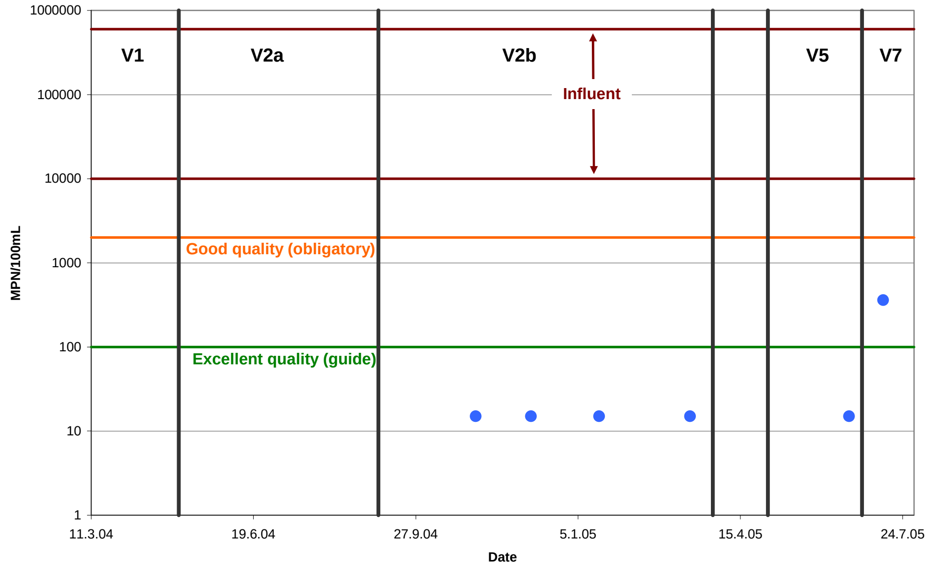


Fig. 3.5.6.8: Faecal coliforms in the influent and effluent of the constructed wetland

In the influent both parameters are investigated only ones to prove the awaited values, which are between 10^5 to 10^6 MPN/100 mL. In the effluent the values are below the excellent quality according the EU-bathing water directives (EU-Directive 1975) in both cases as far as the faecal filtrate and greywater from the apartment house (*Variant V7*) was not treated. If the values for both parameters will always be between the good and excellent quality when the waters from the apartment house are treated in addition has to be seen with the further operation.

3.5.7 Membrane bio-reactor

The study was divided into four phases:

- one starting/adaptation phase (24 May – 13 June) and
- three operating phases corresponding to 3 periods of sludge management (20, 9 and 6 days of sludge retention time (SRT).

The pilot plant was initially seeded with 35 L of sludge adapted to synthetic grey water coming from another MBR pilot plant with a start concentration of 1.5 g/L. First it was fed with grey water coming from the office building of the WWTP (25 May to 27 June 2005) which was extremely diluted compared to values mentioned in literature (Design grey water versus influent office, see **Tab. 3.5.7.2**) After the connection of 10 flats of the apartment house the grey water amount increased by 50% and the concentration increased. Therefore in phase 2 and 3, it can be regarded as more representative.

Tab. 3.5.7.1: **Summary of the operational parameters for the 3 phases (mean values in bracket)**

	PHASE 1	**PHASE 2**	**PHASE 3**
Date	14 June-27 July	28 July-9 August	10 August-7 September
Sludge age (SRT)	20 days	9 days	6 days
MLSS (g/L)	3.3 - 7 (4.4)	7.5 – 11.1 (9.2)	4 - 7.1 (4.7)
Q filtration (L/h)	10.5 – 26.3	21.5	21.5
HRT reactor (h)	2.3 – 4.6	2.0 – 2.2	1.9 - 2.0
HRT buffer max (h)	33.5	12.8	7.7
Temperature (°C)	25.3 – 28.9	25 – 27.1	24.3 – 27.8
Organic load (kgCOD/kgTS/day)	0.96	0.74	0.94
Nitrogen load (kgN/kgTS/day)	0.04	0.02	0.03

The goal of the study was to show, that the same effluent concentration could be achieved for different SRT and HRT. Variation in the incoming water can be equalized by the buffer tank. In **Tab. 3.4.7.1** the sludge age SRT, the mixed liquor suspended solid concentration MLSS, the filtration volume and the hydraulic retention time HRT for the reactor and the buffer tank, the temperature and the organic load is given for the three operating periods. In the first period the values varied in a large range because of problems countered (mixing and feeding). During phase 2 and 3 the operational parameters are very stable and will be considered for the further evaluation. The HRT was started with 4 hours but could be lowered to 2 hours retention time. The volume flow treated in the MBR-pilot plant was 21.5 L/h and the filtration flux was hold from 7 to 7.5 L/(h·m²·bar). The permeability decreases essentially the first running days and then became stable. The cleaning of the membrane was efficient. It allowed obtaining 40 % of the initial permeability. The temperature in the reactor was comprised between 24.3 and 28.9 °C (average value equal to 26 °C). The dissolved oxygen concentration was kept at a high level of about 7 mg/L because of the air volume injected.

The **Fig. 3.5.7.2** exhibits the different periods and mentions the technical problems occurred during the study as well as the evolution of the mixed liquor suspended solids (MLSS) in the reactor. The MLSS concentration measured in the reactor ranged from 1.5 (seeding value) to 11.1 g/L over the 3 months of operation. About 80 % of MLSS are mixed liquor volatile suspended solids (MLVSS). For the sludge production only a rough calculation can be done because of plant size (35L), big variation of MLSS in the reactor and the operational problems. The yield coefficient can be given with 0.06-0.09 g, 0.24g and 0.21g MLSS/COD*d for 20, 9 and 6 days SRT, respectively.

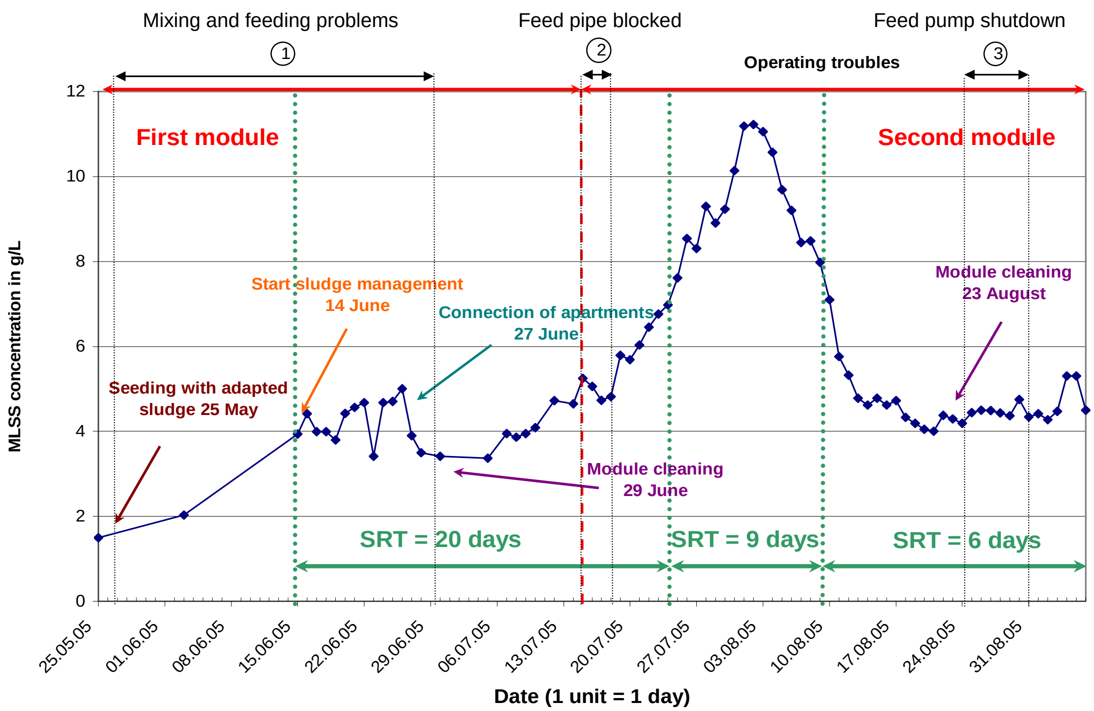


Fig. 3.5.7.1: MLSS evolution in the reactor and operational conditions

To evaluate the biological performances of the pilot plant two types of analyses were realised:

- Routines analyses: grab or 24h-mixed samples of greywater and permeate taken twice per week for each phase
- Profiles for following the evolution of raw greywater and permeate during 24 hours. Profiles were realised only for the two last operating phases (SRT = 9 and 6 days).

The following **Tab. 3.5.7.2** compared the values of greywater in literature ("design greywater") with the real greywater of the office building and after the apartment's connection for the parameters suspended solids SS, COD, total nitrogen, ammonia, nitrate, total phosphorus and phosphate. The influent and effluent parameters are given for the period after connecting the flats from apartment houses to the treatment facilities. And for this period the average elimination efficiency is also listed in **Tab. 3.5.7.2.**

Tab. 3.5.7.2: Greywater in literature ("design values"), Influent of office building, Influent and effluent concentration of greywater (with apartment houses) of MBR-bioreactor, and the elimination rate

Parameter	**Unit**	**Design Grey water**	**Influent (Office)**	**Influent**	**Effluent**	**Elimination**
# samples	-	-	**4**	**45**	**45**	-
Period			**29.5-27.6.**	**28.6- 8.9.05**		
SS	mg/L	120	21	93	-	<99.9
COD	mg/L	440	140	301	23	92
TN	mgN/L	12	9.3	15	8.1	46
NH4-N	mgN/L	4.5	2.4	4	<0.2	95
N03	mgN/L	-	-	-	4	-
TP	mgP/L	8	1.8	6.3	3	52
PO4	mgP/L	7.6	1.1	4.4	3.1	

The values of suspended solids SS, COD and phosphorus concentration TP were about 75% lower for the grey water from the office building compared to design grey water and can not be considered as representative. After connection of the apartment buildings the load increased and the influent concentration for the parameter SS, COD and TP was only 20% lower for grey water from the office building and apartments than expected (“design greywater”), see **Tab. 3.5.7.2.** The TN load was even by 25% higher for the influent concentration with the combined grey water (phase 2 and 3) than the design grey water.

Even when the raw water load increased with the connection of the apartment house, the filtrate quality in regard of the SS and COD concentration did not increase. But only four samples were measured and the elimination for the different parameters during this first period was not calculated.

The elimination of the suspended solids (SS) was 99 % for period 28.6-8.9.05 (phase 2 and phase 3). The COD and N-NH_4 are also well removed in both cases with rates of 95 % and 99 %, respectively. The nitrification was mostly complete with an ammonia concentration of 0.2 mg/L in the effluent. The average N-total removal was 46 %, but varies between 22 and 90%. In **Fig. 3.5.7.2** a representative example of a 24h-profile shows that the majority of nitrogen removal is due to bio assimilation. Higher elimination rate are only achieved when nitrate is eliminated, but this process can not be influenced because the single reactor must be continuously aerated in order to ensure high efficiency for membrane filtration. Phosphorus with an average effluent concentration of 3 mg/L PT, has been eliminated by 52%, which is also due to bio assimilation.

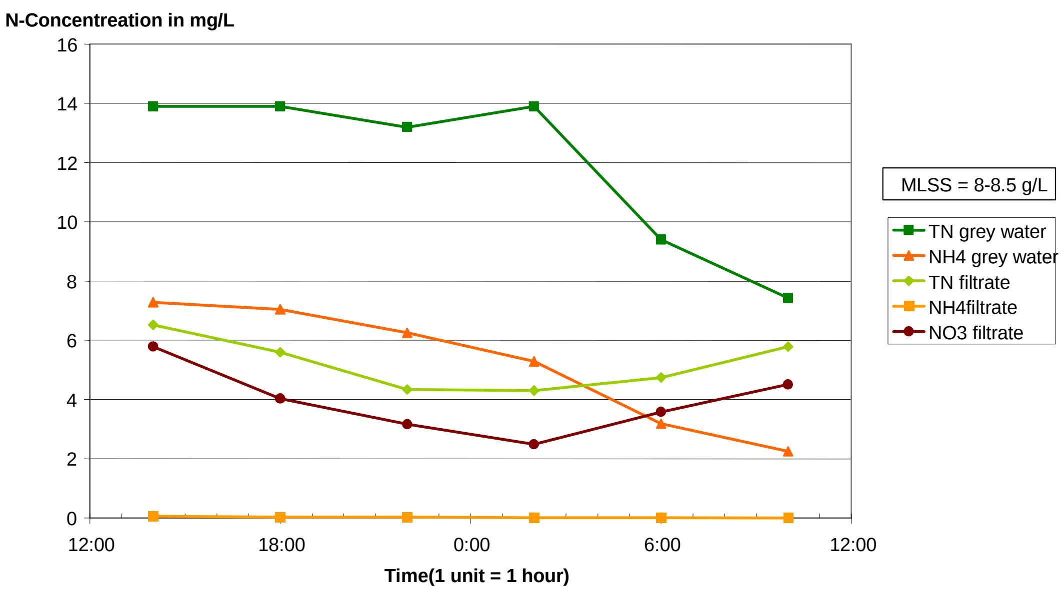


Fig. 3.5.7.2: Evolution of nitrogen concentration in grey water and filtrate during 24 hours

The biological performance of the membrane bioreactor is satisfying especially for SS, COD and NH_4-N removal. Regarding the SRT and the HRT in reactor and buffer tank no differences on the effluent has been observed. Therefore, the MBR could be operated with the lowest time tested which is a SRT of 6 days and a HRT of 2 hours. The phosphorus elimination is not sufficient and should be further targeted. The initial analytical programme was perturbed by some technical problems. For example, it would be interesting to assess the pilot plant during an entire week in order to have a representative period of analyses. More investigations are required to validate the results for obtained, show the bacteria removal and reduce the phosphorus down to 0.5 mg/L.

3.6 Assessment of source separation

The assessment of the effectiveness of the separation in the frame of the tested sanitation concept has been undertaken for the different flows (yellow, brown and greywater) discharged from the office building. Due to the different investigation programs balances are not available for all variants. Mass balances were made under different conditions as follows:

- The values for urine are mean values of the urine collected and analysed in the tanks during the whole period *Variant V1* to *V7.* Period *V7* is taken into consideration until the time of the connection of the apartment building.
- For the brownwater the values from the period with the longest investigation time with more than one gravity toilet (*V2b*) are taken
- Representative greywater values are only available since *Variant V5*, which are used for the balances.

Using this conditions differences in the volume and mass balances will occur, but are assessed as neglectable. Yellow-, brown- and greywater figures of these volume and mass balances are listed in **Tab. 3.6.1**.

Tab. 3.6.1: Volume and mass balances of different parameters of yellow, brown and greywater (data basis: see text above)

		yellow water	brown water	grey water	sum	feaces filtrate	difference brown water feaces filtrate	sum substances for fertiliser	max. sum substances for fertiliser
		A	B	C	D	E	F = B - E	G = A + F	H = A + B
variant		V1 to V7	V2b	V5		V2b			
volume	L/d	7	169	1,419	1,594	169	-	-	-
COD	g O_2/d	58	805	268	1,130	170	635	693	863
N-total	g N/d	28	26	13	67	12	15	42	54
NH_4-N	g N/d	26	4.0	0.6	31	4	0	26	30
Norg	g N/d	1.4	22.4	12	36	8	15	16	24
P-total	g P/d	2.9	6.8	2.9	12.6	3.4	3.4	6.3	10
K	g/d	15	*	10.8	-	*	-	-	-
volume	%	0.4	10.6	89	100	10.6			
COD	%	5,1 (12)	71,2 (47)	23,7 (41)	100	15	56,2 (47)	61,2 (59)	76,3 (59)
N-total	%	41,3 (87)	39,5 (10)	19,2 (3)	100	17.7	21,8 (10)	63,1 (97)	80,8 (97)
NH_4-N	%	85.1	12.9	2	100	14.1	0	84	98
N org	%	4	63.9	33	100	21.2	41.8	45.8	67
P-total	%	22,8 (50)	54,1 (40)	23,1 (10)	100	27	27,1 (40)	49,9 (90)	76,9 (90)

( ) literature value (Otterpohl, 2000)   * not analysed

Before starting an assessment the use of the office building must be taken into consideration. Probably most persons will use mainly their own toilet at home for defecation. Furthermore the urine will be much more diluted than the urine from the morning. Greywater is mainly produced in the showers and the hand washing basins. Greywater volume produced by cooking and food cleaning will be very small due to the use of the building.

As the table shows the volume of yellowwater is very small compared to the other two flows. Brownwater, which consists mainly of flushing water, is only about 10.6 % of the total volume. A better approach of the figures from columns A to C in this table is possible in **Fig. 3.6.1**.

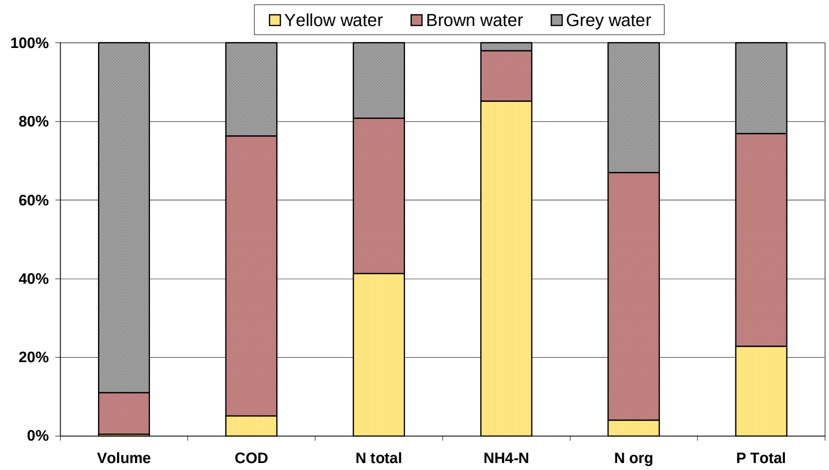


Fig. 3.6.1: Volume and mass balances of different parameters of yellow, brown and grey water (data basis: yellow water: *Variant V1* to *V7*; brown water: *Variant V2b*; grey water: *Variant V5*)

Most of the organic substances (carbon source as COD) will be found in the brownwater. Nitrogen is distributed nearly on the same range among brown- and yellowwater. While yellowwater contains nitrogen in the form of ammonium (93 % NH_4-N) the brownwater was loaded mainly with organic nitrogen (86 %). Probably most of the nitrogen in the brownwater will be fixed in the organic matter. By the use of the gravity separation toilets the nitrogen will be kept away from the greywater – only 19,2 % of the total charge is found in the greywater.

This figure shows that brownwater contains far the most carbon sources (measured as COD). The amount of N-total is the same for brown and yellowwater. The kind of N-total in yellowwater is mainly NH_4-N. This shows column four; urine contains most NH_4-N. Since the amount of NH_4-N should be very less in fresh brownwater the fraction of about 13 % may be a hint for the kind of separation quality of the gravity separation toilets. But a perfect separation can never be expected. The kind of N-total in brownwater is mainly N_{org}. Regarding the distribution of phosphorus, small loads are found in the greywater. Surprisingly the phosphorus load of the urine is very low as well and the brownwater contains the majority of it (54 %).

By comparing the distribution rates with values given in the literature (see values in brackets) great differences can be recognised. With the brown- and greywater higher charging rates and with the urine lower rates occur than documented in the literature. Presumably the specific conditions of the use of the office building compared to housing estates are the reason for the large differences. The future investigations with the connection of the apartment house will justify this assumption.

For the use of the nutrients as fertiliser or fertilising products after the treatment of the flows different calculation are made in the columns E to H in **Tab. 3.6.1**. In addition to the flows of urine (column A) and greywater (column C) the brownwater (column B) was separated in the liquid phase, which passes the faeces separator as filtrate (column E) and the solid phase (column F) hold back by the separator. During the investigation periods the filtrate (column E) was mixed with the greywater and treated together with the greywater in the constructed wetland. Utilising the urine and the eliminated solids from the faeces approximately 61 % (literature 59 %) of COD, 63 % (literature 97) of N-total and approx. 50 % (literature 90 %) of P-total from the total charge in all three waters (yellow, brown and grey) is available for the fertiliser or fertiliser production. If the faeces filtrate could also be used for fertilising the utilisation rate would be increased significantly up to nearly 80 % (see column H). Only about 20 % of N-total and P-total would be lost via greywater.

In spite of the high elimination rates of the faeces separator nutrients are leaving the system and are not available for an utilisation. So the faeces separation has to be improved to obtain a higher amount of substances for the fertilisation.

Due to the analytical program the nitrogen balance for the different flows is really difficult. The urine sample is taken from the Urine tank after an increasing time of storage. During this storage a conversion from urea (the main component of fresh urine) to ammonium takes place. For a balance of total nitrogen in the urine the nitrogen form is neglectable, but not for the brownwater flow. Herein the source of the nitrogen can not be identified: organic nitrogen can be discharged with the faeces as well as the urine diverted into the faecal outlet of the toilets by misuse (use in standing position) or malfunctioning. Therefore effectiveness of the separation toilets can not be calculated using these values. In the next phase a measurement of the dissolved and unsolved organic nitrogen part has to be taken.

3.7 Summary and next steps

Projects period time is from 1 January 2003 until 30 June 2006, but the operation of the outside facilities started still at 11 March 2004. In this interim report only the first phase from 11 March 2004 until 31 July 2005 will be reported.

With this demonstration project two different sanitation concepts are investigated. The two concepts differ mainly in two points as follows:

- Gravity separation toilets and composting of the faeces
- Vacuum separation toilets and digesting of the faeces

The Demonstration site is the office building of the wastewater treatment plant Stahnsdorf and an Apartment house nearby. Both are belonging to the Berliner Wasserbetriebe.

The project started first with the gravity separation toilets installed in the office building. The toilets went in operation in October 2003 and the outside treatment facilities started in March 2004. The vacuum separation toilets went stepwise in operation in these building and have replaced the gravity separation toilets. The first one was taken in operation in December 2003, the next two in December 2004 and the last six in April 2005. These toilets have also been installed in the office building whereas gravity separation toilets have been exchanged. The concept with gravity separation toilets is not stopped because this type of toilet is used in ten flats of the apartment house since April 2005 with a more representative user community than in the office building. The digester for the anaerobic treatment of the faeces from the vacuum separation toilets will be installed in December 2005.

In the EU-proposal eight different variants have been foreseen for testing (see 2.2). Until now the following variants (V) are tested and started (V7), respectively:

- *V1 (With soil filter and with faeces filtrate treatment)*
- *V2a (Without soil filter and without faeces filtrate treatment)*
- *V2b (Without soil filter and with faeces filtrate treatment)*
- *V5 (With membrane bio-reactor and with faeces filtrate treatment)*
- *V7 (Membrane bio-reactor with greywater from apartments and with faeces filtrate treatment)*

For having more knowledge on users acceptance of the new toilets and waterless urinals a user survey with questionnaires has been undertaken. The results show a general acceptance of the gravity separation toilets; mainly the flushing system has to be improved. The acceptance for the vacuum separation toilets is worse, especially the flushing and the flushing noise. This was expected since the toilets are modified gravity separation toilets and are more prototypes than really applicable toilet models. An optimised vacuum separation toilet is not yet available on the market. The experience with the two types of separation toilets show basically that they have to be improved, mainly the flushing systems. The vacuum system itself was in general reliable; in the project only two disturbances occurred. One failure was a vacuum valve which did not close, the other one was a blockage after the disposal of paper, which is normally used for hand drying (one-way-paper towels) after hand washing. This is a typical misuse of the user. Until now no further blockage of any pipe did occur. In the horizontal part of the main urine pipe in the transparent control pipes only a small range of sedimentation can be observed.

The urine collected during the reported investigation time with a nitrogen content of 4,000 mg/L was less concentrated compared to literature values (9,000 mg/L), The main reason for this may be the fact that the urine was only from the users in the office building and in the most cases the users have already used the toilet at home before using the facilities in the office building. The first morning urine shall have the highest concentration of substances. Besides of chemical/physical parameters the urine was also analysed in relation to micro-pollutants (16 substances). Most of these substances have been below the detection value, higher values are found for Bezafibrat (< 1 to 2,200µg/L) and Ibuprofen (263 to 600 µg/L). The stored urine was used for fertilising experiments by the Humboldt University Berlin (*Task 8* of the project).

As mentioned above the faeces from the sanitation concept using gravity separation toilets shall have to be composted. The prerequisite for the composting procedure is a dewatering of the wet material. This took place inside of the filter bags, which separate the solids from the liquid. With this separation technique about 90 % of the suspended solids (SS), 55 % of N-total and 50 % of P-total could be retained in the filter bags. Although most of the solids could be retained in the filter bags the SS-concentration in the filtrate of about 300 mg/L was very high and not satisfying. Therefore the separation process should be improved not only in relation of the better quality of the filtrate but also of the equipment (handling etc.). The existing kind of faeces separator was just chosen for demonstrating the dewatering of the faeces and their handling afterwards. For larger units the optimization of the separation and dewatering equipment, better operated continuously, is mandatory. Concerning composting no final results are available yet, but the first results indicate a satisfying composting process worms by a temperature of about 20 ^{o}C.

For a pre-treatment of the faecal filtrate from the faecal separator especially in relation of pathogenic germs reduction a soil filter has been investigated. The operation of this filter was not successful since the SS-concentration of the faecal filtrate was too high. Due to this fact the operation of the filter was taken out of operation after two months.

As a pre-treatment step for the constructed wetland a 2-chamber septic tank is used. Until the end of June 2005 only greywater and faeces filtrate from office building was treated. Since July 2005 also greywater and faeces filtrate from the apartment house is pumped to the septic tank. The septic tank was very under-loaded only with the volumes from the office building. The utilisation is much better since the loading with greywater and faeces filtrate from both houses. But the dimension criteria are still not reached. The most time the effluent value for the concentration of suspended solids was below 40 mg/l, without the connection of the faecal filtrate concentration dropped down below 20 mg/l. The first results of the operation with volumes from the apartment house show an SS-concentration increase up to about 100 mg/L. According literature the SS-influent concentration to constructed wetlands should not exceed about 100 mg/L to prevent clogging and colmatation.

Like mentioned above the constructed wetland was also under loaded during the first project phase. Since connecting of the volumes from the apartment house the hydraulic load is approximately according the design load. In the first year of operation of the constructed wetland the distribution of the grown reed showed a worse water distribution. Therefore the distribution system was retrofitted in April 2005. Since this time the distribution of the influent is good, an influence of the effluent quality cannot be seen due to the under loading. In the most cases the COD-effluent concentrations were far below 50 mg/L, and the ammonium was always complete nitrified. Nitrate was denitrified between about 20 and 60 %. The P-total-effluent concentration was fare below 1 mg/L. during most of the time. The elimination rate was between approx. 80 and 90 %. Due to the decreasing phosphate binding capacity of the installed iron-containing waterworks sludge particles, the P-effluent concentration increases. Until now the constructed wetland shows a satisfactory effluent quality in relation to pathogenic germs. In the most cases the values of total and faecal coliforms are below the value of excellent quality (guide) according the EU bathing water directive.

In parallel to the constructed wetland a membrane bio-reactor was operated from 25 May 2005 onwards. Until the end of June the influent was just greywater discharged from the office building. Starting from July the influent was a mixture from greywater of the office building (about 48 %) and apartment house (about 52 %). Until now the effluent quality with regard to SS, COD and NH4-N is satisfying. The phosphorus elimination is not sufficient and should be further targeted.

Basing on the analytical values mass balances has been calculated for the different variants and sanitation concepts applied to the office building. These figures have been compared with literature values. This comparison showed that the yellowwater from the office building contains far less and brown as well greywater contains more nutrients than known from other projects. Furthermore a significant part of nutrients from brownwater gets lost via faeces filtrate. It is expected, that the result will differ after the connection of the apartment house. They will be published in the projects final report.

The experience with the two sanitation concepts until now shows mainly that:

- The users accept in general separation toilets whereas the acceptance for gravity separation toilets is higher than for vacuum separation toilets. The latter one is not surprising since the using vacuum separation toilets are just prototypes made by modified gravity separation toilets and therefore at the moment no optimised vacuum separation toilet is available on the market until now;
- Both types of toilets have to be improved, especially the flush systems;
- The quality and handling of faeces separation has to be improved. The used equipment may be used for single or few houses but not for larger settlements.

The main next steps of the project are:

- Continuing the operation of the faeces separator mainly with faeces from the apartment house;
- Upgrading of the analysis to dissolved organic nitrogen and phosphorus in the brownwater for having the possibility of assessment of the effectiveness of the different separation toilets;
- Continuing the operation of the septic tank and constructed wetland with filtrate from faeces separator and greywater from office building and from apartment house;
- Continuing greywater treatment with the membrane bio-reactor, especially with the mixture of greywater from office building and apartment house:
- Continuing pumping yellowater from apartment house to the urine tanks in the office building for collecting the yellowater but also to find out if the pressure pipeline will be clogged by precipitants;
- To install the bio-gas reactor at the end of 2005 and to test it with the faeces from the vacuum separation toilets of the office building and bio-waste from the apartment house;
- Continuing the investigations of the three subcontractors in relation of
  - Life-Cycle-Assessment (Task 5),
  - Industrial style urine treatment for utilisation (Task 7) and
  - Fertiliser usage (Task 8).

Abbreviations

BOD	mg/L	g/d	biological oxygen demand
Brownwater			faeces including flush water
Ca	mg/L		calcium
Cd	mg/L		cadmium
CHPU			Combined Heat and Power Unit
Cl	mg/L		chlorine
COD	mg/L	g/d	chemical oxygen demand
Cr	mg/L		chrome
Cu	mg/L		copper
DO	mg/L	mgO_2/L	dissolved oxygen
DS	kg		dried solids
effl.			effluent
EU			European Union
Greywater			waste water mainly from kitchen, bathroom, washing machine and wash basins without brown and yellow water
Hg	mg/L		mercury
HRT	h		hydraulic retention time
infl.			influent
K	mg/L		potassium
MBR			membrane bio-reactor
Mg	mg/L		magnesium
NH_4-N	mg/L	g/d	ammonia nitrogen
Ni	mg/L		nickel
NO_2-N	mg/L	g/d	nitrite nitrogen
NO_3-N	mg/L	g/d	nitrate nitrogen
Norg	mg/L	g/d	organic nitrogen
N-total	mg/L	g/d	total nitrogen
Pb	mg/L		lead
P_F	mbar		pressure filtration
PO_4-P_f	mg/L	g/d	dissolved phosphate-phosphorus
P_R	mbar		pressure relaxation
P-total, PT, TP	mg/L	g/d	total phosphat-phosphorus
q_A	$m^3/m^2.d$		surface flow rate
Q_A	L/d	m^3/d	dry weather flow
SRT		d	sludge retention time
SS	mg/L	g/d	suspended solids
TMP	mbar		transmembrane pressure
TOC	mg/L		total organic carbon
WWTP			Wastewater treatment plant
Yellowwater			urine without flush water
Zn	mg/L		zinc

References

A3 GmbH (2005): www.a3-gmbh.com

Duravit (2005): Products, www.duravit.de

Ernst (2005):Ernst systems, www.ernstsystems.com

EU-Badewasserrichtlinie (1975): Richtlinie des Rates vom 8. Dezember 1975 über die Qualität der Badegewässer (76/160/EGW). Amtsblatt der Europäischen Gemeinschaften, Nr. L 31/1.

Fugafil-Saran (2005): Fugafil saran, www.fugafil.de

Otterpohl, R. and Niederste-Hollenberg (2000): Innovative Entwässerungskonzepte. wwt 2/2000, S 23 – 26.

Otterpohl, R. (2001): Black, brown, yellow, grey – the new colours of sanitation. Magazine of the International Water Association, WATER 21, October.

Roediger (2001): Roediger-No Mix Toilet. www.roeva.de

Labor 28 (2005): Labor 28 AG, www.labor28.de

K.M. Udert, T.A. Larsen, W. Gujer (2004): Fate of Major Compounds in Source-Separated Urine. 4th IWA World Water Congress Sep. 2004 in Marrakech, Morocco, Paper CD.

Universität Duisburg (2005): Institut für Wasserchemie und Wassertechnologie (IWW), www.theochem.uni-duisburg.de

Urimat (2005): Product info, www.urimat.com

Tacke (2005): Regenwurmfarm Tacke GmbH, www.regenwurm.de

K.J. Winter and D. Goetz (2004): Einfluss der Abwasserzusammensetzung auf die Kolmationsneigung vertical durchströmter Bewachsener Bodenfilter. KA (51), Nr. 9, S. 961- 966.

Annex 7.5

Sanitation Concepts for Separate Treatment of Urine, Faeces and Greywater (SCST)

SCST-Presentations at KWB, Stahnsdorf etc. (no conferences)

Lfd. Nr.	Datum	präsentiert von	Ort	Anlass/Grund	beteiligte Personen/Gruppe
1	1.4..2003	Dr. Peter-Fröhlich	KWB	Informationsreise nach Europa	Mr. Landers, Sydney Water, Australien
2	19.6..2003	Dr. Luck	KWB	Information über KWB	A. Frerot, Generaldirektor von Veolia Water, Paris
3	25.6..2003	Dr. Luck	KWB	Information über KWB	J.M. Lambert, Personaldirektor von Veolia Water, Paris
4	9.7.2003	Dr. Peter-Fröhlich	KWB	Informationsbedarf für dezentrale Abwasserkonzepte	Dr. Henkel und Kollegen vom Verband Deutscher Grundstücksnutzer e.V (VDGN)
5	17.7.2003	Dr. Luck	KWB	Information über KWB	CAEPI (China Association of Environment Protection Industry) (15 Persons)
6	23.9.2003	Dr. Peter-Fröhlich	KWB und Stahnsdorf	Sitzung des ATV-DVWK-Fachaussussses ATV-DVWK FA KA 8 (Weitergehende Abwasser-reinigung) im KWB	Siehe unten beigefügte Teilnehmerliste!
7	15.10.2003	Dr. Luck	KWB	Information über KWB	R. Müller, Betriebsdirektor des Werkes Bendi-go/Veolia, Australien Z. Chowdhury, Senior Assosiate, Malcon & Pirnie, Phönix, USA
8	24.10.2003	Hr. Pawlowski Dr. Peter-Fröhlich Dr. Luck Dr. Weigert	Stahnsdorf	Städtesymposium Wasser – Berlin trifft Paris im dbb-Forum in Berlin am 23.10.2003	Siehe unten beigefügte Teilnehmerliste!
9	2.12.2003	Fr. Kraume	Stahnsdorf	Meeting der EU-Arbeitsgruppe ZerO-M (Sustainable Concepts Towards a Zero Outflow Municipal-ity) an der TU Berlin (Prof. Kraume) www.zero-m.org	Siehe unten beigefügte Teilnehmerliste!
10	22.12.2003	Dr. Luck	KWB	Information über KWB	H.E. Lesueur, Stellvertrentender Direktor F&E Veolia Environment, Paris
11	11.2.2004	Dr. Peter-Fröhlich	EAWAG, Zürich	Erfahrungsaustausch	Dr. Larsen, Dr. Lienert. Dr. Maurer, Dr. Truffer, EAWAG, Zürich
12	16.2.2004	Dr. Peter-Fröhlich	KWB	Information über das KWB	Frau Dr. Peschel-Gutzeit, Aufsichtsratsmitglied der BWH
13	24.2.2004	Dr. Luck	KWB	Information über das KWB	H.R. Black, Personaldirektor Europa Veolia, Paris
14	16.3.2004	Dr. Luck	KWB	Information über das KWB	H.W. Merkel, Direktor des Instituts IWW Mühlheim, Ruhr
15	26.3.2004	Hr. Lesjean	Stahnsdorf	Austauschschüler Gymnasium Lyon mit Canisius-Kolleg in Berlin	ca. 42 Schüler des Gymnasiums Lyon (ca. 16 Jahre alt) und 4 Betreuer.
16	31.3.2004	Dr. Peter-Fröhlich	KWB	Information über das KWB	Siehe unten beigefügte Teilnehmerliste!
17	5.4.2004	Dr. Luck	KWB	Information über das KWB	H.B. Wricke, Direktor des TZW Dresden

Fortsetzung *SCST-Präsentationen im KWB, Stahnsdorf und außerhalb*

Lfd. Nr.	Datum	präsentiert von	Ort	Anlass/Grund	beteiligte Personen/Gruppe
18	28.4.2004	Dr. Peter-Fröhlich	Stahnsdorf	Information über Berlinwasser für Kolleginnen und Kollegen aus Bahrain durch p2m in Berlin am 28.4.2004	Siehe unten beigefügte Teilnehmerliste!
19	3.5.2004	Dr. Luck	KWB	Information über das KWB	H.A. Jansen, Bereich Chemie, TNO-Energie, Umwelt und innovative Verfahren, Niederlande
20	19.5.2004	Dr. Peter-Fröhlich	KWB	Information über das KWB	Frau S. West, Neue Abwasserkonzepte, Sydney Water Cooperation, Australien
21	24.5.2004	Dr. Peter-Fröhlich	Stahnsdorf	Wunsch nach Erfahrunsaustausch, da eigenes Projekt	Siehe unten beigefügte Teilnehmerliste!
22	24.5.2004	Dr. Luck und B. Lesjean	KWB und Stahnsdorf	Information über das KWB	Frau V. Lecompte, Stellvertretende Direktorin für Kommunikation, Veolia Water, Paris
23	27.5.2004	Dr. Luck	KWB	Information über das KWB	Istanbul Water and Sewerage Administration
24	7.6.2004	Dr. Peter-Fröhlich	KWB (Hohenzollerndamm)	Seminar: "Forschungen zum nachhaltigen Management der Wasserressourcen und der Abwasserentsorgung in Berlin (Deutschland)"	Chinesische Delegation über Carl Duisburggesellschaft Siehe unten beigefügte Teilnehmerliste!
25	9.8.2004	B. Lesjean	Stahnsdorf	Ecosan-Study-Tour der GTZ vom 2.8. – 14.8.2004	Siehe unten beigefügte Teilnehmerliste!
26	17.8.2004	Dr. Peter-Fröhlich	Stahnsdorf	Information über SCST	Siehe unten beigefügte Teilnehmerliste!
27	26.8.2004	Dr. Peter-Fröhlich	Stahnsdorf	Information über SCST	Siehe unten beigefügte Teilnehmerliste!
28	30.8.2004	Dr. Peter-Fröhlich Dr. Luck Dr. Weigert	Skórzyn, Polen	Erfahrungsaustausch	Dr. Halicki, Institut für angewandte Ökologie in Skórzyn, Polen
29	31.8.2004	Fr. Kraume	Stahnsdorf	Informationen über SCST	Fr. Prof. Kunst und 20 Studenten der Universität Hannover
30	4.9.2004	Dr. Peter-Fröhlich	Stahnsdorf	Informationen über KWB und SCST	Christof Mainz, Ministerium für Umwelt und Naturschutz, Landwirtschaft und Verbraucherschutz des Landes Nordrhein-Westfalen und 20 Referendare und Referendarinnen der staatlichen Umweltverwaltung Nordrhein-Westfalen
31	7.9.2004	Dr. Peter-Fröhlich	KWB	Besprechung über das KWB-Projekt „Röntgenkontrastmittel"	Prof. Färber, Universität Bonn
32	8.9.2004	Dr. Luck	KWB	Informationen über KWB und SCST	Siehe unten beigefügte Teilnehmerliste!
33	9.9.2004	C. Pineau Dr. Peter-Fröhlich	KWB und Stahnsdorf	Informationen über KWB und SCST	Siehe unten beigefügte Teilnehmerliste!
34	10.9.2004	Dr. Luck	KWB	Informationen über KWB und SCST	Fr. Marielle Villamaux, Leiterin Marketing, Veolia Environnement,
35	22.9.2004	Dr. Luck	Marakkesh, Marokko	Workshop: Alternative Water Management Systems in Urban Areas – Concepts and Imlpementation. 4th IWA World Water Congress and Exhibition, Marrakech, Morocco, 19 – 24 September 2004	Kongress-Teilnehmer (ca. 50) und Panelists Siehe unten beigefügte Teilnehmerliste!
36	6.10.2004	Dr. Peter-Fröhlich	Stahnsdorf	Information über SCST	Frau Kühn, Fa. Syrius Berlin

37	6.11.2004	Dr. Oldenburg Dr. Weigert	Stahnsdorf	Ehemaligentreffen der wissenschaftlichen Mitarbeiter von Prof. Wiesmann an der TU Berlin	Siehe unten beigefügte Teilnehmerliste!
38	12.11.2004	Dr. Peter-Fröhlich	Sydney Water in Sydney	2nd Leading-Edge Conference on Sustainability in Water-Limited Environments, 8 -10 November 2004 in Sydney, Australia	Dr. Nigel Barrett, R&D Program Manager, Dr. Mike du Plessis, Innovation and R&D Manager, Jeff Brown, Manager Water & WastewaterTreatment Planning und weitere acht Personen von Sydney Water
39	24.11.2004	Fr. Kraume	Stahnsdorf	Information über SCST	Siehe unten beigefügte Teilnehmerliste!
40	25.11.2004	Dr. Peter-Fröhlich	UBA Marienfelde	Unterzeichnung des Vorvertrages zur Einrichtung einer Stiftungsprofessur für das Fachgebiet Siedlungswasserwirtschaft an der TU Berlin	Siehe unten beigefügte Teilnehmerliste!
41	3.12.2004	Dr. Peter-Fröhlich	KWB	Information über das KWB und spezielle FuE-Projekte	Siehe unten beigefügte Teilnehmerliste!
42	7.12.2004	Dr. Peter-Fröhlich	TFH Berlin	Vorlesung „Ausgewählte Kapitel des Bauingenieurwesens und der Verfahrens- und Umwelttechnik"	Prof. Heß, Prof. Loroch und ca. 20 Studenten
43	14.12.2004	Dr. Peter-Fröhlich Dr. Luck	KWB und Stahnsdorf	Information zum Stand des ENREM- und SCST-Projektes	Frau Pfirrmann, Particip Freiburg Dr. Kaschl, Technical Desk LIFE-Unit, European Commission, DG Environment D.1
44	15.12.2004	Dr. Peter-Fröhlich	BWB und Stahnsdorf	Information über SCST	Frau Gerhager, GTZ
45	15.12.2004	Dr. Peter-Fröhlich Dr. Luck	KWB und Stahnsdorf	Information über KWB und SCST	Siehe unten beigefügte Teilnehmerliste!
46	24.3.2005	Fr. Kraume	Stahnsdorf	Information über SCST	Janine Kahla und vier weitere Studenten der TU Berlin, Landschaftsplanung
47	24.3.2005	Dr. Peter-Fröhlich	Stahnsdorf	Information über SCST	Herr Fischer (ehem. Vorstand Berliner Stadtreinigungs Betriebe), Senior Experten Service Bonn
48	13.5.2005	Dr. Peter-Fröhlich Hr. Bonhomme	Stahnsdorf	Information über SCST	Siehe unten beigefügte Teilnehmerliste!
49	22.9.2005	Dr. Peter-Fröhlich Dr. Oldenburg (Otterwasser) Hr. Klingel (GTZ)	Stahnsdorf	Information über Alternative Sanitärkonzepte generell und speziell SCST	Ca. 40 Besucher der DWA Jahrestagung in Potsdam
50	18.10.2005	Hr. Bonhomme	Stahnsdorf	Information über SCST	Siehe unten beigefügte Teilnehmerliste!
51	9.11.2005	Hr. Bonhomme	Stahnsdorf	Information über SCST	Siehe unten beigefügte Teilnehmerliste!
52	24.11.2005	Dr. Peter-Fröhlich	KWB	Information über KWB und SCST	Hr. Chazelle und Hr. Laurans Veolia

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	Ahmet	Baban	**MRC-ESERI (**Tübitak-Marmara Research Center (Turkey))
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	N.	Rüster	Mitarbeiter von Frau Klug
	R.	Jäger	MdB
	P.	Brüggemann	Referentin AG Umwelt
18			
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	Mr.	????	Organisator für p2m ??????, , Kingdom of Bahrain
	Frau Carla	Wiedemann	Prouristin/Kaufmännische Leitung, Wiedemann & Reichert, Altenmünster, Deutschland
	Frau Stefanie	Wiedemann	Juristische Abteilung, Organisationsmanagment, Wiedemann & Reichert, Altenmünster, Deutschland
	Hr.	Soppert	Geschäftsführer p2m, Berlinwasser
21			
	Dr. Mathias	Barjenbruch	Universität Rostock
	Fr. Susann	von Wolffersdorff	Universität Rostock, Diplomandin
	Herr	Wriege	Universität Rostock, Doktorand
24			
	Bao	Ligang	Teilnehmer des InWEnt-Fortbildungsprogramms „Management der Wasserversorgung und Abwasserentsorgung“ Oktober 2003-Juni 2004
	Du	Qin	dto.
	Feng	Hong	dto.
	Gu	Jianxin	dto.
	He	Guixian	dto.
	Liu	Xiangdo	dto.
	Ma	Chuanji	dto.
	Nan	Haitao	dto.
	Wan	Guodon	dto.
	Wan	Jungxia	dto.
	Wan	Yanhan	dto.
	Wu	Hong	dto.
	Xia	Ping	dto.
	Xie	Chunde	dto.
	Xing	Haoran	dto.
	Xu	Min	dto.
	Yuan	Qu	dto.
	Zhan	Yanrong	dto.
	Zhou	Quan	dto.

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25			
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	Tong	Boitin	Biogas and ecosan Advisor in the Chinese Research and Training Centre (BRTC), Chengdu (arbeitet für BioTech Environment International Consultants in Berlin)
	Dino Ed-ward	Kohima	Ecosan-Townplaner, GTZ-Servuce Delivery Promotion Project, Municipality of Mariental.
	Kristian	Franzius	GTZ-ecosan Project, Eschborndto.
	Elisabeth-Maria	Huba-Mang	“free lance” Sociologist - Jurnalist
	?	?	aus Namibia
	?	?	aus Südamerika
	?	?	Sechs GTZ-verbundene Studenten
	Petra	Schuster	Diplomandin in Bezug aud das KWB-Projekt “Röntgenkontrastmittel”
26			
	Jürgen	Dr. Kern	Institut für Agrartechnik Potsdam-Bornim
		Dr. Müller	Ing.-Büro Möller & Darmer, Berlin
	Bernd	Kirschbaum	Umweltbundesamt, Fachgebiet II 2.1, Übergreifende Angelegenheiten der Wasserwirtschaft, Grundwasserschutz
	Jörg	Rechenberg	dto.
	Corinna	Hornemann	dto.
	Frau	?	dto.
	Frau	David	Studentin der TU Dresden, z.Z. Praktikantin im KWB für ENREM-Demonstrationsprojekt
27			
	Barbara	Ral	Geschäftsführerin ZebraFilter GmbH, Berlin
	Alexander	Ruhland	TU Berlin, Fachgebiet Wasserreinhaltung
	Ralf	Mühleck	TU Berlin, Fachgebiet Wasserreinhaltung
32			
	Nathalie	de Lataillade	Veolia Wate – Générale des Eaux in Paris, Leitung Pressestelle
	Pascale	Peignen	Chefredakteurin Fachzeitung « Hydroplus »
	Virginie	Lepetit	Technischer Journalist bei der Zeitung „l’Usine Nouvelle“
	Florence	Bauchard	Zeitung „Enjeux les Echos“, Rubrik „Neue Technologien“
33			
	Géraldine	Fort	Veolia Environnement, internationale Kommunikation
	Philippe	Langenieux	Veolia Environnement, internationale Kommunikation
	Nathalie	de Lataillade	Veolia Wate – Générale des Eaux in Paris, Leitung Pressestelle
	Pascale	Peignen	Chefredakteurin Fachzeitung « Hydroplus »
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	Marielle	Villamaux	Leiterin Marketing Veolia Environnement

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35			
	Paul	Reiter	IWA Executive Director, London
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	Harald	Hiessel	Fraunhofergesellschaft Karlsruhe
	Professor	Guijer	ETH Zürich
	Professor	Otterpohl	TU Hamburg-Harburg
	Crace	Mitchell	Sydney, Australien
	Bernd	Heinzmann	Berliner Wasserbetriebe
37			
	Prof.	Wiesmann	TU Berlin
	Prof.	Binder	Fachhochschule Paderborn
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	Dr.	Bruns	Ingenieurbüro Dr. Bruns
	Dr.	Cuno	Umweltministerium Potsdam
	Prof.	Dombrowski	TFH Berlin
	Dr.	Dombrowski	Schering AG
	Dr.	Gao	Huber AG
	Dr.	Kornmüller	ELGA Berkefeld GmbH
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	Anne	Schuchart	TU Berlin
	Dr.	Sommerfeld	Argus GmbH
	Dr.	Walter	Limus GmbH
	Dr.	Zhang	Consulting & Engineering International
39			
	Dr.-Ing.	Müller	TU Berlin, Siedlungswasserwirtschaft
	Dr.-Ing.	Heinl	TU Berlin, Wasserbau
	Reinhardt	Marth	TU Berlin, Wasserbau
	Marko	Nehring	TU Berlin, Wasserbau
	Florian	Gasch	TU Berlin, Bauingenieurwesen

Fortsetzung Teilnehmer an SCST-Präsentation im KWB, in Stahnsdorf und außerhalb (nicht Konferenzen):

40			
	Hernri	Proglio	Veolia Environment, CEO
	Joachim	Bitterlich	Veolia Environment, VP/International Affairs
	Jerome	Contamine	Veolia Environment, Director/Finance
	Michel	Dutang	Veolia Environment, Director Research
	Rupert	Schmid	Veolia Environment, Public Relations
	Cyril	Roger-Lacan	Veolia Water, Stellvert. Vorstandsvorsitzender
	Christophe	Hug	Veolia Water, Director/Veolia Water Deutschland
	Michle	Baum	Veolia Water, Secretary General/Veolia Water Deutschland
	Inge	Herbert	Veolia Water, Büroleiterin/Veolia Water Deutschland
	Jörg	Simon	Berliner Wasserbetriebe, Vorstandsvorsitzender
	Jörg	Simon	Berliner Wasserbetriebe, Vorstandsvorsitzender
	Ludwig	Pawlowski	Berliner Wasserbetriebe, Technischer Vorstand
	Regina	Grirß	Berliner Wasserbetriebe, OE Abwasserwerke
	Erika	Pawlowski-Reusing	Berliner Wasserbetriebe
	Kurt	Kutzler	TU Berlin, Präsident
	Martin	Jekel	TU Berlin, Fachgebiet Wasserreinhaltung
	Andeas	Sasse	HU Berlin, Institut für Pflanzenbauwissenschaften
	Ingrid	Chorus	Umweltbundesamt
	Hartmut	Bartel	Umweltbundesamt
	Gesche	Grützmacher	Umweltbundesamt
	Dieter	Müller	Technologiestiftung Berlin
	Francis	Luck	KompetenzZentrum Wasser Berlin, Geschäftsführer
	Birgit	Fritz	KompetenzZentrum Wasser Berlin
	Marion	Oldenburg	KompetenzZentrum Wasser Berlin
	Kay	Schröder	KompetenzZentrum Wasser Berlin
	Boris	Lesjean	KompetenzZentrum Wasser Berlin
	Bodo	Weigert	Wasserforschung eV, Geschäftsführer
41			
	Herr	Pawlowski	Technischer Vorstand der Berliner Wasserbetriebe
	Herr	Goetze	CDU-Fraktion
	Herr	Loga	CDU-Fraktion
	Herr	Wegner	CDU-Fraktion
	Herr	Niedergesäß	CDU-Fraktion
	Dr.	Heide	CDU-Fraktion

Fortsetzung Teilnehmer an SCST-Präsentation im KWB, in Stahnsdorf und außerhalb (nicht Konferenzen):

45			
	Paul	Roeleveld	Director of Technology, Grontmij Water & Waste Management
	J.H.	Roorda (Jelle)	Grontmij Infrastructure & Milieu
	D.	Swart (Bjartur)	Grontmij, Senior Adviseur Waterbeheer
	Bert	Palsma	Stowa Research Manager
	Steven	Stienstra	Woonconcept Vastgoed
	Bert	Duker	Woonconcept Vastgoed
	Arjen	Van der Mark	Waterschap Reest en Wieden
	Hans	Jansen	Vanboeijen
48			
	Anette	Ochs	UNESCO-IHE, Delft, NL
	Jonathan	Tipping	UNESCO-IHE, Delft, NL
	Raktim	Barua	Bangladesh
	A.L.	Pinzon Pardo	Colombia
	J.A.	Aboagye	Ghana
	D.P.	Chaweza	Malawi
	S.G.S.	Rodriguez	Bolivia
	A.G.	Alvaro	Costa Rica
	D.S.	Hidayat	Indonesia
	R.O	Rodriguez Villamil	Colombia
	G.L	Bokan	Ethiopia
	A.K	Mawira Tarigan	Indonesia
	H.K.R	Al-Hamii	Oman
	B.D	Nyakenda	Uganda
	G.A	Makajuma	Kenya
	K	Whan Lee	South Korea
	A.G	Seyoum	Ethiopia
	K.B	Khatri	Nepal
	W.R	Rushdi El Haddad	Palestine
	J	Kamanyi	Uganda
	B.B	Woldemeskel	Ethiopia
	H.J	Sebastiammah Francis Croos	Sri Lanka
	G.A	Gasmalla	Sudan
	L.M	Than	Vietnam
	B.Y	Beyene	Ethiopia
	A.A	Mwakitalu	Tanzania
	A.Y	Katukiza	Uganda
	A.M	Md. Alhadidi	Yemen
	H	Agung	Indonesia
	D	Kobel	Uganda

Fortsetzung Teilnehmer an SCST-Präsentation im KWB, in Stahnsdorf und außerhalb (nicht Konferenzen):

Fortsetzung lfd. Nr. 48

	H.K	Mwase	Uganda
	M.N	Islam	Bangladesh
	A	Farahmand	Iran
	I.O	Rodriguez Cabanillas	Peru
	R.K	Wabuna	Uganda
	N	Ba Liem	Vietnam
	J.J	Sangueza Quintanilla	Bolivia
	M	Abid M. Al-Waeily	Iraq
	M.Y	Maganga	Tanzania
	C.G	Craner	USA
	D	Ngoc Son	Vietnam
	M	Soto de la Fuente	Bolivia
	J	Kathom Alwan Alamiry	Iraq
	W	Mumba	Zambia
	K.M	Kashwabana Mayumbelo	Zambia
	N	Ahmed	Bangladesh
	A.S	Yetebareke	Ethiopia
	A	Kipkoech Bichii	Kenya
	W	Shane	Zambia
49			
1	Renate	Adolph	Landtag Brandenburg, Hoppegarten
2	Dania	Al Jiroudi-Knieps	Rostock
3	Rainer	Allmenroth	Gemmerich
4	Stephan	Bauer	Honeywell Speciality, Seelze
5	Hannes	Baur	Schwäbisch Hall
6	Johannes	Bergmann	Stöer OUT-OF-HOME MEDIA AG, Köln
7	Silke	Demsat	Rautrum
8	Nicole	Drücker	Hamburg
9	Jörg	Euler	BIOPRACT GmbH, Berlin
10	Christine	Galander	Umweltbundesamt, Berlin
11	Dietmar	Ganzer	Neuwied
12	Christian	Günner	Hamburger Stadtentwässerung, Hamburg
13	Ingo	Hertzsch	Deutsche Kreditbank AG, Berlin
14	Reinhard	Hövel	Oldenburg
15	Hans-Jürgen	Kastner	Verlag moderne Industrie, Wellen
16	Florian	Klingel	GTZ, Eschborn
17	Michale	Krefeld	Oelde
18	Uwe	Künzl	Westfalia Separator, Sangerhausen
19	Reinhard	Löffler	Bundesministerium für Verteidigung, Bonn

Fortsetzung Teilnehmer an SCST-Präsentation im KWB, in Stahnsdorf und außerhalb (nicht Konferenzen):

Fortsetzung lfd. Nr. 49

20	Denis	Montuelle	Berlin
21	Dirk	Noffke	Annaburg
22	Steffen	Petzold	Magdeburg
23	Jan-Henning	Rohde	Kleinmachnow
24	Manfred	Schaffeld	EMU-Unterwasserpumpen GmbH, Hof
25	Christian	Schneider	DWA, Hennef
26	Martin	Strauß	Bad Wildbad
27	Werner	Thiel	Kronos International, Leverkusen
28	Ute	Urban	Regionales Innovationszentrum
29	Günter	Woick	Baruth
30	Wolfgang	Zippler	Fels-Werke GmbH, Goislar
50			
1	Mr. B.K.	Singh	India, Director, Ministry of Environment and Forest
2	Mr. T.	Venugopal	India, Director, Central Pollution Control Board (CPCB)
3	Mr. Anand	Kumar	India, Environmental Engineer, CPCB
4	Mr. T.	Mohan	India, Municipal Engineer, Tirupati Municipal Council
5	Mr. Muralee	Krishnan	India, Asst. Executive Engineer, Kottayam Municipality
6	Mr. G.	Panda	India, Executive Officer, Puri Municipality
7	Mr. B.K.	Sharma	India, Asst. Engineer, Ujjain Municipality
8	Mr. A.K.	Gupta	India, Executive Office, Vrindavan Municipality
51			
1	Andreas	Luczynski	TU Berlin
2	Janine	Kahra	TU Berlin
3	Ulf	Thormann	TU Berlin
4	Martin	Windt	TU Berlin
5	Manuela	Kelm	TU Berlin
6	Joscha	Münter	TU Berlin
7	Sebstian	Helmer	TU Berlin
8	Martin	Wagner	TU Berlin
9	Julian	Engmann	TU Berlin
10	Matthias	Gaißmeier	TU Berlin
11	Melanie	Fischer	TU Berlin
12	Ingo	Marzieller	TU Berlin
13	Meong	Reun Thoma	TU Berlin
14	Andrea	Steinmann	TU Berlin
15	Wiebke	Rohdenburg	TU Berlin
16	Johannes	Hille	TU Berlin
17	Georg	Bock	TU Berlin
18	Thomas	Weichert	TU Berlin

Annex 7.6

Sanitation Concepts for Separate Treatment of Urine, Faeces and Greywater (SCST)

Presentation in different media

Lfd. Nr.	Vortragende(r)	Veranstaltung	Titel des Vortrages bzw. der Veröffentlichung
1	Dr. Peter-Fröhlich	Treffpunkt Wissens Werte, Wasser Welten,Wenn aus Wasser Abwasser wird.... , Podiumsdiskussion von infoRadio (Moderation: Thomas Prinzler) in der Investitionsbank Berlin am 1.4.2003.	Peter-Fröhlich, A. (2003): Wenn aus Wasser Abwasser wird.... Treffpunkt Wissens Werte, Wasser Welten, Podiumsdiskussion von infoRadio (Moderation: Thomas Prinzler) in der Investitionsbank Berlin am 1.4.2003, Sendetermine: 6.4.2003, 9.05 Uhr, 21.4.2003, 11.05 Uhr.
2	--	--	Peter-Fröhlich, A. (2003): Pilotvorhaben Neue Sanitärkonzepte in Berlin. Newsletter 2, KompetenzZentrum Wasser Berlin, S. 1 - 2.
3	Dr. Peter-Fröhlich Dr. Luck Fr. Kraume	Presse- und Fototermin im Klärwerk Stahnsdorf am 24.11.2003	Peter-Fröhlich, A., Luck, F.,Kraume, I.(2003): Neue Sanitärkonzepte für die separate Erfassung und Behandlung der Teilströme Urin, Fäkalien und Grauwasser; Nachhaltiges Örtchen – die sanitäre Revolution. Presse- und Fototermin im Klärwerk Stahnsdorf am 24.11.2003, Presseinformation. (Tagesspiegel, Märkische Allgemeine, WWT 1-2 2004, Entsorga, Wasserspiegel)
4	-	Presse- und Fototermin im Klärwerk Stahnsdorf am 24.11.2003	(2003):Pflanzendünger aus der Toilette – Pilotprojekt im Klärwerk Stahnsdorf: Exremente als Nährstoffe. Presse- und Fototermin im Klärwerk Stahnsdorf am 24.11.2003, Potsdamer Landkurier (Märkische Allgemeine), 25.11., S. 19.
5	-	Presse- und Fototermin im Klärwerk Stahnsdorf am 24.11.2003	(2003):Eine rauschende Idee: Kompetenzzentrum Wasser erforscht ressourcenschonende Toilettensysteme – Projekt wird von der EU gefördert. Presse- und Fototermin im Klärwerk Stahnsdorf am 24.11.2003, Der Tagespiegel, Wissen & Forschen, 25.11., S. 27.
6	-	Presse- und Fototermin im Klärwerk Stahnsdorf am 24.11.2003	(2003):Das getrennte Örtchen: Im Klärwerk Stahnsdorf werden neue Sanitärkonzepte erprobt / Europäische Union fördert Forschungsprojekt mit 466.000 Euro. Presse- und Fototermin im Klärwerk Stahnsdorf am 24.11.2003, Wasserspiegel-Magazin, Die Mitarbeiterzeitschrift der Berlinwasser, Nr. 6, S. 15.
7	Dr. Peter-Fröhlich Dr. Luck	Presse- und Fototermin im Klärwerk Stahnsdorf am 11.12.2003	Peter-Fröhlich, A., Luck, F. (2003): Neue Sanitärkonzepte für die separate Erfassung und Behandlung der Teilströme Urin, Fäkalien und Grauwasser; Nachhaltiges Örtchen – die sanitäre Revolution. Presse- und Fototermin im Klärwerk Stahnsdorf am 11.12.2003, Presseinformation. (Berliner Kurier)
8	-	Presse- und Fototermin im Klärwerk Stahnsdorf am 11.12.2003	(2003):Wie ein Berliner aus Sch... richtig Schotter machte – Wunder-Klo Mit Vakuum-Technik geht's ökologischer und gibt's EU-Mittel. Presse- und Fototermin im Klärwerk Stahnsdorf am 11.12.2003, Berliner Kurier, 18.12., S. 19.
9	Dr. Peter-Fröhlich	Presse- und Fototermin im Klärwerk Stahnsdorf mit Merita Schmidt, Stahnsdorfer Ortsanzeiger, am 12.12.2003	Peter-Fröhlich, A. (2004): Ein maßgeblicher Beitrag zum Umweltschutz – Pilotprojekt im Klärwerk Stahnsdorf: Neue Sanitärsysteme für Ressourcenschonung von Wasser, Nährstoffen und Energie. Presse- und Fototermin im Klärwerk Stahnsdorf mit Merita Schmidt, Stahnsdorfer Ortsanzeiger, am 12.12.2003, Stahnsdorfer Ortsanzeiger, 15. Jahrgang, Heft 1, S. 4.
10	-	Presse- und Fototermin im Klärwerk Stahnsdorf mit Merita Schmidt, Stahnsdorfer Ortsanzeiger, am 12.12.2003	(2004): Ein maßgeblicher Beitrag zum Umweltschutz – Pilotprojekt im Klärwerk Stahnsdorf: Neue Sanitärsysteme für Ressourcenschonung von Wasser, Nährstoffen und Energie. Presse- und Fototermin im Klärwerk Stahnsdorf mit Merita Schmidt, Stahnsdorfer Ortsanzeiger, am 12.12.2003, Stahnsdorfer Ortsanzeiger, 15. Jahrgang, Heft 1, S. 4.
11	Dr. Peter-Fröhlich	Pressetermin mit Herrn Björkmann von der Schwedischen Wasserwirtschaftzeitschrift „Cirkulation" im KompetenzZentrum Wasser Berlin am 19.1.2004	(2004): Vattenforskning far nytt institut i Berlin. Wasserwirtschaftszeitschrift „Cirkulation", September, S. 22-24.
12	-	Presse- und Fototermin im Klärwerk Stahnsdorf am 24.11.2003	(2004): Kompetenzzentrum Wasser Berlin gGmbH: Teilstrom-Projekt gestartet. Presse- und Fototermin im Klärwerk Stahnsdorf am 24.11.2003, WWT 1-2, S 7.

Fortsetzung SCST- Präsentation in Medien

13	-	Presse- und Fototermin im Klärwerk Stahnsdorf am 24.11.2003	(2004): Kompetenzzentrum Wasser Berlin testet die NoMix-Toilette: Ökologie im Örtchen. Presse- und Fototermin im Klärwerk Stahnsdorf am 24.11.2003, Entsorga-Magazin 1-2, S 33-34.
14	-	Interview von Claire Pineau des KWB mit A. Peter-Fröhlich zum SCST-Projekt im März 2004	(2004): Innovative Sanitärkonzepte in Berlin. Interview mit A. Peter-Fröhlich zum SCST-Projekt, Newsletter 4, Kompetenzzentrum Wasser Berlin, S 2.
15	-	-	(2003): SCST – Sanitärkonzepte zur separaten Behandlung von Urin, Fäkalien und Grauwasser. Tätigkeitsbericht, KompetenzZentrum Wasser Berlin, www.kompetenz-wasser.de, S. 10-11.
16	Dr. Peter-Fröhlich	Presse- und Fototermin mit Märkischer Oderzeitung im Klärwerk Stahnsdorf am 7.7.2004	(2004): Artikel über SCST-Projekt in Märkischer Oderzeitung. Presse- und Fototermin mit Märischer Oderzeitung im Klärwerk Stahnsdorf am 7.7.2004, (in Vorbereitung)
17	-	-	(2005): Wozu die Schwerkraft nützlich ist – Das Berliner Kompetenzzentrum testet im Klärwerk Stahnsdorf zwei neue Sanitärsysteme. Das Grundblatt, Nr. 3, März 2005, 12. Jg., S. 10.

Sanitation Concepts for Separate Treatment of Urine, Faeces and Greywater (SCST)

Presentations and publications

Lfd. Nr.	Vortragende(r)	Veranstaltung	Titel des Vortrages bzw. der Veröffentlichung
1	Dr. Peter-Fröhlich	Informationsveranstaltung des KompetenzZentrums WasserBerlin (KWB) am 21.11.2001 auf der Schleuseninsel in Berlin	Lesouéf, A., Peter-Fröhlich, A., Kraume, I., Phan, L. (2001): Pilotvorhaben dezentrale Sanitärtechniken. Informationsveranstaltung des Kompetenz-Zentrums WasserBerlin (KWB) am 21.11.2001 auf der Schleuseninsel in Berlin (keine schriftliche Fassung)
2	Dr. Peter-Fröhlich	Informationsveranstaltung des KompetenzZentrums WasserBerlin (KWB) für Freifrau von Friesen, Senatorin für Wirtschaft und Technologie in Berlin, am 28.11.2001 im Klärwerk Ruhleben	Lesouéf, A., Peter-Fröhlich, A., Kraume, I., Phan, L. (2001): Pilotvorhaben dezentrale Sanitärtechniken. Informationsveranstaltung des Kompetenz-Zentrums WasserBerlin (KWB) für Freifrau von Friesen, Senatorin für Wirtschaft und Technologie in Berlin, am 28.11.2001 im Klärwerk Ruhleben (keine schriftliche Fassung)
3	Dr. Peter-Fröhlich	Workshop Zukunftsfähiges Abwassermanagement Lambertsmühle in der Lambertsmühle am 6.6.2002.	Peter-Fröhlich, A., Lesouéf, A., Kraume, I., Phan, L., Gommery, L. (2002): Neue Sanitärkonzepte für die separate Erfassung und Behandlung der Teilströme Urin, Fäkalien und Grauwasser. Workshop Zukunftsfähiges Abwassermanagement Lambertsmühle in der Lambertsmühle am 6.6.2002, KA, H 10, S. 1339-1342.
4	Dr. Peter-Fröhlich	Information der für Stahnsdorf zuständigen Gesundheitsbehörde in Belzig am 16.6.2002.	Peter-Fröhlich, A., Lesouéf, A., Kraume, I., Phan, L., Gommery, L. (2002): Neue Sanitärkonzepte für die separate Erfassung und Behandlung der Teilströme Urin, Fäkalien und Grauwasser. Information der für Stahnsdorf zuständigen Gesundheitsbehörde in Belzig am 16.6.2002.(PowerPoint-Präsentation als Tischvorlage verteilt)
5	Herr Keller Frau Kraume Dr. Peter-Fröhlich	Betreuung des SCST-Standes auf Schaufenster der Wissenschaft „Welt des Wassers“ in den Arkaden des Potsdamer Platzes in Berlin vom 11.-15.9.2002.	Keller, S., Kraume, I., Peter-Fröhlich, A. (2002): Neue Sanitärkonzepte für die separate Erfassung und Behandlung der Teilströme Urin, Fäkalien und Grauwasser. Schaufenster der Wissenschaft „Welt des Wassers“ des Forschungsmarktes Berlin in den Arkaden des Potsdamer Platzes in Berlin vom 11.-15.9.2002. (Ausstellung und PowerPoint-Präsentation)
6	Dr. Peter-Fröhlich	Vortragsreihe „Die Welt des Wassers“ in der URANIA in Berlin am 14.9.2002.	Peter-Fröhlich, A., Lesouéf, A., Kraume, I., Phan, L., Gommery, L. (2002): Neue Sanitärkonzepte für die separate Erfassung und Behandlung der Teilströme Urin, Fäkalien und Grauwasser. Vortragsreihe „Die Welt des Wassers“ in der URANIA in Berlin am 14.9.2002. (keine schriftliche Fassung)
7	Dr. Peter-Fröhlich	Water Management and R&D Activities in Berlin, Study Tour of Senior Water Professionals from USA, KompetenzZentrum Wasser Berlin, 23.-25.9.2002.	Peter-Fröhlich, A., Lesouéf, A., Kraume, I., Phan, L., Gommery, L. (2002): Sanitation Concepts for Separate Treatment of Urine, Faeces and Greywater. Water Management and R&D Activities in Berlin, Study Tour of Senior Water Professionals from USA, KompetenzZentrum Wasser Berlin, 23.-25.9.2002. (keine schriftliche Fassung)
8	Dr. Peter-Fröhlich	Fortbildungsprogramm „Städtischer Umweltschutz China“ an der TU Berlin am 13.2.2003.	Peter-Fröhlich, A., Lesouéf, A., Kraume, I., Phan, L., Gommery, L. (2003): Neue Sanitärkonzepte für die separate Erfassung und Behandlung der Teilströme Urin, Fäkalien und Grauwasser. Fortbildungsprogramm „Städtischer Umweltschutz China“ an der TU Berlin am 13.2.2003. (gleiche Präsentation wie in URANIA, keine schriftliche Fassung)
9	Dr. Peter-Fröhlich	2nd International Symposium on Ecological Sanitation in Lübeck, 6.-11.4.2003.	Peter-Fröhlich, A., Kraume, I., Lesouéf, A., Phan, L., Gommery, L. and Oldenburg, M. (2003): Sanitation Concepts for Separate Treatment of Urine, Faeces and Greywater. 2nd International Symposium on Ecological Sanitation in Lübeck, 6.-11.4.2003, Preprints on www.gtz.de/ecosan/download/ecosan-Symposium-luebeck-proceedings-draft.pdf
10	Dr. Peter-Fröhlich	Conference Wasser Berlin 2003, Berlin Centre of Competence for Water – Research for the Future, 11.4.2003.	Peter-Fröhlich, A., Kraume, I., Lesouéf, A., Phan, L., and Oldenburg, M. (2003): New Sanitation Concepts for Separate Treatment of Urine, Faeces and Greywater- Pilot project. Conference Wasser Berlin 2003, Berlin Centre of Competence for Water – Research for the Future, 11.4.2003, Conference Proceedings and www.kompetenz-wasser.de (in preparation). Furthermore Conference CD (English and German version) (in preparation).
11	L. Gommery S. Keller L. Phan R.J. Schwarz	Trade Fair, Wasser Berlin 2003, Berlin Centre of Competence for Water, 7.- 11.4.2003.	Peter-Fröhlich, A. (2003): New Sanitation Concepts for Separate Treatment of Urine, Faeces and Greywater (SCST) - Pilot project. Trade Fair, Wasser Berlin 2003, Berlin Centre of Competence for Water, 7.-11.4.2003, Poster.

Fortsetzung
Sanitation Concepts for Separate Treatment of Urine, Faeces and Greywater (SCST)
Vorträge und Publikationen

12	Dr. Peter-Fröhlich	World Water & Environmental Resources Congress 2003 in Philadelphia, USA, 23.- 26.6.2003.	Peter-Fröhlich, A. ., Kraume, I., Lesouéf, A. and Oldenburg, M. (2003): Separate Discharge and Treatment of Urine, Faeces and Greywater - Pilot Project. World Water & Environmental Resources Congress 2003 in Philadelphia, USA, 23.- 26.6.2003. American Society of Civil Engineers (ASCE).
13	--	--	Peter-Fröhlich, A. ., Kraume, I., Lesouéf, A. and Oldenburg, M. (2003): Separate Discharge and Treatment of Urine, Faeces and Greywater - Pilot Project. Hydroplus, nº 135, July-August, pp 81-86.
14	Dr. Peter-Fröhlich	Water Middle East 2003, International Exhibition and Conference for Water Technology, 6.- 8.10.2003 in Manama, Bahrain	Peter-Fröhlich, A. ., Kraume, I., Lesouéf, A. and Oldenburg, M. (2003): Sanitation Concepts for Separate Treatment of Urine, Faeces and Greywater – Recycling of Nutrients. Conference Papers of Water Middle East 2003, International Exhibition and Conference for Water Technology, 6.- 8.10.2003 in Manama, Bahrain, BCEB – Bahrain Convention & Exhibition Bureau, P.O. Box 11644, Manama, Kingdom of Bahrain, www.bahrainexhebitions.com, pp 285 – 294.
15	Dr. Peter-Fröhlich	Städtesymposium Wasser – Berlin trifft Paris im dbb-Forum in Berlin am 23.10.2003	Peter-Fröhlich, A., Luck, F., Lesouéf, A., Kraume, I., Lesjean, B.,Oldenburg, M. (2003): Sanitation Concepts for Separate Treatment of Urine, Faeces and Greywater. Städtesymposium Wasser – Berlin trifft Paris im dbb-Forum in Berlin am 23.10.2003, www.kompetenz-wasser.de/engl/projekte/scst and www.kompetenz-wasser.de/engl/veranstaltungen
16	Dr. Peter-Fröhlich	Sitzung Arbeitskreis Abwasser der Brandenburgischen und Berliner Wasserver- und Abwasserentsorgungsunternehmen in der Unternehmenszentrale der Berliner Wasserbetriebe am 30.10.2003.	Peter-Fröhlich, A., Luck, F., Lesouéf, A., Kraume, I., Lesjean, B.,Oldenburg, M. (2003): Neue Sanitärkonzepte für die separate Erfassung und Behandlung der Teilströme Urin, Fäkalien und Grauwasser. Sitzung Arbeitskreis Abwasser der Brandenburgischen und Berliner Wasserver- und Abwasserentsorgungsunternehmen in der Unternehmenszentrale der Berliner Wasserbetriebe am 30.10.2003 (Vortrag als ppt-Datei an Teilnehmer verteilt).
17	--	--	Peter-Fröhlich, A., Kraume, I., Lesouéf, A. und Oldenburg, M. (2004): Separate Ableitung und Behandlung von Urin, Fäkalien und Grauwasser. Korrespondenz Abwasser, H1, S. 38-43.
18	Dr. Peter-Fröhlich	2nd IWA Leading-Edge Conference on Water and Wastewater Treatment Technologies. Prague, Chech Republic, 1 – 4 June 2004.	Peter-Fröhlich, A., Kraume, I., Luck, F., Lesouéf, A. and Oldenburg, M. (2004): Demonstration Project for Separate Treatment of Urine, Faeces and Greywater – Cost Comparison with the Conventional Wastewater System. 2nd IWA Leading-Edge Conference on Water and Wastewater Treatment Technologies. Prague, Chech Republic, 1 – 4 June. Final Programme and Abstract Book, pp 127-129.
19	Dr. Peter-Fröhlich	4th IWA World Water Congress and Exhibition, Marrakech, Morocco, 19 – 24 September 2004	Peter-Fröhlich, A., Kraume, I., Luck, F., Lesouéf, A. and Oldenburg, M. (2004): Sanitation Concepts for Separate Treatment of Urine, Faeces and Greywater – Demonstration Project in Berlin, Germany. 4th IWA World Water Congress and Exhibition, Marrakech, Morocco, 19 – 24 September. Conference CD, documents, Paper ID 115978.
20	B.Lesjean	International Conference on Sustainable Systems in Wastewater Management, Berlin, Germany, 4 – 6 October 2004	Lesjean, B. (2004): Vision of Advanced Decentralised Systems in Wastewater Management. International Conference on Sustainable Systems in Wastewater Management, Berlin, Germany, 4 – 6 October 2004, Conference-CD.
21	Dr. Weigert Hr Lesjean Hr. Sahlmann Hr. Schröder Dr. Luck Dr. Peter-Fröhlich	KWB-Ausstellerstand auf dem 4th IWA World Water Congress and Exhibition, Marrakech, Morocco, 19 – 24 September 2004	Peter-Fröhlich (2004): New Sanitation Concepts for Separate Discharge Treatment of Urine, Faeces and Greywater – Demonstration Project. Poster auf dem KWB-Ausstellerstand des 4th IWA World Water Congress and Exhibition, Marrakech, Morocco, 19 – 24 September.
22	Dr. Peter-Fröhlich	Sino-German Workshop 2004, Wastewater as Resource, 10 – 13 October 2004	Peter-Fröhlich, A. (2004): New Sanitation Concepts for Separate Treatment of Urine, Faeces and Greywater – Recycling of Nutrients and Water. Sino-German Workshop 2004, Wastewater as Resource, 10 – 13 October, PowerPoint-Presentation in preprints (Chinese) and on CD in German and Chinese, Technical University Berlin, Dept. of Water Quality Control, www.tu-berlin.de .
23	Dr. Peter-Fröhlich	2nd Leading-Edge Conference on Sustainability in Water-Limited Environments, 8 -10 November 2004 in Sydney, Australia	Peter-Fröhlich, A., Kraume, I., Luck, F., Lesouéf, A. and Oldenburg, M. (2004): Demonstration Project for Separate Discharge and Treatment of Urine, Faeces and Greywater – First Results. 2nd Leading-Edge Conference on Sustainability in Water-Limited Environments, 8 -10 November 2004 in Sydney, Australia, Conference-CD, No …95996.
24	Dr. Peter-Fröhlich	At the End of the Pipe – Looking beyond current solutions. Informal meeting on 27 January 2005 in The Hague, Netherlands.	Peter-Fröhlich, A. (2005): New Sanitation Concepts – Demonstration Project in Berlin. At the End of the Pipe – Looking beyond current solutions. Informal meeting on 27 January 2005 in The Hague, Netherlands, organised by WASTE etc., www.waste.nl.

Fortsetzung

Sanitation Concepts for Separate Treatment of Urine, Faeces and Greywater (SCST)

Vorträge und Publikationen

25	Dr. Peter-Fröhlich	Tradition & Transformation – Die Zukunft der Stadt. 8. Weltkongress von Metropolis, 11. – 15. Mai 2005 im Hotel Intercontinental Berlin, Germany.	Peter-Fröhlich, A. (2005): Sanitation Concepts for Separate Treatment of Urine, Faeces and Greywater Demonstration Project in Belin, Germany. Wassermanagement in großen Metropolen, Tradition & Transformation – Die Zukunft der Stadt. 8. Weltkongress von Metropolis, 11. – 15. Mai 2005 im Hotel Intercontinental Berlin, Germany. (kein Manuskript).
26	Dr. Peter-Fröhlich	WILO EMU GmbH und German Water-Tagung Innnovation in der Abwassertechnik, 28.9.2005 in Würzburg	Peter-Fröhlich, A. (2005): EU-Demonstrationsprojekt Alternative Sanitärkonzepte am Standort Stahnsdorf. WILO EMU GmbH und German Water-Tagung Innovation in der Abwassertechnik, 28.9.2005 in Würzburg, Kurzfassung im Tagungsband.
27	Dr. Peter-Fröhlich	Neuartige Sanitärsysteme, 7. Wasserwerkstatt, Kolloquium des KompetenzZentrum Wasser Berlin, 1.12.2005 in Berlin	Peter-Fröhlich, A. (2005): Konsequente Trennung und Behandlung von Abwasserteilströmen – Erfahrungsbericht aus einem laufenden Berliner Demonstrationsvorhaben. Neuartige Sanitärsysteme, 7. Wasserwerkstatt, Kolloquium des KompetenzZentrum Wasser Berlin, 1.12.2005 in Berlin (kein Manuskript).
28	Dr. Peter-Fröhlich	Petersberg Phase II, Protection and Sustainable Use of Trans-boundary Waters in South East Europe, Roundtable on Transboundary Water Management of BMU and World Bank, 5. 7.12.2005 in Berlin	Peter-Fröhlich, A. (2005): Alternative Concepts for Sanitation. Petersberg Phase II, Protection and Sustainable Use of Trans-boundary Waters in South East Europe, Roundtable on Transboundary Water Management of BMU and World Bank, 5. 7.12.2005 in Berlin, Abstract for Preprints.

Annex 7.8

Zusammenfassung des Stahnsdorf-Workshops im Rahmen des SCST-Projekts am 30. Juni 2005

1. Veranlassung

Der Workshop fand im Rahmen des von der EU als Life-Projekt geförderten Projekts „New Sanitation Concepts for Separate Treatment of Urine, Faeces and Greywater - Recycling of Nutrients and Water" (SCST-Projekt) statt. Das Projekt und deren erste Ergebnisse sollte dabei einer Fachöffentlichkeit zugänglich gemacht werden. Gleichzeitig sollte bei dieser Gelegenheit die in Linz vor einem Jahr begonnene Diskussion über die Nutzung von Reststoffen fortgeführt werden. Eingeladen zu dem Workshop hatten die Berliner Wasserbetriebe und das Kompetenzzentrum Wasser Berlin.

2. Zusammenfassung der Vorträge

Während der Vorstellungsrunde der Teilnehmer wies Prof. Otterpohl auf die weltweite Verbreitung der teilstromorientierten Sanitärkonzepte hin. Weltweit werden derzeit ca. 1 Mio. Trenntoiletten eingesetzt, deren Anwendung sich hauptsächlich auf China erstreckt. Die Qualität der Reststoffe, ist dabei stark abhängig von Umweltbedingungen, Lebensgewohnheit und Ernährung der Menschen; so ist aus Indonesien eine Belastung des menschlichen Urins mit Quecksilber bekannt.

Zu Beginn der anschließenden Vorträge gab Dr. Anton-Peter Fröhlich von den Berliner Wasserbetrieben eine Übersicht über das Demonstrationsprojekt „Neue Sanitärtechniken" auf dem Gelände der Kläranlage Stahnsdorf. Er stellte die einzelnen Bausteine des Projekts und die Mitwirkenden vor. Neben dem Bau und dem Betrieb der Anlagen im Betriebsgebäude der Kläranlage und des angrenzenden Wohngebäudes als Demonstrationsanlage (Berliner Wasserbetriebe und Kompetenzzentrum Wasser Berlin) gibt es die Teilprojekte der Untersuchungen zur Urinaufbereitung (Technische Universität Hamburg-Harburg), die Untersuchungen zur landwirtschaftlichen Verwertung der Reststoffe (Humboldt-Universität Berlin) und das Life Cycle Assessment (Ökobilanz) (Technische Universität Berlin).

Hieran schloss sich der Vortrag von Hr. Bonhomme an, der die Ergebnisse der laufenden Untersuchungen vorstellte. Die dargestellte Differenz bei den Wassermengen der Teilströme kann dabei auf einen Messfehler zurückzuführen sein; hier sind nähere Untersuchungen notwendig. Die Konzentrationen, hier insbesondere des Teilstroms Grauwasser, sind sehr niedrig; dementsprechend niedrig ist auch die Belastung der Behandlungsanlagen. Da es sich bei dem Abwasser nur um die Entwässerung des Betriebsgebäudes handelt, in dem das Grauwasser hauptsächlich aus den Waschbecken und der Dusche stammt, ist dies auch plausibel. Durch den Anschluss des Wohngebäudes wird eine deutliche Veränderung der Zusammensetzung der Teilströme und somit auch eine erheblich höhere Belastung der Anlagenteile erwartet.

Herr *Tettenborn* von der Technischen Universität Hamburg-Harburg berichtete über den Stand der Untersuchungen zur Nährstoffrückgewinnung aus Urin. Das Teilprojekt „Erprobung und Entwicklung von Prozessen zur Urinaufbereitung" untersucht verschiedene Aufbereitungsmöglichkeiten für Urin. Anhand von Literaturdaten ist aus seiner Sicht eine stark ansteigende Nachfrage an Stickstoffdünger zu erwarten, der insbesondere von dem asiatischen Raum (China) ausgeht, während der Anspruch an die Nahrungsqualitäten und der Fleischkonsum steigen wird. Da keine Erweiterung der Anbauflächen möglich ist, wird sich die flächenbezogene Produktivität steigern müssen; dies ist nur durch eine höhere Nährstoffzufuhr (Düngung) möglich. Von der technischen Urinbehandlung wird eine Volumenreduktion, eine Konzentration und selektive Extraktion von Stoffen, die verwertet

werden können, und eine Elimination von Mikroverunreinigungen erwartet.
Es werden Verfahren zur Verdampfung (Evaporation) und zur Dampfstrippung untersucht. Bei den Versuchen stellte sich Urin als relativ schwierig zu verarbeitender Stoff dar, der insbesondere bei Hitzebehandlungen zu Ausfällungen, Verstopfungen und starker Schaumbildung neigt. Ferner ist bei der Vakuumverdampfung derzeit noch ein Stickstoffverlust in das Destillat durch Schaumbildung und aufgrund des hohen pH-Wertes von gelagertem Urin zu beobachten. Zur Vermeidung von Stickstoffverlusten ist ein niedriger pH-Wert erforderlich. Die Eindampfzeiten sind noch sehr hoch, ferner gibt es noch verfahrenstechnische Probleme zu bewältigen. In bisherigen Versuchen der Dampfstrippung wurde unbehandelter frischer und gelagerter Urin bei pH-Werten zwischen 8,6 - 11,6 verwendet.Die Dampfstrippung erzielt bisher noch nicht die erwarteten Ergebnisse, hier liegen die erzielten Konzentrationen erst bei 10 % der erwarteten Werte. Im Kondensat nach der Strippung mit Dampf (100°C, 1atm) konnten diverse Arzneimittelrückstände (u.a. Diclofenac, Carbamazepin etc.) in geringen Mengen (1 – 4 % der Ausgangskonzentration) nachgewiesen werden, d.h. es findet ein geringer Transfer dieser Stoffe über die Dampfphase statt.
Trotz der anfänglichen Schwierigkeiten werden die Pilotanlagen für Eindampfung und Strippung optimiert, da bei der Behandlung größerer Volumina eine Reduzierung der Probleme (Verstopfungen, Fällung etc.) erwartet werden und nach wie vor ein großes Potential in den Verfahren gesehen wird. Untersuchungen zur MAP-Fällung und Kristallisation sind angestrebt und auch die Elimination von pharmazeutischen Rückständen durch verschiedene Verfahrensschritte (UV-Behandlung, Ozonisierung und Kristallisation) sollen näher betrachtet werden. Behandlungstests sind noch nicht durchgeführt worden, da noch an dem Aufbau einer adäquaten Analytik gearbeitet wird.
In der anschließenden Diskussion ergänzte Prof. Ellmer (HUB) den jährlichen Stickstoffdüngerbedarf in Deutschland von ca. 1 Mio. t N, dem ein Potential aus Urinstickstoff von ca. 400.000 t N je Jahr gegenüber steht. Der Urin kann durchaus den gleichen Ertrag wie Mineraldünger erbringen, hier sind allerdings die Bodenverhältnisse zu berücksichtigen; bei der Applikation sind Stickstoffverluste zu vermeiden (Dr. Clemens). Dr. Clemens wies auf analytische Besonderheiten hin, da der Harnstoff bei der Kjeldahl-Stickstoff-Bestimmung (TKN) nur unzureichend erfasst wird.

Frau *Hammer* von der Technischen Universität Hamburg-Harburg beschäftigt sich mit der „Teilstrombehandlung und –nutzung von Urin im Hinblick auf pharmazeutische Rückstände“. In einer ersten Phase wird die Literatur zum Thema gesichtet und systematisch aufbereitet; hieran werden sich in der nächsten Phase Anwendungsversuche anschließen, die die Grundlagen für eine Risikoanalyse bilden. Für die erste Phase ist eine Datenbank aufgebaut worden, um die vorhandenen Literaturstellen auszuwerten. Hierin werden die jeweiligen Substanzen, deren Vorkommen und Medium (Wasser, Abwasser, Boden etc.) als auch deren Abbau (Behandlung, Metabolite etc.) erfasst. Derzeit umfasst die Datenbank 230 verschiedene Substanzen aus 80 Artikeln. Hierbei ist die Qualität der Aussagen stark unterschiedlich und auch die verwendeten Detektionsverfahren sind oftmals nicht vergleichbar. Es ist beabsichtigt, auch Literaturstellen aus den Fachbereichen Medizin und Pharmazie auszuwerten. Hinsichtlich des Vorkommens ist jetzt ersichtlich, dass die Konzentrationen in den untersuchten Kläranlagen sehr großen Schwankungen unterliegen und dass ein Trend bzgl. der Medikationsgruppe oder anderer Kenngrößen (z.B. Oktanol-Wasser-Koeffizient) bisher nicht erkennbar ist. Es wird aber deutlich, dass die Ozonisierung sich nicht bei allen Substanzen positiv auswirkt. In fast allen Abwasserproben zu findende Substanzen sind Koffein und Nikotin; Koffein wird daher oft auch als Tracer genutzt. Abbauprodukte sind derzeit nur für acht Substanzen gefunden worden. In den weiteren Schritten ist beabsichtigt, die Verbrauchsmengen zu berechnen und pharmakokinetische Daten zu berücksichtigen und den identifizierten Mengen gegenüber zu stellen.
In der anschließenden Diskussion wurde deutlich, dass diese Arbeit wichtig für die weitere Entwicklung der Urinseparation sein wird. Es wurde nochmals darauf hingewiesen, dass bei der Interpretation der Messwerte die Analysengrenzen von besonderer Wichtigkeit sind.

Dr. *Clemens* von der Universität Bonn begann seinen Vortrag „Welche Substrate benötigt die Landwirtschaft und welche Fläche kann mit den Nährstoffen aus Urin und Fäkalien gedüngt werden?“ mit dem Statement, dass es in Deutschland voraussichtlich nicht möglich sein wird, Urin als Düngemittel zugelassen zu bekommen, obwohl weltweit die Verwendung von organischem Stickstoffdünger genauso verbreitet ist wie Mineraldünger. Er beginnt mit einem Projektbeispiel aus Vietnam und dem

„Bottom up approach“ zur Erreichung eines „sustainable agroecosystem“. In diesen Ländern sieht er ein sofortiges Umsetzungspotential für Düngestoffe aus menschlichen Ausscheidungen
Nach seinen Erfahrungen ist der Nährstoffgehalt von Urin höher als der in Gülle, und die Düngewirkung von Urin entspricht der von Mineraldünger. Die Ammoniakemissionen (NH_3) sind geringer und die N_2O-Emissionen nicht höher als bei herkömmlichen Düngern. Der Urin könnte dann bei bekanntem Nährstoffgehalt mit den allgemein anerkannten Regeln der Technik bodennah, besser noch mit sofortiger Einarbeitung, ausgebracht werden. Ein zeitlicher Abstand von einem Monat sollte zwischen Düngung und Ernte liegen, wobei eine Zugabe zu Blattgemüse und Salat nicht erfolgen darf. Erste Versuche der Bilanzierung des Verbleibs von Mikroverunreinigungen ließen ca. 2 – 20 % der Aufgabemenge im Boden, 10 – 20 % im Sickerwasser und < 2 – 10 % in der Pflanze wieder finden. Über den Verbleib des restlichen Anteils kann keine Aussage getroffen werden.
Trotz seines negativen Eingangsstatements erläutert Dr. Clemens die rechtlichen Regelungen der Düngeverordnung und Düngemittelverordnung in Deutschland zur Verwendung und der guten Praxis der Aufbringung von Dünger. Solange Urin nicht als Dünger in Tab. 11 bzw. 12 der Düngemittelverordnung (DüMV) aufgeführt ist, kann die Nutzung von Urin nur nach § 8 DüMV mit Ausnahmegenehmigung durch die zuständigen Behörden erfolgen. In beiden Fällen gilt die Voraussetzung, dass keine Gefährdung der Fruchtbarkeit des Bodens und der Gesundheit von Mensch und Tier, z.B. durch toxikologisch oder pharmakologisch wirksame Substanzen, gegeben ist. Die Nährstoffgehalte im Urin sind für ein Düngemittel zu gering, für einen Bodenhilfsstoff zu hoch. Ferner ist Urin kein Wirtschaftsdünger. Aus den mikrobiellen Verunreinigungen und den Hormonen und Pharmakarückständen des unbehandelten Urins kann eine potentielle Schädigung der Umwelt abgeleitet werden. Technologien zur Aufbereitung von Urin könnten die Einführung von Urin als Düngestoff entscheidend beeinflussen. Struvit aus Urin als Düngemittel ist derzeit durchaus genehmigungsfähig, wobei die Düngewirkung getesteter Struvitformen stark voneinander differiert.
Die Diskussion um eine Nutzung von Urin als Nährstoffquelle werden sehr stark durch ethische Bedenken geleitet und verhindert.
Handlungsmöglichkeiten werden von Dr. Clemens mit unterschiedlichen Zeithorizonten vorgeschlagen. Kurzfristig sollte versucht werden, Urin mit so wenig Behandlungsschritten als möglich als Düngemittel einsetzen zu können. Die Anwendung sollte zunächst auf den Bereich der nachwachsenden Rohstoffe beschränkt werden. Für eine Risikobewertung ist der Nachweis der Abwesenheit von infektiösem Material erforderlich. Mittelfristig besteht der Forschungsbedarf bei der Durchführung von Toxizitäts- und Abbautests mit realen Frachten.

In der anschließenden Diskussion wurde noch einmal auf die Wichtigkeit der Verwendung der richtigen Begrifflichkeiten hingewiesen. Urin ist kein Dünger, Düngemittel oder Düngestoff, da er derzeit in Deutschland nicht nach DüMV klassifiziert und zugelassen ist. Prof. Ellmer unterstützt die Forderung nach Langzeitversuchen zur Bewertung der Düngewirkung von Urin. Dr. Steinmüller schlägt vor, die in Schweden vorhandenen Daten der seit 10 Jahre laufenden Urinapplikation auszuwerten. Dr. Clemens weist darauf hin, dass in seinem Institut Flächen sind, die seit ca. 40 Jahren mit Klärschlamm gedüngt werden. Hier ließe sich die Deposition von Pharamkarückständen gut untersuchen, leider ist hierfür derzeit kein Geld vorhanden.

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Dr. *Roschke* vom Landesamt für Verbraucherschutz, Landwirtschaft und Flurneuordnung Brandenburg stellte in seinem Vortrag „Anforderungen an Düngemittel aus Fäkalien und ihre Verwertung auf landwirtschaftlichen Nutzflächen“ die rechtliche Situation der Verwertung dar. Nach Kreislaufwirtschafts-/Abfallgesetz (KrW-/AbfG) sind Fäkalien Bestandteil von Klärschlamm, demnach ist die Klärschlammverordnung (AbfKlärV) bei einer Verwertung auf landwirtschaftlichen Nutzflächen zu beachten. Die Anforderungen hinsichtlich Nähr- und Schadstoffuntersuchungen sind hier formuliert. Das Inverkehrbringen von Düngemitteln ist in der Düngemittelverordnung (DüMV) geregelt. Ausgangsstoffe für Düngemittel müssen in der DüMV Tab. 11 oder 12 enthalten sein, Klärschlamm ist in Tab. 11 Nr. 46 aufgeführt. Derzeit werden bei Klärschlammverwertung in Klärschlämmen Arzneimittelrückstände und Antibiotika nicht untersucht. Dr. Roschke sieht einen Forschungsbedarf bei Verbleib und Abbauverhalten dieser Rückstände im Boden und deren Transfer in andere Medien. Des Weiteren erläuterte er die Regelungen der Düngeverordnung (DüV) hinsichtlich des Aufbringens der Dünger. Er schlägt vor, alte Rieselfelder auf Rückstände an Arzneimitteln und Antibiotika zu untersuchen um Erkenntnisse über den langfristigen Verbleib dieser Stoffe zu erhalten. Seiner Meinung können Fäkalien, die die Anforderungen an die AbfKlärV und die DüMV erfüllen als org. NK-Dünger in Verkehr gebracht werden. Der im Urin enthaltene Stickstoff liegt im Wesentlichen als Ammonium N vor und ist somit wie Mineraldünger einsetzbar. Die üblichen Regelungen nach DüMV und DüV hinsichtlich Überwachung, Aufbringung, Lagerung etc. müssen natürlich eingehalten werden. Für das Land Brandenburg zeigt sich in langjährigen Nährstoffvergleichen zwischen Zufuhr von Nährstoffen mit Düngemitteln und der Abfuhr mit pflanzlichen Produkten bei Stickstoff ein Überschuss von ca. 40 kg/ha N und bei Phosphor eine Unterbilanz in Höhe von ca. 5 kg/ha P.

In der nachfolgenden Diskussion führte Dr. *Werres* (IWW) aus, dass nach seiner Meinung Indikatortests und die Identifikation von Indikatorsubstanzen erforderlich sind. Dies wurde von Dr. Gulyas (TUHH) als wenig Erfolg versprechend angesehen.

Dr. *Hohenblum* vom Umweltbundesamt in Österreich stellte in seinem Vortrag „Verhalten ausgewählter organischer Schadstoffe bei der Ausbringung auf Böden und deren Abbau in Kläranlagen“ Untersuchungsergebnisse aus Österreich vor. Es werden Ergebnisse aus Untersuchungen bzgl. Pharmazeutika in den Zu- und Abflüssen von Kläranlagen, in der Donau, im Deponiesickerwasser und im Klärschlamm vorgestellt. Interessant ist der Nachweis von Nonylphenol im Weizen. Nonylphenol wurde offensichtlich durch die Luft aufgenommen, da sowohl bei den exponierten Pflanzen als auch bei einem unbehandelten Vergleichskollektiv ähnliche Konzentrationen gemessen wurden. Die Möglichkeit des Eintrags von Nonylphenol wurde durch Feinstaubmessungen bestätigt.

Nach einer Besichtigung der Anlagen vor Ort wurde das Programm mit der Diskussion weitergeführt.

Für die Diskussion am Nachmittag wurden die wesentlichen Fragestellungen zur möglichen Nutzung von Urin und Fäkalien als Düngemittel in Deutschland formuliert.
Die Aspekte

1. Findung einer konsensfähigen Terminologie,
2. Erfahrungen mit Sanitärinstallationen und
3. Techniken der Urinaufbereitung, Mögliche Verfahren und Verfahrensabfolgen und deren Probleme

wurden an den neu gegründeten DWA-Fachausschuss KA 1 „Neuartige Sanitärsysteme“ der DWA verwiesen.

Für die Fragestellung

4. Einordnung der Mikroverunreinigungen (Relevanz, Abgrenzung Human-, Veterinärpharmaka, Indikatorsubstanzen, Aussagefähigkeit und Übertragbarkeit bisheriger Untersuchungen, Toxizitätstests und Ökotoxikologie)

wird auf die Bearbeitung dieses Punkts durch Frau Hammer verwiesen. Dr. Werres schlägt vor, die Diskussion auf bestimmte Stoffe zu beschränken. Prof. Londong (Uni Weimar) verweist auf die DWA-Arbeitsgruppe KA 8.1 „Anthropogene Stoffe im Wasserlauf" des Fachausschusses KA 8, die diese Stoffgruppen betrachtet. Frau Hammer soll für ihre Arbeiten Kontakt mit dieser Arbeitsgruppe aufnehmen.

Der Punkt

5. Untersuchungen zur landwirtschaftlichen Verwertung (Langzeituntersuchungen, statistisch belastbare Erkenntnisse zur Düngewirkung und zur Umweltrelevanz, landwirtschaftliche Untersuchungen in internationalem Maßstab)

wird diskutiert. Der Vorschlag, die Schädlichkeit von Urin und Fäkalien in Relation zu Mineraldüngern zu setzen, wird von Dr. Roschke abgelehnt. Er verweist auf die Möglichkeit die im Rahmen von Sonderregeln zeitlich befristete Ausnahmegenehmigung für die Aufbringung der Stoffe (DMG §2, Abs. 3, Nr. 2) für Versuchs- und Untersuchungszwecke zu nutzen.
Prof. Bischof merkt an, dass der zukünftige Markt für diese Konzepte nicht innerhalb der EU sondern in z.B. in China zu suchen ist, wo die in Europa gesehenen Probleme nicht relevant sind.
Dr. Clemens bietet an, diverse Substrate in Topfversuchen zu testen, um eine Datenbank über die Erkenntnisse aufzubauen. Prof. Ellmer schlägt vor, Substrate aus Stahnsdorf in Langzeitversuchen im Umland auf landwirtschaftlichen Flächen zu testen. Prof. Otterpohl verweist auf das 6. Rahmenprogramm der EU zur Nutzung von Fördermöglichkeiten für Projekte.

Die Frage

6. Wirtschaftlichkeit bei Einsatz der Reststoffe und erforderliche Infrastruktur

wird nicht näher diskutiert, vielmehr wird auf den DWA -Fachausschuss KA 1 verweisen.

Die umfassende Betrachtung

7. Welche Fragen des letzten Jahres, die im Linz-Workshop formuliert wurden, sind beantwortet

soll durch das Verteilen der Antworten durch Dr. Steinmüller an alle Teilnehmer erledigt werden.

Bei dem Punkt

8. Rechtliche Rahmenbedingungen

schlägt Dr. Clemens vor, sich mehr auf das Ausland zu konzentrieren, wo das Problem der Arzneimittelrückstände nicht so problematisch gesehen wird wie in Europa/Deutschland.

Lübeck, 7.10.2005

Dr.-Ing. Martin Oldenburg
OtterWasser GmbH

3. Programm

Berliner Wasserbetriebe
AE-T/V/Pe
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1. Juni 2005

Stahnsdorf-Workshop

„Wie lassen sich Urin und Fäkalien als Düngemittel in der Landwirtschaft nutzen?“

am 29. Juni 2005, 18:00 Uhr bei Veolia Water in Berlin, Unter den Linden 21 (++49-(0)30-20921130)
und am 30. Juni 2005, 8:30 – 16:00 Uhr im Klärwerk Stahnsdorf (++49-(0)30-86448643 oder 8620

29. Juni Mittwoch		
18:00	Empfang bei Veolia Water in Berlin incl. Buffet	
30. Juni Donnerstag		
	Moderation	*Peter-Fröhlich*
8:30	Begrüßung und Erläuterung des Tagesablaufes	*Luck* Kompetenzzentrum Wasser Berlin
8:45	Kurze Übersicht zum Demonstrationsprojekt „Neue Sanitär-konzepte“ in Stahnsdorf	*Peter-Fröhlich* Berliner Wasserbetriebe
9:00	Urinbehandlung, Zwischenbericht	*OtterpohlTettenborn* TU Hamburg-Harburg
9:30	Teilstrombehandlung und -Nutzung von Urin im Hinblick auf pharmazeutische Rückstände, Zwischenbericht	*OtterpohlHammer* TU Hamburg-Harburg
10:00	Pause	
10:15	Welche Substrate benötigt die Landwirtschaft und welche Flä-che kann mit den Nährstoffen aus Urin und Fäkalien gedüngt werden?	*Goldbach/Clemens* *Uni Bonn*
10:30	Untersuchungen zum Verbleib von Pharmazeutika bei Ver-wendung von Urin als Dünger am Beispiel Lambertsmühle	*Goldbach/Clemens* *Uni Bonn*
11:00	Anforderungen an Düngemittel aus Fäkalien und ihre Verwer-tung auf landwirtschaftlichen Nutzflächen	*Roschke* Landesamt Verbraucher-schutz Brandenburg
11:30	Verhalten ausgewählter organischer Schadstoffe bei der Ausbringung auf Böden und deren Abbau in Kläranlagen	*Hohenblum* *UBA Österreich*
12:00	Mittagessen	
13:00	Besichtigung des Demonstrationsprojektes „Neue Sanitärkon-zepte“ in Stahnsdorf	
14.00	Identifikation der wesentlichen Fragestellungen zur möglichen Nutzung von Urin und Fäkalien als Düngemittel in Deutsch-land bzw. in der EU	
14:45	Ermittlung der Aktivitäten zur Beantwortung der Fragestellun-gen (zukünftige Arbeiten, Forschungsprojekte, strategisches Vorgehen, Identifikation potentieller Partner)	
15:30	Abschlussdiskussion	
16:00	Ende der Veranstaltung	

4. Teilnehmer

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Annex 7.9

**Thesen
aus dem Stahnsdorf-Workshop
im Rahmen des SCST-Projekts
am 30. Juni 2005**

1. Potentiale der Urinnutzung

- Stickstoffbedarf wird weltweit noch ansteigen
- In Deutschland könnte rechnerisch durch Urin ca. 40 % des Stickstoffdüngers ersetzt werden.
- Die zukünftigen, rasch erschließbaren Märkte liegen im außereuropäischen Raum, da hier die Restriktionen der Verwertung und Bedenken nicht so stark sind wie in Europa

2. Mikroverunreinigungen

- Eine Systematik bzw. einfachere Einteilung zur Beuteilung, z.B.über Indikatorsubstanzen, ist derzeit noch nicht erkennbar
- technische Verfahren wie UV-Behandlung, Ozonisierung, Kristallisation zur Elimination sind noch nicht ausreichen erforscht insbesondere im Bezug auf Urin
- Die Ozonisierung ist möglicherweise in manchen Fällen kontraproduktiv bei der Entfernung von Pharmarückständen da hierbei u.a. Aldehyde und andere unerwünschte Substanzen entstehen können
- Abbauwege und Metaboliten sind derzeit unbekannt, Daten können möglicherweise aus Pharmakokinetik gewonnen werden
- Bei der Aufnahme von Substanzen in den Fruchtstand (z.B. Getreide) kommen auch andere Übertragungswege, wie z.B. Luft, in Frage
- Verschiedene Analyseverfahren erschweren die Vergleichbarkeit der Analysenwerte
- Systematische Arbeiten werden derzeit an der TU Hamburg-Harburg durchgeführt
- Systematische Untersuchungen sind Grundlage für Risikobewertung

3. Verwertung der Reststoffe in der Landwirtschaft

- Urin in der Düngewirkung gleichwertig zu Mineraldüngern und Gülle
- Ammoniakemissionen bei der Düngung geringer als bei Wirtschaftsdüngern
- Nährstoffgehalt des Urins für ein Düngemittel zu gering, für einen Bodenhilfsstoff zu hoch (Hinweis: wenn im Urin mehr als 1,5 % N und mehr als 0,75 % K_20 in der TS (!) oder 3% N für org. N-Dünger enthalten sind, erfüllt es die Mindestnährstoffgehalte für ein Düngemittel)
- Derzeit ist Urin weder als alleiniger Ausgangsstoff für ein Düngemittel (Tab. 11) noch als Zugabestoff (Tab. 12) in der Düngemittelverordnung aufgeführt

- Mikroverunreinigungen können von Pflanzen aufgenommen werden, Abschätzungen und deren Risikobewertung ist derzeit nicht möglich
- Mikroverunreinigungen verhindern derzeit in Europa eine erfolgreiche Einführung von Urin als Nährstoffquelle, da eine Gefährdung der Fruchtbarkeit des Bodens und der Gesundheit von Mensch und Tier derzeit nicht mit Sicherheit ausgeschlossen werden können.
- Ethische Bedenken überwiegen gegenüber fachlichen Aspekten
- Die technische Aufbereitung kann die Verwertung von Urin vereinfachen
- Die Verwertung von Struvit aus Urin für die Düngemittelherstellung ist derzeit möglich
- Das Düngepotential von Struvit ist abhängig von der Herstellungsform
- Derzeit ist Urin als alleiniger Ausgangsstoff für ein Düngemittel in der Düngemittelverordnung nicht aufgeführt

4. Technische Behandlung von Urin

- Die MAP-Fällung scheint zu einem verwertbaren Produkt bei der Urinaufbereitung zu führen
- Belastbare Erkenntnisse über andere technische Aufbereitungsverfahren liegen derzeit noch nicht vor
- Für die technischen Verfahren Eindampfung und Dampfstrippung ist noch erheblicher Forschungsbedarf vorhanden, der derzeit in einem Projekt an der TUHH bearbeitet wird.
- Die Strippung scheint derzeit die Medikamentenrückstände nur teilweise aus dem Urin zu entfernen

5. rechtliche Aspekte der landwirtschaftlichen Verwertung

- Verwertung über Ausnahmegenehmigungen derzeit möglich
- Verwertung von Fäkalien und Urin gemäß AbfKlärV möglich

6. Forschungsbedarf und Defizite

- Langzeitversuche zur Bewertung der Düngewirkung
- Auswertung der schwedischen Versuche, die bereits 10 Jahre laufen
- Untersuchung von Flächen mit Langzeitapplikation von Klärschlamm

7. Vorschläge zur Vorgehensweise

- Es sollte eine Anfrage an den wissenschaftlichen Beirat nach § 7 des Düngemittelgesetzes gerichtet werden, unter welchen Voraussetzungen Urin nach Tab. 11 oder 12 der DüMV eingesetzt werden darf
- Systematische Düngeversuche, Akzeptanzstudien und Risikobewertung
- Durchführung von Toxizitäts- und Abbautests mit realen Frachten, systematische Stoffbilanzierungen
- Grundsätzlich sollte Urin mit so wenig Behandlungsschritten wie möglich als Düngemittel oder als Ausgangsstoff für Düngemittel verwendet werden. Die Anwendung sollte zunächst auf den Bereich der nachwachsenden Rohstoffe beschränkt werden.

8. Begleitende Fachausschüsse

- DWA Fachausschuss KA 1 „Neuartige Sanitärsysteme“ kommt wichtige Aufgabe zu bei:’
  Erarbeitung einer konsensfähigen Terminologie
  Erfahrungsaustausch und –dokumentation
  Darstellung von möglichen Techniken und Verfahrenstechnologien

9. Entwicklung des Wissenstands

- Gegenüber des Workshops in Linz hat sich die Liste der Fragen verlängert, es wurden kaum Fragen gelöst
  Es sind aber Tendenzen und Möglichkeiten der Vorgehensweise sichtbar, die durch interdisziplinäre Arbeitsgruppen und Arbeitsausschüsse abgearbeitet werden können.

Lübeck, 7.10.2005

Dr.-Ing. Martin Oldenburg
OtterWasser GmbH