PRIVATE-PUBLIC INNOVATION PROJECT

WASTEWATER TREATMENT AT HERLEV HOSPITAL, DENMARK

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BACKGROUND AND PROJECT OBJECTIVES

HOSPITAL WASTEWATER CONTAINS A COMPLEX MIXTURE OF HAZARDOUS PHARMACEUTICALS, HARMFUL PATHOGENS AND ANTIBIOTIC RESISTENT BACTERIA. THESE CANNOT BE REMOVED BY CONVENTIONAL MEANS OF WASTEWATER TREATMENT. HOWEVER, THEY POSE A THREAT TO PUBLIC HEALTH, THE ENVIRONMENT AND TO PEOPLE WHOSE DAILY WORK BRINGS THEM IN CLOSE CONTACT WITH THE WASTEWATER.

Herlev Hospital, located in the Capital Region of Denmark, faces these wastewater challenges as the Danish government wants to ensure that hospital wastewater is handled according to the Environmental Protection Act's regulations concerning the use of the Best Available Techniques (BAT).
Their objectives are to seek a treatment solution for Herlev Hospital's wastewater which will allow the hospital to obtain a license to operate either via a permit for discharge to public sewer works or via a permit for direct discharge to a local recipient (Kags Stream). This will then allow the Capital Region of Denmark and Herlev Hospital to implement their solution in other hospitals in the region.

However, (BAT) the best available techniques (here specifically technology that is both technically and economically feasible to treat the hospital wastewater) has not yet been defined and therefore the requirements for any discharge permit cannot be specified at present.

The purpose of this project is to address the above objectives and has been organised as a private-public consortium. It will demonstrate and document the treatment capabilities and economic consequences of a full-scale wastewater treatment plant (WWTP) treating the wastewater at the point of source as opposed to, for example, a centralised solution.

Project deliverables also include:
- demonstrating that air emissions can be treated for pathogens and odour.
- demonstrating that the by-products can be disposed of in an environmentally sound manner.
- Developing a control method to detect when GAC filters are saturated in order to optimise replacement intervals.

Long term performance testing of technologies

The full-scale plant will be performance tested through an intensive monitoring and test programme. Tests of each part of the technology will be used to evaluate exactly where in the process adjustments are needed to improve the removal of pollutants. The test programme includes the evaluation of robustness, energy consumption and total economic performance under long-term operating conditions.

THE TEST PROGRAMME INCLUDES THE EVALUATION OF ROBUSTNESS, ENERGY CONSUMPTION AND TOTAL ECONOMIC PERFORMANCE UNDER LONG-TERM OPERATING CONDITIONS.

Environmental and health risk assessments

Hospital wastewater is characterised by a complex mixture of hazardous substances and pathogens. Therefore risk assessments are crucial instruments to evaluate whether the treatment technologies can remove all the important risks whilst at the same time not create any unintended risks. DHI will carry out environmental and health risk assessments in relation to all emissions from the WWTP which are comprised of water effluents, sludge and air emissions. The risk assessments include analysis for pharmaceuticals, disinfectants, detergents, pathogens – including multi-resistant bacteria – as well as bio-tests to measure any genotoxic and endocrine effects on organisms living in water.

TIME SCHEDULE

2012 Pre-project, collection of international experience, lab-scale tests

2013 Planning and establishment of the full scale pilot treatment plant

2014 Test period and reporting of interim results

2015 Final report due

Gain for the environment and economic gain for the hospital

The treatment technologies used to remove pharmaceuticals and pathogens from the hospital's wastewater result in high quality water which should be viewed as a resource which can be utilised. The ultimate aim of this project is to discharge the treated water directly into the nearby stream (Kags Stream), which needs water through the summer period. Achieving this goal will also bring the hospital a very attractive payback time on their investment. This is due to significant savings on their effluent discharges to public sewer and treatment works.

At the same time, the improved effluent water quality opens up for the possibility to reuse the water as technical water (cooling water/boiler water) inside the hospital and/or for use as recreational water as part of the architectural design of the hospital area.

Knowledge gained so far

Performed pilot/lab tests on wastewater from Herlev Hospital and Rigshospitalet in Denmark as well as other projects in Europe focusing on the elimination of pharmaceuticals have shown good treatment results using either ozone or activated carbon. Test results have also indicated though that both ozone and activated carbon might be needed to fully eliminate the ecotoxicity of the treated effluent, even though pharmaceuticals are below the limits of detection. Previous tests raise some uncertainty as to which technology or sequence of ozone and activated carbon will be optimal from a cost/performance point of view.

Full flow treatment

Previous studies in the Capital Region of Denmark have proven that it is very difficult to target specific pharmaceutical-rich wastewater streams. Consumption of environmentally critical pharmaceuticals is spread across hospital departments, patients move around to toilets located in different premises of the hospital, and departments are relocated over time. At Herlev Hospital all wastewater will therefore be treated in the WWTP to ensure that no hazardous pharmaceuticals, harmful pathogens or antibiotic resistant bacteria will end up in the environment.

OPEN UP FOR DENMARK'S MOST ADVANCED WWTP

This full-scale pilot wastewater treatment plant (WWTP) will have a capacity that matches a small town with 2500 inhabitants.
A glass front allows by-passers to get an inside look of what will become Denmark's most advanced WWTP.

Featuring:

- Wastewater treated for pharamceuticals, harmful pathogens and antibiotic resistant bacteria,
- Air emissions treated for pathogens and odour

ABOUT THE FULL SCALE PILOT WASTEWATER TREATMENT PLANT

The pilot WWTP will have a capacity that matches a small town with 2500 inhabitants.
When completed it will be the most advanced WWTP in Denmark equipped with membrane bioreactors, activated carbon and ozone technologies and will provide a very high water quality similar to that of drinking water levels.

Plant definition
Herlev Hospital will be expanded in terms of both activities and buildings. Additional medical specialities and an expansion of the on-site sterilisation centre will also be assembled at the hospital. The number of beds will increase from 595 beds to 825 beds and the number of people working at the hospital will increase from about 4000 people to about 6000 people.
The hospital expects to finalise construction work and start these new activities by 2017.
The wastewater treatment plant has been designed to be able to manage this future activity as well.

Volumetric capacities of the new wastewater treatment plant:

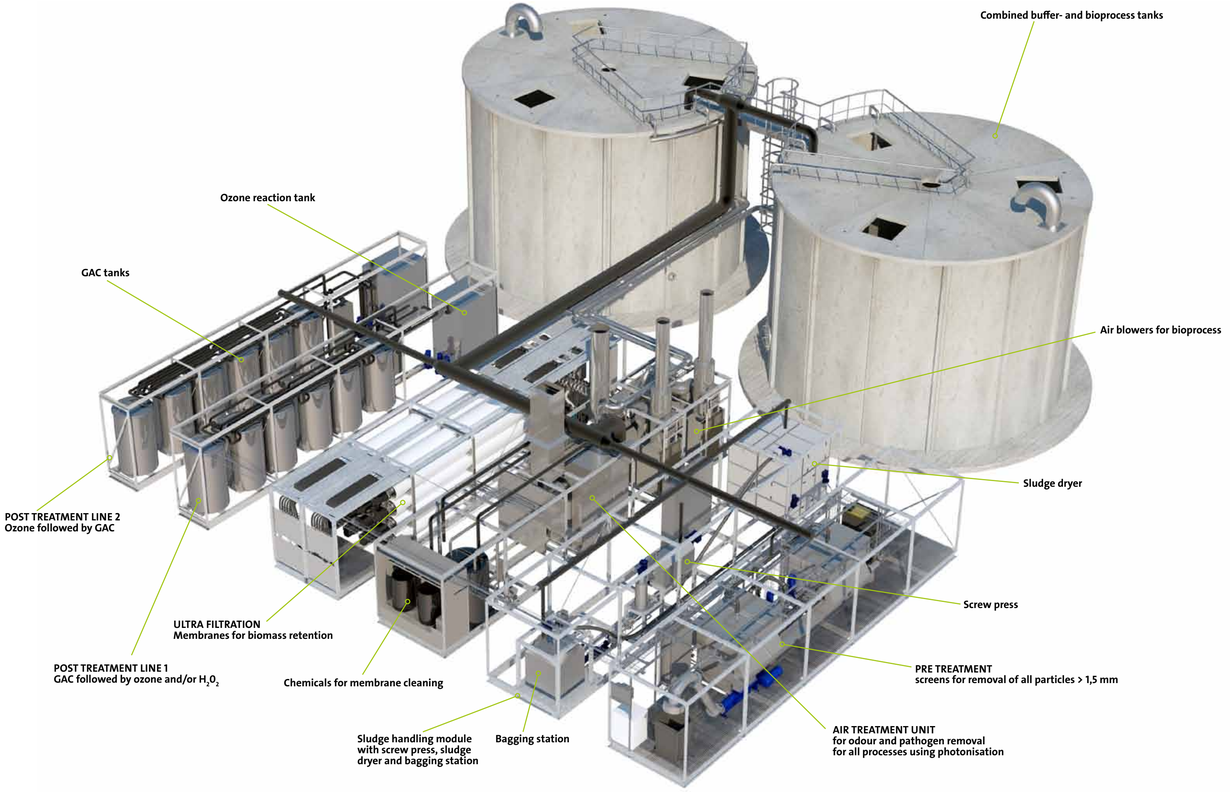
Parameter	Unit	Present 2013	From 2017
Max daily flow	m^3/day	<650	< 650
Average flow workdays	m^3/day	400	560
Average flow weekends	m^3/day	255	355
Annual average flow	m^3/day	360	500
Annual volume	m^3	131000	183000

The MBR part
The plant design is based around an MBR system (Membrane Biological Reactor) which consists of biological process tanks followed by ultra-filtration membrane for the retention of biomass. The resultant particle and bacteria free water provides optimal conditions for the next post-treatment step and allows for the adjustment of the biological treatment capacity to match the hospital's future requirements in the same process tanks.

The process tanks work as combined buffer and process tanks. All biological processes take place inside the process tanks. The process tanks can be operated with or without full removal of Nitrogen (using intermittent aeration) and Phosphorous (through Bio-P and/or chemical precipitation) to meet any future requirements for the discharge of the effluent.

Expected effluent discharge parameters with full N and P removal:

Parameter	Unit	Typical inlets	Outlet expectations
COD	mg/litre	698	<45
Total – N	mg/litre	63	<8
NH4-N	mg/litre	62	<1
Total – P	mg/litre	10,5	<0,5



Post-treatment
In order to find the ideal way of eliminating pharmaceuticals, the post-treatment has been divided into two parallel operating lines: Post-treatment line 1 and Post-treatment line 2.

Post-treatment line 1
Line 1 consists of Granular Activated Carbon, followed by Ozone and/or H_2O_2.
This skid is equipped with an option to add H_2O_2 prior to ozone injection which ensures the full transformation of ozone into hydroxyl radicals. The latter oxidizes the pharmaceutical much faster and more effectively than molecular ozone.

Finally the skid uses UV light to eliminate any residual ozone before discharge and as an extra safety barrier against pathogens.

Post-treatment line 2
Line 2 consists of Ozone followed by Granular Activated Carbon. This skid also has UV light as an extra safety barrier against pathogens.

Air treatment
All process related air emissions are treated using photoionisation, UV light and a catalyst before release in order to eliminate pathogens and odours from the air; it is therefore safe to install a wastewater treatment plant close to a hospital.

Disposal of debris and bio-sludge
All debris from inlet screens and excess sludge from the biological process are sent to incineration in order to completely eliminate any threats from these sources. As the bio-sludge contains pharmaceuticals both in the microbes and in the water phase, the bio-sludge cannot be dewatered after leaving the site as this will release pharmaceuticals into the environment again. To keep the cost of transport and incineration to a minimum and improve handling, the bio-sludge is dewatered and dried on site by up to 90%, this dry matter is then stored in big bags which are transported directly to the incineration plant.

PROJECT PARTICIPANTS

Steering Committee
Herlev Hospital
The Capital Region of Denmark
Grundfos
DHI

Project partners
Herlev Hospital (owner of the plant)
Grundfos BioBooster A/S (project holder and MBR technology)
DHI (testing and documentation)
Ultraaqua (ozone, activated carbon, UV light)
Neutralox Umwelttechnik GmbH (air treatment)

Advisory group
The Danish Nature Agency
Hospitals: Rigshospitalet, New North Zealand Hospital,
Hvidovre Hospital, Glostrup Hospital, Viborg Hospital
Municipalities: Hvidovre and Viborg

FUNDING

This project can only be realised due to the kind financial support allocated by various partners and external funds. The overall budget for the project reaches a total of 42.9 million DKK (€5.7 million)

The Danish Business Innovation Fund has granted the project 8.6 million DKK (€ 1.1 million)

BUSINESSINNOVATIONFUND

Other significant financial support comes from:
The Capital Region of Denmark
Lynettefælleskabet I/S
The City of Copenhagen
The Municipality of Herlev

Project partners who also support the project:
Grundfos BioBooster A/S
DHI
Ultraaqua
Neutralox Umwelttechnik GmbH

THE CAPITAL REGION OF DENMARK

Public-private innovation is a golden opportunity to simultaneously stimulate growth for businesses as well as innovative solutions for hospital building projects for the benefit of the environment, staff and patients. Innovation collaboration will contribute to lifting the Capital Region's political ambitions of building green and innovative hospitals. Together with Grundfos we are working to develop solutions for the treatment of wastewater from hospitals, which will be measured in the most environmentally friendly and responsible manner as possible. We aim to reach a better and more innovative solution than those that are available now. Our cooperation is a good example of creating value by combining corporate origination with the hospitals knowledge of current conditions and procedures.

Kasper Jacoby, Group Project Director
Capital Region's Consolidated Construction Management

GRUNDFOS

Grundfos is a leading global supplier of water and wastewater systems.
Grundfos is in the process of building new business areas within, among other things, decentralised water treatment and Grundfos BioBooster specifically is working with the development of innovative MBR technology for small to medium sized wastewater treatment plants that treat the wastewater either decentralised or at the point of source.
Grundfos sees great worldwide market potential for the treatment of hospital wastewater and therefore wishes to enter into this collaboration with the Capital Region of Denmark and Herlev Hospital to develop a product that addresses the specific needs of hospitals.

"We will demonstrate that hospital wastewater can be treated locally, on the hospital's premises, with a cost-effective economy and in a safe manner. Furthermore, we will demonstrate that the treated water should be seen as a valuable resource that can substitute and save on drinking water resources."

Jakob Søholm, Municipal Segment Director
Grundfos BioBooster A/S

DHI

DHI is an independent, international consulting and research organisation specialised within water environments. DHI offers a wide range of consulting services and leading edge technologies, environmental laboratories, treatment test facilities as well as field surveys and monitoring programmes. Within this project, DHI will be carrying out the pre-testing of the innovative treatment technology combinations as well as all the treatment plant performance assessments and reporting. This includes performance test planning, routine monitoring programmes, robustness evaluations plus health and environmental risk assessments.

Ulf Nielsen, Msc Chief Enviromental Planner, Urban and Industry
DHI

ULTRAAQUA

As specialists in the field of water treatment, this is an exciting opportunity for Ultraaqua to work with wastewater from hospitals. We think that the team around this product is very strong, just as the modular concept is extremely suitable for the market. Our specialist knowledge of activated carbon, ozone, UV light and plant design is challenged to the fullest in cooperation with scientists and other specialists. Environmentally speaking, it is a great pleasure to work with solutions that will protect Danish and foreign aquatic environments against contamination by medicinal residues.

Ole Grønborg, Managing Director
Ultraaqua

NEUTRALOX

NEUTRALOX ® Umwelttechnik GmbH is a German manufacturer for turnkey odour control and off-gas treatment plants. NEUTRALOX ® focuses on odour control for sewage pumping stations, wastewater treatment plants and related facilities. Odours from wastewater treatment works are amongst the most challenging with respect to odour control. This is particularly true in dense population areas. The challenges come not only from the strength of the odours and their variability (spikes), but also from the proximity to houses, buildings and recreational areas, and often from the limited space available. There is also the issue of the presence of germs and pathogens in this air. These challenges require very effective and reliable treatment. The NEUTRALOX ® Photoionisation process heralds a new generation of odour control allowing for effective elimination of sewage odours, while providing a high degree of air disinfection at the same time.

Stefan Zimmermann, Managing Director
Neutralox

THE DANISH NATURE AGENCY

The Danish Nature Agency is the agency under the Danish Ministry of the Environment which is responsible for implementing the government's policy for the water sector through guidelines and regulations etc. The Government wants to ensure that hospital wastewater is handled according to the Environmental Protection Act's regulations concerning the use of the best available techniques as a manifestation of the technology that is technically and economically feasible to purify wastewater. The Government insists that the best available techniques be incorporated into the design of new hospitals and the renovation of existing hospitals. As a result of this project, we will gain valuable knowledge about what is technically and economically feasible in the treatment of hospital wastewater, which we can then use for any future initiatives in this field to ensure the implementation of government policy.

Jakob Møller Nielsen, Head of Division
Danish Ministry of the Environment, Nature agency.

MUNICIPALITIES AFFILIATED WITH LYNETTEFÆLLESKABET

All municipalities affiliated with Lynettefællesskabet focus on hospitals as a source of medicinal residues. Lynettefællesskabet has surveyed a large area to identify the extent of the problem and therefore views the decentralised wastewater treatment plant as a natural extension of this work. Reports from the survey can be found at www.spildevandsinfo.dk [in Danish and Swedish only]. New cleaning technologies are required to competently remove medicinal residues from hospital wastewater. Today the technological possibilities for the removal of medicinal residues in hospital wastewater are limited, so it is exciting to follow the project at Herlev Hospital. Municipalities, as the environmental authority, must ensure the quality of the wastewater which is discharged by companies, including hospitals, into the public drains. The discharged wastewater must not pose a risk to the wastewater treatment plant nor to the people who work at the treatment plant nor people who work with the drains. The wastewater must also not pose any risk to the recipients of the treated wastewater. Municipalities are responsible for providing connection permits for the discharge of wastewater from hospitals, and they therefore decide which conditions apply for the release of hazardous substances including medicinal residues.

The Municipality of Herlev, The Municipality of Hvidovre, The City of Copenhagen

LYNETTEFÆLLESKABET

At Lynettefællesskabet we have managed wastewater from hospitals for many years. Predominantly, we have implemented a number of studies that have documented that hospital wastewater poses a problem for the aquatic environment. Secondly, we have also, via the press, sought to raise awareness of this problem. It was therefore natural for us to offer financial support for the development of a solution for the environmentally sound management of hospital wastewater. This is especially true of Project Herlev, where for the first time; a full-scale treatment plant for hospital wastewater is being established.

Torben Knudsen, Director
Lynettefællesskabet I/S

Contact and additional information

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