

EOX-BIOPED PROJECT: FIRST APPLICATION OF ELECTROCHEMICAL AND BIOLOGICAL TECHNOLOGIES INTEGRATED FOR THE URBAN WASTEWATER TREATMENT

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Abstract

EOX-BIOPED project has been conceived as an innovative and integral solution for urban wastewater in small communities. It integrates a system with an electrochemical oxidation-promoting agent and a biological system with the inclusion of carriers in fluidized bed and stabilization in the treatment system. With the combination of these technologies an effective and stable operation with load and flow fluctuations of this water is reached, as well as a reduction of space requirements, the possibility of composting the sludge produced by simplifying the management of sludge facilitate maintenance and exploration and ultimately reducing costs.

Keywords: *electrocoagulation, fluidized bed reactor, activated carbon*

Introduction

According to the EU Directive 91/271, European populations larger than 2.000 inhabitants have to perform at least a primary treatment of its urban wastewater, when no secondary if they settle on areas classified as sensitive. 31,9% of Spanish population live in towns containing less than 20.000 inhabitants (INE, 2009). In the same country, the responsibility of urban wastewater depuration falls on local administration, which usually lacks of resources to achieve with this goal. This situation forces small municipalities to depuration, but without the financial or technical resources to do so. The installation of traditional wastewater treatment facilities is economically unfeasible for small communities, and soft technologies (e.g. green filters), in most cases, represent an unbeatable obstacle due to its space requirements. The solution is to find a system for urban wastewater depollution that ensure the sufficient clearance and which cost of installation and maintenance are affordable for small towns' budget.

Our main issue is to provide a more efficient and environmentally friendly technology for the treatment of urban wastewater, at a minimum cost of investment and management, providing means for the technological application of the environmental regulations. To achieve that, an innovative pilot plant (EOX-BIOPED) combining an electrochemical system followed by a biological reactor with biomass support has been developed, and tested in the WWTP of Morón de la Frontera (Spain).

The proposed innovative system EOX-BIOPED consists of two main parts: 1) an electrochemical system followed by flotation (EOXPED + FLOTPED); and 2) a biological system including fluidized bed media (BIOSOPOR).

During the electrocoagulation process, the contaminants present in an aqueous medium (suspended, emulsified or dissolved) are destabilized by introducing an electric current in the middle (Boye et al, 2003; Boye et al, 2004; Brillas et al, 2009). The electrical current provides the electromotive force to drive chemical reactions, forcing compounds to a more stable state (Brillas & Casado, 2002). This state produces a less soluble solid than the compound in the equilibrium values. As this occurs, the contaminants form hydrophobic entities that precipitate and can easily be removed with secondary separation techniques (electrolytic flotation).

Combined with the previous system, a biological sequential unit has been developed including the integration of porous and absorbent material to immobilize the biomass (Ødegaard, 2006). The highly porous activated carbon has been selected to provide a greater retention of microbial cell surfaces forming consistent biofilms and, therefore, to increase the efficiency of the system.

Methods

Essays at laboratory scale have been conducted with the targeted WW, to optimize parameters for the design and construction of the pilot plant. In the electrocoagulation unit, the oxidation promoter has been varied and different configurations of the electrochemicals cells have been tested and verified to measure the discharge in conjunction with the study of the suitability of decanting or floating the SST (solid suspension). The first tests have been based on the application of different current densities (mA/cm²) according to the wastewater demand. Subsequently, a battery of oxidants has been included to the selected current density to test the possible increase of the oxidative power. Within the biological system tests, the O₂ consumption during the biooxidation and biomass generation (quality and quantity compared to conventional systems) have been controlled, looking for the stabilization of the system and the minimization of the space. Finally, the combination of both units has been tested to quantify the whole efficiency.

Based on the results at a laboratory scale, the pilot plant has been constructed, and settled in the WWTP of Morón de la Frontera, where it has been operating during 12 months in real conditions. The pilot plant outflow has been controlled and the efficiency tested compared to the laboratory conditions.

Results and Discussion

EOX-BIOPED is an integral treatment plant consisting of electrochemical and biological systems, plus filtration and sedimentation. The plant includes pneumatic and hydraulic systems, and a control system for the optimization of all processes.

Both units, the electrochemical (EOXPED + FLOTPED) and biological (BIOSOPOR), reached the minimum levels permitted by the environmental applicable law separately, but optimum values were reached when working jointly. The final design of the system allows smaller dimensions of the biological system than conventional plants, and also diminishes the problem of changes in flow and load of wastewater.

Although the electrochemical technologies have already been used for industrial wastewater depuration (Poyatos et al, 2010), the successful application to the urban wastewater sector is an innovation by itself. Ultraviolet light was chosen as main oxidant agent due to its capacity for depolluting while leaving no harmful traces the treated effluent, disinfectant effect and reduced cost. This oxidant reacts with iron ions from the anode (iron), Fenton reaction, producing hydroxyl radicals, $\text{OH}\cdot$.

The resulting benefits of the BIOSOPOR proposal compared to conventional biological technologies without such supports (Chan et al, 2009) are an increase in the removal of organic matter and a process stability system making it less susceptible to biological changes in temperature, pH and pollutant load, due to its large capacity and faster time formation of a biomass film on the media. Energy requirement is minimal and the maintenance and operation is very simple. Sludge generation with this system is lower, which markedly decrease spending on management.

Conclusions

The integration of the two proposed technologies achieved an effective and stable operation with different loads and fluctuations of wastewater, reaching a balance between yields on treated water quality and investment and maintenance costs. Compared to conventional technologies, the lower space requirements, the possibility of composting the resulting sludge, and the easy maintenance and exploitation make it a feasible option for urban wastewater treatment in small communities.

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