

From DIANYA to HIPPOCRATES, A Story of Scaling up a Pilot Unit to a Demonstration Unit at a General Hospital in Crete, Greece

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Abstract

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. 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. cytostatic compounds), disinfectants as well as multi-resistant bacteria (Verlicchi, 2018). Given that the contribution of hospitals to the total amounts of pharmaceutical substances detected in urban wastewater varies between 20 and 100% depending on the type of substance, abroad during the last decade there has been a trend for on-site treatment of liquid hospital waste by adopting technologies that combine biological treatment methods and ozonation to remove specific micropollutants (Kovalova et al., 2012; Hansen et al., 2016; Tang et al., 2019). This article presents the demonstration unit HIPPOCRATES, which was recently funded by the European Programme for the Environment and Climate Action (LIFE, Project: LIFE22-ENV-EL-HIPPOCRATES-101113941). The main objective of the project is to determine if and how (optimum operating mode) the innovative combined eco-technologies (HIPPOCRATES' system) developed and tested successfully in pilot scale (1.0 m³/ day), for the removal of selected CEC through the on-site treatment of hospital wastewater effluent, before entering the main sewage system, are achieving similar high efficiency (removal vs cost) at large demonstration scale (40 m³/ day or 80% of the daily produced wastewater in Venizeleio Hospital and 20% of the daily produced wastewater in the Hospital Center Emile Mayrisch), in an all year continues operation, with real hospital effluent and in different geographical areas of Europe (south vs north).

There will be three locations where the main activities of the project HIPPOCRATES will take place: a) Heraklion, Crete in Greece where both the Venizelio General Hospital and the Municipal Water and Wastewater Company will be involved (stake holders), b) Esch-sur-Alzette in Luxembourg where again the Hospital Center Emile Mayrisch and the local Wastewater Facility will be involved (stake holders), and c) Limassol Cyprus, where the local Wastewater Council will be involved (stake holder). The background, starting point / quantified baseline of HIPPOCRATES is the DIANYA project (<https://dianya.gr/?lang=en>), realised between 2019 and 2023, funded by the Greek General Secretary for Research and Technology (project code T2EDK02905), which regards the successful pilot scale, on site application, of a combination of four technologies: a) Anaerobic Moving Bed Biofilm Reactor, AnMBBR (biological), b) aerobic Membrane Biological Reactor (MBR), c) Advanced Oxidation Process unit, using UV radiation and addition of H₂O₂, and d) chlorine disinfection unit, allowing the overall reduction of CECs, in the final hospital effluents by more than 85%. The pilot unit of DIANYA project (1.0 m³/ day) it was developed in Venizeleio General Hospital in Heraklion (GHH). The AnMBBR constructed in the DIANYA project is 400 L volume. Effluent from the inlet vessel via a screw pump feeds the Anaerobic Fluidized Bed Reactor (AnMBBR). Regarding CECs, the AnMBBR contributes to a different extent to the removal of different groups of pharmaceuticals ranging from <20% (for antihypertensive or anticonvulsant drugs) to more than 80% (for antibiotics such as metronidazole and trimethoprim). In parallel, almost 60% removal of organic loading was achieved in this bioreactor while the production of biogas exceeded 130 L per m³ of reactor per day. This resulted to an estimated production of energy due to the valorisation of biogas higher than 0.5 kWh per m³ of treated wastewater. The MBR constructed in the DIANYA project is 2000 L volume. As far as CECs removal, MBRs have shown varying removal efficiency for different pharmaceuticals such as metronidazole, trimethoprim, ciprofloxacin, sulfamethoxazole, paracetamol, valsartan and carbamazepine ranging between 60 and 100%. The Advanced Oxidation Process unit included UV radiation and addition of H₂O₂. Depending on the operational conditions applied, the H₂O₂-UV process results to >95% removal of cefadroxil, amoxicillin and other pharmaceuticals.

Keywords: Hospital, wastewater, pilot unit, demonstration unit, pharmaceuticals, anaerobic, aerobic, advanced oxidation processes.

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