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Editorial

Application of Biological and Chemical Processes to Wastewater Treatment

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Existing wastewater treatment plants (WWTPs) face huge challenges that can impede the achievement of sustainable development goals for clean water and sanitation (SDG 6) and clean energy (SDG 7), amongst others. Owing to intense industrialization and the growth of population, new and emerging pollutants are widely detected in wastewaters rendering existing conventional WWTPs incapable of effectively treating them. For example, pharmaceuticals [1] and compounds derived from the petrochemical industry [2,3] are very difficult to treat due to their persistent and non-biodegradable nature. The presence of such substances in the environment, even at trace concentrations, can cause serious adverse effects to the eco-system and organisms, including humans. Therefore, there is a pressing need to upgrade current WWTPs either by intensifying operational parameters and/or by adding new technologies in the treatment train system to effectively remove persistent pollutants and promote the successful attainment of SDG 6.

Moreover, conventional WWTPs are strongly associated with high energy demands, leading to increased total greenhouse gas emissions. In addition, high energy demands equal high operational costs, which developing countries are struggling to cover. To tackle this problem and increase the sustainability of conventional WWTPs a movement towards zero and/or negative net energy facilities (i.e., energy produced during treatment is greater than the energy required for their operation) should be made. Clean energy as set out in SDG 7 can be produced during wastewater treatment by technologies such as anaerobic digestion [4] and microbial fuel cells [5].

This Special Issue focuses on the development of environmentally friendly and sustainable technologies that can effectively treat wastewater. For this purpose, emphasis is given on the removal of priority and hazardous pollutants from wastewater, as well as on reducing the overall energy consumption in WWTPs. To be more specific, this Special Issue comprises the following papers that deal with the application of biological, chemical, and physical processes for wastewater treatment.

McMichael et al. [6] provide a comprehensive literature review of photoelectrocatalytic (PEC) processes, including the types of PEC reactors, (photo)electrodes used, and the contaminants degraded. It was observed that PEC can improve the performance of immobilized photocatalytic systems. More research is needed though on the optimization of the electrodes and reactor design to enable pilot-scale testing, since PEC is currently applied at lab-scale only.

Alrousan et al. [7] investigated the treatment of real grey water using TiO_2-based oxidation processes in a custom-built stirred tank reactor. Immobilized TiO_2 was combined with H_2O_2 and O_3 under dark or UVA irradiation. It was observed that combining the different treatment methods with UVA irradiation dramatically enhanced the organic mineralization efficiency. For example, at optimal conditions TOC removal was about 54% by means of photocatalytic peroxonation. The UVA and/or visible light enhancement of the H_2O_2/TiO_2 system was deemed as a very promising and viable option to reduce the organic content of grey water thus enabling water reclamation.

Gowland et al. [8] carried out a literature review of the photocatalytic treatment of natural organic matter (NOM), which is a complex mixture of organic persistent substances

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found in surface waters. Emphasis was given on TiO_2-based heterogeneous and homogeneous photo-oxidation systems. Coupling photocatalysis with other water treatment technologies, such as membrane filtration, adsorption, coagulation, and biodegradation, could also be a viable option to overcome the inadequacies of photocatalysis as a standalone technology.

Tursi et al. [2] studied the treatment of benzene, toluene, and xylenes (BTX) petroleum products by means of adsorption on cellulose fibers, extracted from Spanish Broom plants. The effect of surface hydrophobization of the fibers was investigated and it was found that, surprisingly, the unmodified cellulose fiber showed the highest adsorption capacity for the BTX pollutants. This was attributed to the existence of a hydrophobic core under the surface of the fibers, which can make their use very attractive in the purification of pollutants emitted from the petrochemical industry.

Lee et al. [3] studied the biodegradation of 1,4-dioxane, which is usually used as a solvent in industry, by means of a mixed consortium of bacteria enriched from the activated sludge at a textile wastewater treatment plant. It was observed that the biodegradation of 1,4-dioxane was not affected by the presence of dextrose but was almost completely inhibited by the presence of high concentrations of tetrahydrofuran, 2-methyl-1,3-dioxolane, and 1,4-dioxene. This indicates that substantially longer treatment times are required for the proper treatment of 1,4-dioxane when such structural analogs are present in the wastewater.

Sakaveli et al. [4] explored the anaerobic digestion of the primary, instead of the combined primary and secondary, sludge from a municipal WWTP and assessed its treatment and energy recovery potential. It was found that the overall yield in methane production during anaerobic digestion of primary sludge alone was higher (up to 40%) than that obtained by the anaerobic digestion of mixed primary and secondary sludge. Additionally, the addition of both organic polyelectrolyte and attapulgite enhanced the production of methane by up to 170%.

Song et al. [9] studied the aerobic denitrification of a recirculating marine aquaculture system effluent. The effects of hydraulic retention time (HRT), influent nitrate-N concentration, and the microbial community composition on nitrogen removal were assessed. Results showed that over 98% of nitrogen was removed, while the maximum nitrogen removal rates were observed at HRT of 6 or 7 h when influent nitrate-N was 150 mg/L. DNA sequencing analysis revealed that the microbial phyla Proteobacteria and Bacteroidetes were predominant in the reactor, giving insights into the biological processes that can inform the design and operation of denitrifying reactors for marine aquaculture systems.

Xu et al. [5] developed an aircathode microbial desalination cell by inoculating anaerobic sludge into the anode of a microbial desalination cell. It was observed that the desalination rate gradually decreased, but salt removal gradually increased when the salinity was decreased, and the highest salt removal was about 98%. The pollutants removal rate and desalination were deemed sufficient for treating actual coastal saline–alkaline soil-washing water, but the output power could not meet the actual demand.

Wang et al. [1] studied at pilot-scale the treatment of mixed pharmaceutical and domestic wastewater by means of hydrolysis acidification-ozone-modified anaerobic–anoxic–aerobic-ozone (A2/O) (pre-ozone) or hydrolysis acidification-modified A2/O-ozone (post-ozone). Mixing with domestic wastewater and O_3 were used to reduce toxicity of pharmaceuticals and improve the biodegradability. Results showed that the post-ozone treatment was more efficient than pre-ozone for the treatment of mixed wastewater.

In conclusion, this Special Issue provided new ways to decarbonize wastewater treatment by optimizing the degradation of persistent pollutants, studying the application of early lab-scale technologies, and increasing the amount of energy produced in WWTPs.

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