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Optimising conventional treatment of domestic waste water: quality, required surface area, solid waste minimisation and biogas production for medium and small-scale applications

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INTRODUCTION

Municipal waste water, or sewage, is a combination of domestic and industrial effluent. The increasing volume of sewage due to urbanisation and economic growth places pressure on the treatment performance of existing waste treatment systems. Increasing volumes of industrial effluent disrupt the optimal functioning of biological waste water treatment facilities. This results in poor-quality treated waste water being discharged into the environment.

A CSIR project, the integrated research infrastructure platform (IRIP), aims to demonstrate that the generation of electricity from renewable resources is not only economically feasible, but can serve as a catalyst to create sustainable jobs for the economic renewal of rural towns, improve service delivery and mitigate the negative effects of climate change on food and water security. IRIP aims to demonstrate the feasibility of this concept through the integration of different technologies. One of the major components of IRIP focuses on the recovery of energy from organic waste (sewage).

The sewage treatment technology selected for IRIP includes a combination of improved biological treatment processes; membrane bioreactor technology (MBR) and an enhanced anaerobic digestion (AD) process.

BACKGROUND ON SEWAGE TREATMENT

In conventional sewage treatment facilities (see photo) the influent sewage stream passes through the screening and degritting stations before being separated into the liquid fraction and the primary sludge fraction through primary settling. The primary liquid fraction contains particles of suspended organic material, dissolved organic material and dissolved nutrients

Conventional sewage treatment facility

The primary sludge contains a large fraction of the total organic content but represents a fraction of the total incoming sewage volume. This concentrated organic waste fraction can be treated by anaerobic digestion (AD) technology. AD technology is well known (see photo) and the methane-rich gas yield is used for heating the AD reactor itself. Increased efficiency due to technological progress can increase the gas yield, reduce the reactor dependency on biogas for heating and allow more efficient use of the biogas.

Conventional anaerobic digestion technology

It is also critical that the final treated water is of the required quality for irrigation, discharge or other reuse options. Conventional activated sludge (CAS) systems are vulnerable to changes in hydraulic and pollutant load of the raw water and rely solely on clarifier technology for the separation of the final treated water from the remaining biological and solid content. The quality of the final treated effluent is often highly variable. CAS technology is expensive in terms of capital investment. An alternative sewage treatment system, membrane bio-reactor (MBR) technology, can address these drawbacks. This technology is an integral part of the sewage treatment component of IRIP.

MEMBRANE BIOREACTOR (MBR) TECHNOLOGY

MBR technology represents an activated sludge process combined with high-quality membrane filtration. This reduces the surface footprint of the treatment system and eliminates the use of expensive clarifier technology. The MBR process is operated at much higher sludge densities (10-20 g/L compared to 3-5 g/L for CAS systems), increased sludge ages and produces much less waste sludge than CAS systems.

The membrane filter that retains the microbial populations inside the reactor also provides barrier protection against pathogen breakthrough and excellent and consistent turbidity removal, independent of the nutrient removal performance of the biological component of the system.

EXAMPLES OF MBR TECHNOLOGY

These MBR systems vary in size, energy requirements and operational sophistication. Retrofitting of existing CAS systems is also an option.

Small-scale MBR systems

These systems typically treat less than 0,5 ML/day but include systems developed to treat the waste of only a small number of households. The hydraulic layout is based on 75 m^3/d that is equal to 500 people equivalents (PE) and 150 liter usage per PE/day. It costs approximately R600 000 and can be used to investigate the integration with the other components of IRIP, mainly the algal production facility and the AD.

Intermediate MBR systems

These systems can treat approximately 1 ML/day of municipal sewage, can be modified to improve nutrient removal and are being considered for the IRIP concept of implementation in small towns of approximately 5 000 households (**Figure 1**).

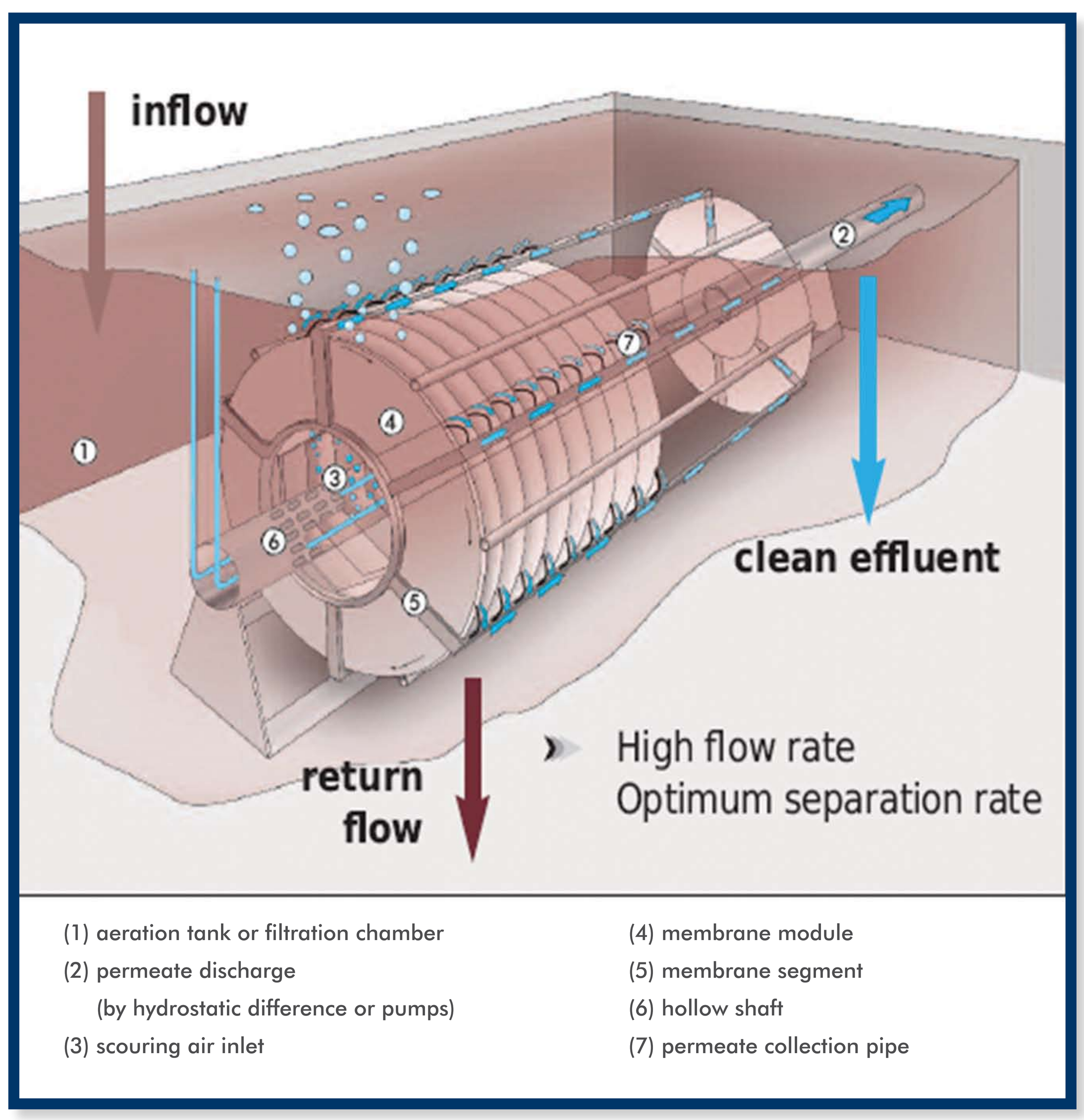

Figure 1: MBR system that could be applied in the IRIP concept

ANAEROBIC DIGESTION TECHNOLOGY

The current energy requirements for the optimum operation of the AD process rely heavily on the cost effectiveness of the reactor. Alternative energy sources for AD reactor temperature control may also allow such a system to operate independently from the national power grid. The use of renewable energy sources does not limit the operational temperature range of AD reactors and either mesophylic (35˚C) or thermophylic (55˚C) temperatures can be achieved inside the reactors.

Alternative energy sources can be used to supply the required energy for the monitoring equipment and control system. The CSIR has developed a scalable anaerobic digester that uses alternative energy for the electrical and heat requirements of AD operations. This digester operates at the mesophylic temperature of 35˚C, without using any of the biogas produced as energy source for its operational requirements (see photo).

Electricity production from biogas in Sweden

Advances at the CSIR allow for an integrated approach to the treatment of wet organic waste to produce a source of energy and reusable water

Waste to watt

CONCLUSIONS

Advances in AD technology by the CSIR allow the combination of AD processes with MBR technology for an enhanced integrated system for sewage treatment, including effective energy recovery and nutrient reuse as well as the production of treated water of a very high quality. This system will be able to provide complete sewage treatment almost anywhere, depending on the availability of an adequate power source for the entire operation. Further development regarding the use of the biogas, combined with renewable energy, will allow this system to provide high-quality sewage treatment independent of its location.