Full scale MET-assisted biofilters for urban wastewater treatment: The H2020 iMETland project

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Abstract: In this communication we present the H2020 iMETLAND project. iMETland project aims to construct and validate a full-scale application of a low-cost, eco-friendly device to treat and disinfect urban wastewater from small communities at zero-energy operation cost. Our concept has already passed the pilot plan period and comes from the integration of Microbial Electrochemical Technologies (MET) with natural wastewater treatments inspired on the biofilters used in constructed wetlands. The inclusion of information & communication technologies (ICT) will confer the *i* component to allow a friendly unique interactive communication among depuration process and the end-user´s smartphone. The new concept operates at different scale including full scale (80m^2) for treating treating 25m^3/day of real urban wastewater at four different locations (Spain). The results confirmed that the hybrid MET-wetland acted as electrically conductive biofilter for efficient removal of organic matter, nitrogen, TSS and phosphorous even under organic matter load 3-fold higher than the one classically treated by standard constructed wetlands. Interestingly, COD removal was enhanced till 10-fold allowing a strong reduction in area requirements.

Keywords: Microbial Electrochemical Technology ; Constructed wetland; urban wastewater treatment

Introduction

Wastewater treatment is based on biological degradation of the sewage through oxidative reactions where microbes generate electrons. These treatments are usually limited by the availability of electron acceptors (e.g. oxygen), which are key for consuming those electrons. Microbes operating at METs, the so-called electrogenic bacteria, break down organic compounds while forming a biofilm on an electrically conductive material. Then, electrons are transferred to this material that behaves as an unlimited electron-acceptor while harvesting them from microbial metabolism. All those electrons are finally consumed by soluble electron acceptors present in the water. The mere presence of this conductive material has been proved to accelerate the biodegradation rate of bacteria though a process so-called DIET, Direct Interspecies Electron Transfer (Energy & Environmental Science 5:8982-8989). Constructed wetlands are natural wastewater treatment systems that have been set up all over the world over the last few decades as a good alternative to conventional systems for the sanitation of small communities. They are basically an emergent macrophyte community planted in a porous medium (usually gravel or sand), through which wastewater is passed for purification due to the activity of a microbial biofilm. Now, our iMETland is a hybrid concept between the use of electrically conductive biofilter and the concept of wetland.

Material and Methods

Hybrid METland construction: The consortium is planning is currently constructing a full—scale METland unit bed consisted of 80cm-deep electrically conductive bed covered by a 10-cm-gravel bed. Water was discontinously pumped into the METland at a total flow of 25m^3/day. Samples were analyzed for: Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), pH, Electrical Conductivity (EC), Total Nitrogen (TN), Nitrates (NO3–N), Ammonium (NH4–N) and Total Phosphorus (TP). A three-electrode system (anode,cathode) and reference) controlled by a potentiostat was placed at different locations to monitor the current production. Phylogenetic analysis of 16S rRNAs*:* was used for identifying the microbial species.

Results and Conclusions

Integration of MET with a constructed wetland was set up at different scales from lab scale to full scale in a seawage treatment plant. This novel hybrid MET-wetland was fed by real urban wastewater (2500 PE) from the municipality of Carrion de los Cespedes (Seville, Spain) together with the runoff collected in a combined sewer system. The system was fed with an organic load of 22g BOD_5/m^2d that is 3-fold higher than the recommended value for standard HSSF wetland.

The conductive biofilter enhanced the COD removal, showing biodegradation rates as high as 10-fold higher than the standard non-conductive bed (gravel) (Figure 1). A molecular ecology analysis by genome sequencing revealed the predominant presence of bacteria from the *Geobacter* genus in the conductive area but not in the gravel zone. *Geobacter* is the model microorganism for MET so the analysis of our METland will be benefitted from the deep understanding of this microbial metabolism.

To our knowledge this is the first full scale demonstration of a hybrid MET-constructed wetland and probably also the largest MET demonstration ever. Our results show that the integration of polarized conductive material in constructed wetlands efficiently accelerates the rates of COD removal in urban wastewater. On top of that we prove that the technology was robust enough to operate for long term operations under scenarios where no external energy was applied to the system.

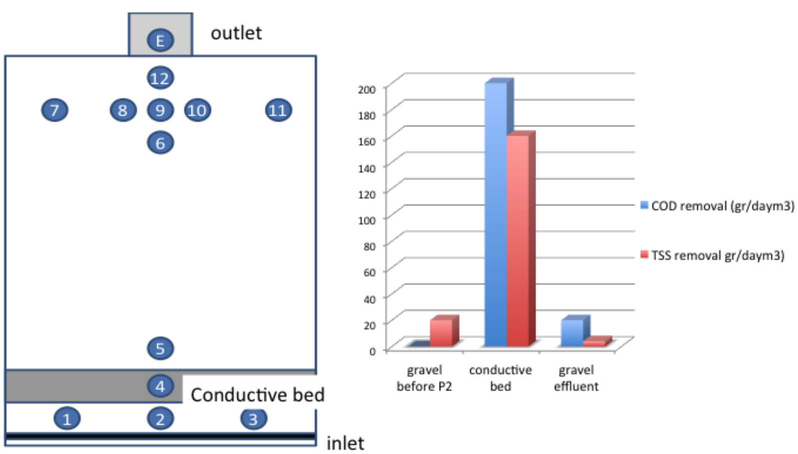

Figure 1) Scheme of the MET-Wetland showing the conductive bed between gravel zones and sampling sites. **B**) Removal rates normalized per volume of biofilter bed, for COD and TSS.

Figure 2. iMETland will be validat