German research underway on trickling filter practices

Trickling filter technology is one focus of a joint research project – EXPOVAL – funded by the German government that will validate engineering guidelines and optimum conditions for achieving high performance. Dr. Christian-Dominik Henrich of GEA 2H Water Technologies Gmbh reports.

Poor wastewater treatment is one of the biggest enemies of a safe and sustainable water supply all over the world. Next to frugal handling of existing water resources, the treatment of wastewater, sometimes towards future reuse, is important. Unfortunately, the elusive effects of improving water supply through groundwater recharge or surface water must be weighed against capital cost, cost of energy demand, and other variable costs of wastewater treatment facilities. With the costs per unit of energy constantly rising, it is of utmost importance that future wastewater treatment is energy-efficient. Important considerations, especially in developing countries, should include the reliability and simplicity of a wastewater treatment process. Low-maintenance unit operations ensure a continuous treatment of incoming wastewater.

A trickling filter is a fixed-growth biofilm treatment system where the wastewater trickles through a media on which a biofilm grows. The wastewater is distributed at the top of the filter, with the use of rotating distributor arms that can be either hydraulically or electrically driven. Oxygen is provided to the system through ventilation openings at the bottom of the filter, through which air can freely flow. The media is placed onto a substructure usually made out of parallel beams placed on concrete feet. Originally, trickling filters were packed with a stone or lava filling. Now, these filters are packed with plastic media – first made out of thermoformed polyvinyl chloride (PVC) sheets glued to structured packings, and later made out of the more environmentally friendly polypropylene corrugated sheets that are not glued but welded together to structured packings.

Until the 1980s, trickling filters were promoted in the western hemisphere as an energy-efficient process for using microbial systems to treat wastewaters. In those areas, the only need for energy was to lift effluent by pumping it for distribution on top of the filter. Pumping costs were reduced by using hillsides for gravitational flow. The main difference between trickling filters and an activated sludge system is in oxygen supply. In trickling filters, oxygen demand is often satisfied by natural ventilation without any need for energy-intensive aeration and high-tech equipment. However, increasing effluent demands and process issues – such as media clogging in conventional, stone-packed trickling filters, along with a poor understanding of nutrient removal characteristics and poor modeling of actual processes inside trickling filters – led to a decline in the use of trickling filters.

Because of the newly developed plastic media, as well as the increased importance of sustainability, the trickling filter is going through a renaissance. Especially in combination with other unit operations such as anaerobic pre-treatment and optimized process design, these new-generation trickling filter systems are able to treat wastewater to very high standards, while offering low energy demand and a high degree of simplicity and robustness. Because of these improvements new trickling filter projects are being implemented all over the world, many of them receiving funding from institutions such as the KfW Development Bank in Germany, which focuses on sustainable development.

With the new generation trickling filter technology and an intelligent plant design and operation, high flexibility is achievable. This includes the ability to treat waters to effluent

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Right: Trickling filter pilot plant at Warsan Sewage Treatment Plant in Dubai, United Arab Emirates.

If the findings are confirmed, a reliable calculation algorithm for the optimal sizing of trickling filter systems under different climatic conditions can be defined.

Partnership explores biofilm process efficiency

A partnership between Cranfield University in the United Kingdom and Warden Biomedia, a UK manufacturer of filter media for aerobic wastewater treatment, will focus research and development efforts on biofilm processes with the aim to improve the efficiency, cost-effectiveness, and sustainability of process units such as submerged aerated filter, moving bed biofilm reactor, and trickling filters.

Warden Biomedia manufactures five different types of random filter media, injection-molded in polypropylene, with specific design features to increase the efficiency of the biological process. "This approach to wastewater treatment holds much greater potential than is currently being harnessed," said Managing Director Mark Barrett. The company is sponsoring this postgraduate research project to provide a foundation for the next generation of biofilm processes, he explained.

Cranfield University Water Science Institute will supervise the research. Operating in this field of research for almost 40 years, the Institute employs 15 academics with significant expertise in water processes. Cranfield is a postgraduate-only university, working in close collaboration with industry and all of its 60 PhD students have industrial sponsors.

The project will begin with an MSc thesis due to be completed by postgraduate student Joana Manuel Silva Dias. Next, a PhD project on the design, operation, and efficiency of biofilm processes will analyze existing full-scale process units that use Warden's Biomedia. It will also involve laboratory, pilot and active, scale investigations of alternative design approaches. The project will be structured across six research phases, culminating in a final thesis towards the end of 2017. Dr. Ana Soares, lecturer in biological engineering and water program director, will supervise the project.

Dr. Soares commented, "Collaboration between industry and academia is crucial for a project such as this. We are able to address fundamental questions and universal laws of water science, but we are also able to study how these apply and their implications across wastewater treatment applications.

"There are important pressures and drivers within the wastewater treatment industry, such as the need to reduce energy consumption, and the requirements of various regulatory frameworks. A partnership of this type enables us to consider all aspects of the process to develop more effective solutions."

This partnership marks Warden Biomedia's first sponsorship of postgraduate research. Barrett says the research will provide a deeper understanding of the science at the heart of these aerobic processes, which will help to determine where best to focus the company's investments in product development. He added, "Our biomedia range offers significantly improved performance over alternative media, while the traditional alternative is to use natural aggregates, from quarrying or dredging, or blast furnace clinker, which have limitations in terms of sustainability and availability." Another advantage is that they are manufactured in recycled polypropylene, reusing plastics that would otherwise go to landfill.

quality comparable to activated sludge (AS) and activated sludge biological nutrient removal (AS-BNR) processes. Additionally, these filters can provide the ability to produce a variety of effluents that are treated to meet specific local needs during seasonal variations at very low operational and maintenance costs.

Unfortunately, existing engineering guidelines are primarily based on research that was done long ago, when stone-filled trickling filters were standard. Here, many operational recommendations and design equations or constants cannot be directly transferred to new generation trickling filters filled with structured packings. Additionally, these guidelines were developed for standard western climate zones at moderate temperatures. Hence, when using these old design equations for filters located in hot or cold climates, these filters are vastly over- or under-designed.

In 2012, the joint project EXPOVAL (the name taken from the study's title, "Export-oriented research and development in the field of wastewater – validation of technical facilities") began as a part of the funding focal point of sustainable water management (NaWaM). Seventy-seven percent of the project – a total of US$9.71 million – is financed by the German Federal Ministry for Education and Research (BMBF). The study's main goal is to expand the dimensioning approaches that apply in Germany, and that are only directed toward the prevailing conditions there compared to other climates, specifically to higher or lower wastewater temperatures. The focuses of the study are on municipal wastewater treatment procedures. These include the activated sludge process (which includes compressed aeration systems), the trickling filter process, anaerobic treatment and wastewater ponds, wastewater disinfection and recycling or treating the sewage sludge. Six German universities and 11 industrial partners are involved in the more than four-year project – including GEA 2H Water Technologies, together with the University of Stuttgart, which are examining the trickling filter processes specifically.

This project will provide, among other things, a new directive from the German Association for Water Management, Wastewater and Waste (DWA) for consulting engineers that considers country-specific factors, such as wastewater and air temperatures, inlet and outlet values and higher salinities. This directive will serve as a practical resource that enables engineers to make a well-founded decision as to under which conditions the trickling filter process offers benefits compared to other methods. The document will also provide specific sizing and operating information.

The scientific and theoretical foundations were already created in the previous project, "Export-oriented research and development in the field of water supply and sewage disposal." In that study, the cleaning performance of a semi-industrial trickling filter pilot plant was examined at high temperatures of wastewater and air in laboratory conditions. It is the goal of the current study to validate the results and conclusions through practice. If the findings are confirmed, a reliable calculation algorithm for the optimal sizing of trickling filter systems under different climatic conditions can be defined.

For the validation, five plants – in Namibia on the African continent; Georgia; Albania; Dubai, United Arab Emirates; and Nicaragua in Central America – were selected. These plants cover the full range of technical and climatic conditions. They are in different climate zones and each operates one or more trickling filters. In addition, the selected plants, with the exception of Dubai, are in regions where there is a lack of energy and infrastructure. Additionally, two 6-meter-diameter trickling filter pilot plants were erected in Dubai – filled with polypropylene structured packing to investigate carbonaceous material removal and separate or combined nitrification.

The results of this research project will be fully investigated and the resulting DWA directive will be published in early 2016.

Author's Note

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