On-site integrate management of hospital wastewater: The case study of a pilot scale unit at a General Hospital in Crete

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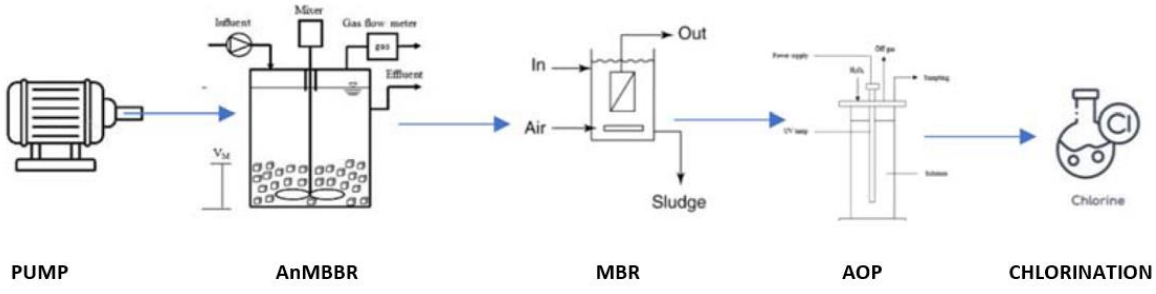
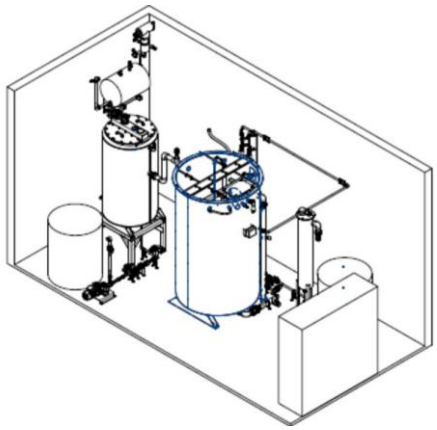
Hospitals are one of the main sources of pharmaceuticals pollutant emissions sent to wastewater treatment plants (WWTP) that are poorly equipped to treat efficiently these types of compounds. The qualitative and quantitative characteristics of hospital wastewater differ significantly between the clinics of the same hospital as well as between different hospitals depending on the size of the clinic, the number of beds, the number and type of services offered, the country and the season (Al Aukidy et al., 2014). Hospital wastewater, in addition to conventional urban wastewater pollutants (BOD5, COD, TSS, NH4-N, TP), also contains a wide variety of micro-pollutants including widely used pharmaceutical compounds (such as analgesics, anti-inflammatory, antibiotics), specialized chemicals for the treatment of specific diseases (e.g. cytostative compounds), disinfectants as well as multi-resistant bacteria (Verlicchi, 2018).
Hospitals require large amounts of water every day for various purposes and services, however, each hospital has a different daily water consumption rate. The quantity of wastewater produced by hospitals also depends on several factors, including their number of beds, water supply, availability of general services (i.e., laundry, kitchen, and air conditioning), types and number of wards or units, and management policies (Verlicchi P. et al., 2010).

The pilot plant for the treatment of hospital wastewater includes the following distinct stages of processing:

- Reservoir for the collection and supply of hospital wastewater
- Anaerobic fluidized bed reactor unit (AnMBBR)
- Aerobic biological treatment unit with the method of immersion biomembrane (MBR)
- Advanced oxidation unit using ultraviolet radiation and addition H_2O_2
- Chlorine disinfection unit



Picture 01: Flowchart of hospital wastewater pilot plant unit



Picture 02: Hospital wastewater pilot plant unit

Hospital Wastewater Supply

The hospital wastewater that will supply the pilot plant will be pumped from an inlet shaft of the existing WWTP through its submersible pump construction house. For the continuous smooth and adjustable supply of the anaerobic digester or underwater a pump which will be installed in a manhole of the entrance of the existing WWTP of the hospital will feed a plastic container (200 L).

In this container will be installed a screw pump, which will be able to regulate its operation from 10 – 100l/ h and will feed on the anaerobic digester. In the depression of this pump will be installed electromagnetic flowmeter to check the hourly supply and the daily amount of wastewater entering the system. The inlet vessel will have a safety overflow from which through gravitational pipeline will return to the pumping shaft the excess amount of wastewater.

AnMBBR anaerobic Treatment Unit

Hospital wastewater from the inlet vessel through a screw pump will feed the anaerobic fluidized bed reactor (AnMBBR). The system will consist of the following sections

- Stainless steel (AISI 304) double-walled cylindrical anaerobic reactor total volume 400 L
- Stainless steel (AISI 304) vertical motor propeller type stirrer power ~0.18kW
- Suitable biocarriers to be placed in the reactor in up to 40% of the operating volume
- System for controlling the temperature of the liquid in the reactor which will can be kept stable at up to 40°C using a thermostat, and resistance or hot water
- On-line pH and temperature measurement sensor with digital Logger.
- Miligascounter gas flow meter of low and maximum level
- Overflow to the MBR reactor
- Emptied valve on the bottom.

Aerobic Processing Unit MBR

The Hospital wastewater after the anaerobic reactor will enter the ventilated reactor of immersion ultrafiltration membranes (MBR). The system will consist of the following sections:

- Stainless steel (AISI 304) double-walled cylindrical anaerobic reactor total volume 2000 L.
- In the reactor will be installed array of ultrafiltration membrane with porous ≈ 0.04 μm, hydrophilic.
- Filtration and reverse wash pump of suitable supply for the treatment of at least 2000 L of waste per 24h side channel blower (FPZ) suitable for cleaning membranes and for the aeration of the biological level.
- MBR reactor level meter
- MBR electromagnetic filtration flowmeter
- Pressure gauge for transmembrane pressure measurement (TMP) in the MBR

Advanced Oxidation Reactor - AOP

The advanced oxidation plant will consist of an H_2O_2 storage tank, disinfection system with UV lamps and recirculation pump. A 200L plastic tank will be installed that will collect the outflow of MBR. From this tank will be supplied the disinfection system (UV) with a pump flow (1+r) Q. The dosing of H_2O_2 will be done before entering the UV while the outflow from this it will turn back to the supply tank thus ensuring time stay in the closed circuit of the system.

From this container there will be overflow of the tertiary most processed outflow towards the system of static chlorinator. Using the above layout, it is possible to dosing and solid catalyst which will be recirculated within the system container – UV and could be removed from the container.

Instruments

The following instruments – meters will be installed to monitor the processing system:

- Anaerobic inlet tank sensors of low and maximum level
- Electromagnetic anaerobic input flowmeter
- Low and maximum anaerobic MBBR sensors
- PH meter in the anaerobic MBBR reactor
- Temperature meter in the anaerobic MBBR reactor
- Biogas flow meter in the anaerobic MBBR reactor
- MBR reactor level meter
- MBR electromagnetic filtration flowmeter
- Pressure gauge for transmembrane pressure measurement (TMP) in the MBR
- Low and maximum level AOX inlet tank sensors

Expected Results

The construction and the operation of the pilot scale hospital wastewater unit at the General Hospital of Heraklion will offer integrated wastewater management. Also, the hospital wastewater will be effectively treated by producing, simultaneously, biogas and recovered water. Additionally, it will be well studied the possible removal of multi-resistant bacteria, resistance genes and organic micro-pollutants for the reuse of treated hospital wastewater at hospital gardens. Finally, the last expected result is the economic and technical evaluation of the proposed hospital wastewater treatment unit to accelerate the commercialization process of the technology.

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