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EnviCare® Engineering GmbH

Ingenieurbüro für Verfahrenstechnik

Eisteichgasse 20/9. Stock/Tür 36
A-8042 Graz

T: +43 316 38 10 38
E: office@envicare.at

www.envicare.at

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Membrane bioreactor for the cleaning of surface water of a solid waste treatment site

Abstract

Author Teresa Garstenauer, MSc, EnviCare® Engineering GmbH

Dr. Bernhard Mayr, EnviCare® Engineering GmbH

Introduction

At solid waste treatment facilities, waste is partially stored outdoor on sealed surfaces. Therefore, rainwater might be considerably polluted with organic and inorganic compounds, depending on the leaching behaviour of the waste pile.

The discharge of rainwater is by law only allowed into storm water or combined wastewater sewers. If it is going to be discharged into a receiving water body, anthropogenic polluted surface water has to be treated according to the state of the art. The so-called first flush, the rainwater from the first 15 minutes during heavy rain events, has to be collected, stored and cleaned properly. Normally the water quality after the first flush already allows for direct discharge.

High fluctuating quantities and qualities of this surface water with differing temperature causes high demands on the treatment technology. In the case presented in this paper the COD (Chemical Oxygen Demand) concentration in the inflow ranges from 50 mg/l to 1,000 mg/l, in addition there can also be fluctuating and substantial nitrogen and phosphorus loads. In biological treatment plants, the retention of activated sludge has to be guaranteed for sudden heavy rain events as well as for longer dry periods. Membrane bioreactors meet both criteria while in a conventional sedimentation-based system, the activated sludge flocs will be washed out.

In membrane bioreactors (MBR) biological wastewater treatment is combined with membrane technology. Organic compounds, nitrogen and phosphorus are removed in aerobic/anoxic/precipitation processes. Ultrafiltration membranes prevent biomass and inert particles from wash-out. In this case hollow fibre membranes with a cut off of 50 nm are used.

This paper presents the design, construction and operation of a MBR plant for the cleaning of surface water of a solid waste treatment site.

VAT Nr: ATU62568929

bank account: Steiermärkische Bank und Sparkassen AG/Austria,, IBAN: AT96 2081 5201 0010 2407, BIC: STSPAT2G

Head office: Graz, FN 277966 z Landesgericht für ZRS, Graz

Objectives and methods

In order to reduce the entrepreneurial risk, an MBR pilot plant was installed at the waste treatment facility and operated for four months to evaluate the suitability of this technology. The large-scale plant was designed, constructed and put into operation based on the results from the pilot phase.

Figure 1: MBR large-scale plant at the waste treatment facility

At the waste treatment facility, the surface water is collected separately from several areas in retention basins. The collected surface water is then treated in the MBR plant.

Results

The pilot phase proofed that the MBR technology is suitable to clean the polluted surface water, so the clean filtrate can be discharged directly into the receiving water body.

The limit value for COD was met during the pilot phase after an intensive optimization phase at the beginning. With the large-scale plant the COD limit value was met right from the start of the operation, due to the previously gained experiences.

At the beginning of the pilot test strong green alga growth in the retention basin and subsequently in the MBR plant led to considerable problems. The algae inhibited the growth of the activated sludge and had to be eliminated with different process engineering measures.

The nutrient composition concerning nitrogen and phosphorus fluctuates over time. But during the operation it could be proved, that a dosage of surplus nutrients is not necessary, while simultaneously meeting the according limit values. Additionally, there is no need for pH adjustment.

A regular acidic and alkaline cleaning of the membrane is necessary to maintain the permeability of the ultrafiltration membrane in the MBR plant. After one year of operation of the large-scale plant no negative impact on the permeability could be observed.

The operation over a longer period also showed that the produced amount of sludge is about 0.30 kg DS/kg COD, provided a sufficient COD load in the inflow. During longer dry periods the sludge growth stagnated or the dry substance (DS) content even slightly declined. In general, the MBR is operated with a DS content between 4 and 10 g DS/l.

Findings

A pilot test offers several advantages like becoming familiar with the wastewater, the operating conditions, but also the important "human factor" in plant management. In general, and especially in the presented case with a pilot test the technical and entrepreneurial risks for planner, supplier and client can be minimized.

It is recommended to design the membrane surface with sufficient hydraulic reserves. Thus, a flexibility for higher amounts of surface water can be ensured and the average lower hydraulic load extends the lifetime and generally leads to a more relaxed operation.

Foaming can occur for various reasons in every biological wastewater treatment plant. Therefore, sufficient measures for foam detection and control such as automatic measuring probes, spray systems and a dosage of an antifoam chemical must be included in the design. However, a constant antifoam dosage is not recommended since the biology adapts and after a certain period of time the antifoam might be rapidly degraded and loses its effect. In the presented case a spraying system proved to be sufficient to counteract foaming.

The experiences gained by application of MBR as treatment for surface water at a waste treatment facility show that the technology is reliable and robust and can be adapted easily to different requirements. The main advantages include cost-effective construction works due to reduced space requirements and an unnecessary final sedimentation basin. Additionally, the freely selectable sludge age allows for high degradation rates since the sludge is completely restrained.

Keywords: waste treatment, surface water treatment, membrane bioreactor, MBR, ultrafiltration