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Editorial

Leading edge technologies in wastewater treatment

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In this special edition of *AIMS Environmental Science*, we highlight different aspects of some advanced (leading edge) technologies in the field of wastewater treatment. Water is one of the most valuable resources of our planet and in the following years the concepts of water treatment and water reuse will be more relevant than even today. The technological research trends in this field are closely related to the new challenges of water science. As an example, currently new technologies are required for the efficient treatment of micropollutants such as pharmaceuticals or for reaching the quality standards for water reuse [1]. Other challenges are related with the need of technologies that can help us to extract the different resources enclosed into the wastewater such as nutrients [2] or to reduce greenhouse gases emissions [3] from wastewater treatment facilities. In this issue, a series of different articles try to cover, on one hand, specific advanced areas which are well established such as membrane bioreactors (MBR) or moved bed bioreactor (MBBR). On the other hand, other emerging technologies which are not widely used in full-scale facilities are analyzed as the application of heterogeneous Fenton-like processes or the use of the biogeochemical cycle of iron to recover resources from wastewater.

Wastewater treatment has been from its birth a field in continuous evolution. Since 100 years ago, when Ardern and Lockett discovered the activated sludge process [4], several advances have been done with the objective of reaching the requirements always demanded by the authorities and society. Despite of these advances and that activated sludge is one of the most important biotechnological processes used around in the world, still there remain significant gaps related to some aspects such as the flocs formation. Aspects related to how the floc development is initiated or which are the relative contributions of cell replication and cell recruitment to floc growth are poorly described. A promising approach to addressing these knowledge gaps is studied in this special issue [5].

MBR is an advanced technology which is currently highly implemented in different urban and industrial wastewater treatment facilities [6]. MBR technology is a step forward in the classical activated sludge treatment. In the activated sludge treatment the solid-liquid separation unit is a settler where the suspended solids are separated from the effluent by sedimentation. In MBR, membrane separation processes replace the settler units. With this replacement several goals are achieved. The first one is that the operational surface needed to carry out the solid-liquid separation is significantly reduced. The second goal is that the quality of the effluents is also increased. The main drawback related with MBR are the necessity of using high amounts of energy and also the operational problems derived from the operation and maintenance of the membranes [7]. In this special issue, all these aspects are faced in a full-scale MBR water reuse facility [8].

In the last 20 years, MBBR has been established as a simple-yet-robust, flexible and compact technology for wastewater treatment [9]. It has shown great potential in pollution load reduction and has definite edge over the surface aeration system [10] and its application in wastewater treatment has increased over the past decade. MBBRs have become an interesting alternative for wastewater treatment as it is a reliable and compact system due to development in the design and operation which has resulted in decreased footprints, significantly lower suspended solid production, consistent production of high quality and reusable water and minimal waste disposal. It is one of the advanced aerobic wastewater treatment processes having advantages of both attached and suspended growth systems. In MBBR the biomass grows as a biofilm on small plastic carriers that move freely into the wastewater [11]. A screen is provided at the outfall end of the reactor to keep media from passing out of the reactor. Contrary to the activated sludge reactor, it does not need any sludge recycle. Since no sludge recirculation takes place, only the surplus biomass has to be separated, which is a considerable advantage over the activated sludge process [12]. Moreover, nitrification and de-nitrification can also be successfully achieved in biofilm-based processes since nitrifiers, which are slow growing micro-organisms, are retained by the biofilm [13]. Several processes with different kinds of floating carriers have been developed [14], with porous materials such as polyurethane and with nonporous material such as polyethylene. In this issue it will be presented a study related with the upgrading of a full scale wastewater treatment plant to MBBR [15].

The removal of organic matter from contaminated effluents usually is removed biologically in activated sludge systems, or in more advanced systems such as MBR or MBBR. The removal in all those treatments is carried out biologically, so only that fraction of the organic matter which is really biodegradable can be removed. In the case of industrial wastewaters, the concentration of refractory or non-biodegradable organic compounds used to be high. The presence of these kind of compounds in wastewaters, which can be carcinogenic or/and mutagenic, with high toxicological potentials, is a global issue because of the increasing demand for public health awareness and environmental quality. So the development of quick and simple methods for their removal are still required. Advanced Oxidation Processes (AOP's) have emerged as interesting alternative for the destruction of organic pollutants in industrial wastewater [16]. These processes involve the generation of non-selective and highly reactive hydroxyl radicals, which are one of the most powerful oxidation agents. The reaction of hydrogen peroxide with ferrous salts (Fenton's reagent) or other low-valence transition metals (Fenton-like reactions) is a well-known source of hydroxyl radicals at room temperature [17]. In this issue, it will be studied how to overcome the main drawbacks of the Fenton process by using heterogeneous catalysts [18].

New technologies based on the study of the biogeochemical cycles can have a big impact in the future of the wastewater treatment plants. One example based in the biogeochemical cycle of iron is the BioIronTech process which is covered by an article in this special issue [19]. BioIronTech process have shown to remove/recover more than 90% of phosphorous from reject water thus replacing the conventional process of phosphate precipitation by ferric/ferrous salts, which are

20-100 times more expensive than iron ore, which is used in BioIronTech process. BioIronTech process can remarkably improve the aerobic and anaerobic treatments of municipal and industrial wastewaters, especially anaerobic digestion of lipid- and sulphate-containing food-processing wastewater. It can also remove the recalcitrant compounds from industrial wastewater, enhance sustainability and quality of water resources, and recover ammonium and phosphate from municipal and food-processing wastes.

Overall this review series provides a snapshot of the power of leading edge technologies and concepts which can be relevant in the future wastewater treatment facilities. Obviously, the field of leading edge technologies related to water is really wide and is difficult to cover all the areas which are in development in different research centers around the world. Some of the areas not covered in this review and that deserve to be mentioned are some emerging areas related with the resource recovery from wastewater such as bioplastics [20], nutrients in form of different fertilizers such as struvite [21] or the energy contained into the organic matter using biolectrochemical systems [22]. Topics related with micropollutants removal [23] and water reuse [24] that will be highly relevant in future were also not covered in this special issue. Undoubtedly, these new areas, as well as further research into the topics covered in this review series, will provide further advances in the development of water treatments

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Conflict of Interest

Author declares no conflicts of interest in this paper.

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