New approaches and technologies for wastewater treatment

Reuse of treated wastewater for non-potable use

A short general description

Population growth, increasing living standards, but also environmental hazards with global climate change as the most significant are all contributing to an increasing water stress in many parts of the world. While access to fresh water for drinking water is getting more costly due to environmental pollution, uses of drinking water conflicts with water needs for agricultural and industrial use, which are in need of substantial water quantities.

The reclamation of wastewater is a promising approach to meet societies increasing water demands and to help mitigating environmental problems related to water use around the world. However, even so the basic approach is not new, regulations and experiences on required reuse water qualities, what treatment technologies to be used, how to accomplish a resource-efficient treatment at minimum environmental impact due to the treatment itself and at lowest possible costs, are sparse.

These various challenges were identified and studied within the collaborative ReUse-project between IVL Swedish Environmental Research Institute and Xylem Inc. during the years 2012-2014. After defining reuse quality criteria based on a number of different standards, regulations etc. from various regions in the world working with water reuse, eight treatment systems for different non-potable reuse applications (agriculture, industry and groundwater recharge) were setup based on out of the shelf technology. These systems were tested and optimised in pilot-scale at the R&D-facility Hammarby Sjöstadsverk in Stockholm, Sweden.

A throughout environmental impact and lifecycle (installation and operational) costs assessment was carried out simultaneously to treatment system optimization in order to develop the most resource-efficient treatment systems to achieve desired reuse water qualities. The individual results of treatment performance, environmental impact and cost were combined to achieve the most sustainable wastewater reuse systems.

Description of economic and environmental benefits

The project results show that

The chosen treatment system setups can meet designated reuse effluent quality requirements with even an over performance of many treatment systems implying a better effluent water quality than required by the defined limits!

The developed treatment systems are ready to be implemented as they are based on available technologies. The project just optimized the operation of these techniques and their interaction in treatment systems towards sustainability.

The total environmental impact of the optimized ReUse-systems may not be higher than conventional wastewater treatment despite the fact that wastewater is treated to a reuse water quality while conventional treatment only partly removes nutrients and organic matter. In fact, the total environmental impact for some of the optimized ReUse-systems can be lower than for traditional treatment systems as far as this can be quantified considering all benefits the reuse of wastewater generates!

Costs for different reuse applications are in the same range or even lower than reported costs for existing conventional wastewater treatment plants in Sweden! While conventional wastewater treatment in Sweden currently costs about 3-5 SEK/m^3, developed ReUse-systems costs according to project calculations between 1-4.5 SEK/m^3 depending on required reuse water quality. This Life Cycle Cost (LCC) includes both CAPEX (Capital Expenditure) and OPEX (Operating expense) which is commonly not fully accounted for in current wastewater treatment costs calculations.

Thus, wastewater reuse for various reuse purposes is feasible without increasing the total environmental impact and without increase in costs and at the same time fulfilling regulation targets.

These outcomes applies for new WWTPs designed as wastewater ReUse facilities. However, results for tertiary treatment processes investigated by the project can also be applied to existing WWTPs that needs to be upgraded in order to achieve wastewater reclamation.

Detailed technical data

The starting point was to test conventional and emerging secondary, tertiary and disinfection treatment techniques in various combinations, optimized from an overall sustainability perspective. The ReUse-project worked with eight different treatment systems comprising various state-of-the-art technologies and targeting various effluent qualities for agriculture reuse, industrial reuse or groundwater recharge. The treatment techniques that have been used in the project are:

- Conventional activated sludge process (here as SBR-Sequential Batch Reactor with continuous inflow)
- Microfiltration (disk filter) and ultrafiltration (with submerged and pressurized membranes)
- Ozonation
- Dual-media gravity filter
- BAF - Biological active filters (multimedia filter med Anthracite or Granulated Active Carbon)

- GAC - Granulated activated carbon
- UV - Ultraviolet light
- Chlorination

The secondary treatment was operated in different modes for partial or advanced nitrogen removal, chemical and biological phosphorous removal.

Contaminants investigated include a wide range of standard and emerging micropollutants as well as ecotoxicity. Further, greenhouse gas emissions were measured. Besides pilot-scale data, data from a number of full-scale treatment plants were used for the environmental and economic impact assessments.

The full-scale analysis included three different full-scale sizes (20 000 person equivalents (PE), 100 000 PE and 500 000 PE). For example, 100,000 PE is approximately 6 MGD or 23 MLD. Operational data for different processes was used from existing full-scale plants while optimization and new treatments systems were tested in pilot-scale at the R&D-facility Hammarby Sjöstadsverk.

Experiences of implementation, operations and maintenance

Even so, the outcomes of this project are relatively new and as the wastewater treatment sector is quite traditional, several reuse treatment systems have already been installed for example in the Middle East. In addition, numerous full-scale installations of specific treatment processes as a part of the reuse system have been implemented and are available all over the globe due to the global partner Xylem global services.

Both costs and performance of these systems have been verified by these installations and operational and maintenance aspects are well known. In addition, presented costs and performances by the project are based on full-scale facilities and can as such be assumed as real-life information.

Potential and limitations for wider implementation and strategic/economic benefits from a social or political perspective

Reuse of wastewater for various reuse purposes is feasible without necessarily increasing the environmental impact and without increase in costs.

Considering our societies dependence on natures welfare and that there is only one water, wastewater reuse has never felt more important and feasible than now to reach a sustainable society.

Increasing water stress caused by global environmental problems like global warming can be abated. Overall costs for access to fresh water for drinking water can be reduced as wastewater reclamation mitigates several challenges simultaneously, i.e. as less fresh water sources are required for other water sectors, ecosystems with internal water cycles are maintained or restored by e.g. groundwater augmentation, and economic growth limitations due to water stress can be avoided.

Water is an essential component of national and local economies, and is needed to create and maintain jobs across all sectors of the economy. Thus, sustainable water management and access to a safe, reliable and affordable supply of water improve living standards, expand local economies, and lead to the creation of more jobs and greater social inclusion as stated in World Water Development Report 2016. Sustainable water management and specifically the reuse of wastewater is also an essential driver of green growth and sustainable development.

For Xylem, developing knowledge in sustainable solutions and more specifically on environmental impacts and life cycle cost is crucial to maintain their position as equipment and solution supplier in a competitive market. Xylem plays a pro-active role in developing a responsible thought leadership and acts as a technical and commercial adviser to the European Union in the development of Wastewater Reuse Directive. It is with solid benchmarked references that Xylem can support member states in developing the right quality standards and governance model for implementing a sustainable reuse framework in Europe. Sustainability experience also supports Xylem in developing a strong technical sales force and directly in engaging its customers, including engineering consultants and end users, in discussions on the reuse opportunities and optimal solutions adapted to their requirements. This grounded expertise gives Xylem a competitive edge and additional value to its proposal when bidding on Reuse and other water treatment projects.

Other commercial impacts of the project are optimized reuse Solutions including systems adapted to local and regional requirements, lowest possible life cycle costs, best micropollutant reduction, most environmental and financial sustainable solution, and unique process guarantee.

References

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