Wastewater treatment and emerging contaminants removal in electro membrane bioreactor using self-forming dynamic membranes

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Abstract

In recent years, the technical-scientific community has been paying increasing attention to the presence of emerging contaminants that are intercepted in surface water and wastewater since these compounds could have harmful effects on human health and on environment too.

Conventional wastewater treatment installations represent a source of pollution from emerging contaminants because they are not designed to remove these compounds from the wastewater in their treatment cycle.

Several studies have shown the possibility of removing successfully these compounds from wastewater through the use of membrane bioreactors (MBR) combined with electrochemical processes, using conventional membranes.

The present study first examined the possibility of combining electrochemical processes with MBR (eMBR), through the use of self-forming dynamic membranes (SFDM) for the removal of emerging contaminants from municipal wastewater.

Thanks to this extremely innovative hybrid system, it has been possible to reduce the problems linked to the use of traditional membranes, in particular the high costs both of initial investment and of cleaning following fouling.

Particularly, the four most drugs used by humans representing different therapeutic groups, diclofenac (DCF) as anti-inflammatory, carbamazepine (CBZ) as anti-epileptic, amoxicillin (AMX) as antibiotic, estrone (E1) as sexual hormone and as a pesticide used in agriculture, atrazine (ATZ) it has been analysed.

Keywords: Electrochemical processes; Current density; Pharmaceuticals; Membrane fouling; Organic micropollutant

1. Introduction

Membrane bioreactor (MBR) is a reliable and promising technology for wastewater treatment and reclamation (Aslam et al., 2017), due to its notable advantages such as excellent effluent quality, good disinfection capability, higher volumetric loading and reduced footprint and sludge production.

However, membrane fouling is the main obstacle for the application of this technology since it reduces system productivity and it increases the frequency of chemical membranes cleaning (Lin et al., 2014).

Scientific research has studied several strategies for fouling control, including the integration of electrochemical processes into MBR in order to reduce fouling and to improve the quality of treated effluents (Ensano et al., 2017; Jiang et al., 2017).

These studies have shown, in addition to the reduction of the membrane fouling speed, also excellent removal capacities in terms of conventional and emerging contaminants.

Only recently scientific research has given more attention to the use of dynamic self-forming membranes (SFDM) for the treatment of civil wastewater (Hu et al., 2017; Salerno et al., 2017), exploiting the membrane fouling to obtain high depurative capacity.

However, although these studies have successfully removed conventional contaminants from wastewater, scientific research has not paid attention to the possibility of combining biological processes with electrochemical ones using dynamic self-forming membranes for wastewater treatment and removal of emerging contaminants present in them.

The pollution brought by emerging contaminants in our water resources has now become a global environmental problem (Richardson 2009).

Pharmaceutical and chemical compounds, used mainly in agriculture, are gaining great attention from the scientific community because of their potential environmental risks and the negative effects on human health (Vernouillet et al. 2010, Houtman et al. 2014).

Consequently, this study examined for the first time the possibility of combining electrochemical processes together with membrane bioreactors (eMBR), using self-forming dynamic membranes (eSFDMBR) to evaluate the possibility of successfully removing emerging contaminants from municipal wastewater.

2. Materials and methods

A laboratory-scale eSFDMBR plant worked with a working volume of 17 liters. It has been continuously fed with synthetic wastewater prepared in the laboratory and with similar characteristics to those of real wastewater according to a previous study (Borea et al., 2017).
The material making up the membrane was dacron (Saati SpA), with a porosity of 30 μm, inserted in a plexiglass support. The removal efficiencies obtained by the eSFDMBR system in terms of conventional contaminants were evaluated using standard methods (APAT and CNR-IRSA, 2003). DCF, CBZ, AMX, E1 and ATZ concentrations were measured according to Ensano et al. (2017).
In Figure 1 the experimental setup of the system is shown.

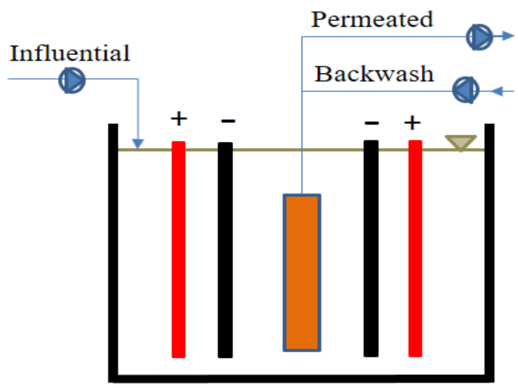

Figure 1. Scheme of experimental setup

3. Results and Discussion

The combination of eMBR with the SFDM process has implicated an increase of the treatment performances with high removals of organic and nutrient compounds.
With reference to membrane fouling, this study demonstrated how the application of an intermittent electric field in an SFDMBR minimizes to minimum membrane fouling with a decrease in TMP over time.
Removal efficiencies of conventional and emerging contaminants have been greater than those of traditional MBRs due to the different electrochemical mechanisms developed within the bioreactor. It has been achieved removals of 90% for COD, 98% for ammonia nitrogen (NH4-N) and 85% for total nitrogen.
The possibility of improving removal of emerging contaminants using SFDM will add further appeal for the implementation of wastewater treatment.

4. Conclusion

This study showed that the innovative eSFDMBR system is a potential tool to replace the conventional activated sludge treatment system and the use of traditional membranes, which still require high costs.

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