Special Issue: Municipal Wastewater Management

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Municipal wastewater management is a well-established field in most parts of the world nowadays. However, there are still many challenges that need to be faced, not only in developing countries, where municipal wastewater is often discharged without previous treatment, but also in developed countries, where wastewater treatment plants have been employed for decades, with the goal of reaching the stage of highly advanced sustainable municipal wastewater management that would protect both the environment and humans' health, be energy-, water-, and cost-efficient, and have the ability to adapt to the current environment and the needs of the community.

In that sense, special issues, focused on the particular subject of "Municipal Wastewater Management" are always relevant and worth being reintroduced, as they bring together scientific aspects of the particular subject that might have not been revealed or met, unless such a special issue had been developed. This particular issue had the chance to bring together, after a rigorous peer review process, five original research papers and four review articles that focus on municipal wastewater management at a broad range of scales, that is: from practical local actions to global principles.

The aim of this editorial is to point out key aspects of the guest-editing process and to highlight the contributions, in a way that: (a) their importance is enhanced, and (b) how they link together, under the umbrella of this special issue, is defined, so that all contributions can stimulate a broader scientific audience, awareness and understanding.

Starting by highlighting the original research papers, contributed to this Special Issue, Fytianos et al. (Contribution 1) in "Biocorrosion of Concrete Sewers in Greece: Current Practices and Challenges", address a topic that exists in the majority of aged municipal wastewater collection systems, where concrete was used before polyvinyl chloride (PVC) pipes became common practice in the mid-1980s. According to estimations, the biogenic corrosion of concrete sewer pipes, due to the production of H_2S in sewage, represents approximately 10% of the total sewage treatment cost. In their holistic approach, Fytianos et al. administered a questionnaire survey to stakeholders working in municipal wastewater treatment plants serving more than 50% of the total country's population, and validated the survey answers with field measurements and analyses. With their work, not only is the nature and extent of concrete biocorrosion problems in Greece presented for the first time, but also the need for holistic approaches to handle complex aspects of municipal wastewater management, such as biocorrosion in old sewer networks, is highlighted, providing a broader research interest in this work.

As the holistic approach to deal with biocorrosion in old municipal sewer networks cannot exclude the integration of both technical and financial information in applying sustainable maintenance methodologies to the sewage network, in their follow-up paper entitled "Least Cost Analysis for Biocorrosion Mitigation Strategies in Concrete Sewers", Fytianos et al. (Contribution 2) use the same research area as before and this time present results from a cost-comparative analysis, focusing on an annuities calculation for the evaluation of microbiologically induced corrosion or biocorrosion mitigation methodologies, used in the maintenance of concrete sewers. They conclude that spraying with magnesium hydroxide slurry is the most advantageous maintenance technique, based on direct and indirect economic assessment. As each case is different, a universal tool for the economic

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evaluation of various biocorrosion mitigation strategies could be useful. In that sense, the authors' future work, focusing on the development of such a universal financial assessment tool, is worth being followed.

The application of SCADA (Supervisory Control and Data Acquisition) systems to the remote monitoring and controlling of wastewater treatment plants is the focus of Brad et al.'s (Contribution 3) publication entitled "Lifecycle Design of Disruptive SCADA Systems for Waste-Water Treatment Installations". The major contribution of this paper is a proposed structured methodology for optimizing SCADA systems from a lifecycle perspective for their application to the specific case of wastewater treatment plants. This kind of approach was not previously reported in the literature for this stage of design. The theoretical model developed by the authors is tested under practical conditions, illustrating both its applicability and its limitations.

García-López et al.'s (Contribution 4) publication entitled "The financing of wastewater treatment and the balance of payments for water services: Evidence from municipalities in the Region of Valencia" casts light on the issue of how tax rates can provide the necessary revenue to finance the cost of urban wastewater treatment, using evidence from municipalities in the region of Valencia, in south eastern Spain. The analysis provided in this work demonstrates the importance of an appropriate wastewater treatment tariff structure that would include aspects, such as water pollution and energy costs, that are not currently intergraded into wastewater treatment tariffs, not only in Valencia but in most municipalities within Europe and around the world. Through the local insights, provided in this work, we can gain an understanding of how wastewater treatment taxes can lead to the economic sustainability of urban wastewater treatment plants, a matter of great importance and challenge for all urban wastewater services worldwide.

Tsiakiri et al.'s (Contribution 5) publication entitled "Estimation of Energy Recovery Potential from Primary Residues of a Municipal Wastewater Treatment Plant" aims towards the identification of the biomethane potential of non-conventional sources derived from municipal wastewater treatment processes. In this work, byproducts deduced from the primary treatment process stage were collected from four sewage treatment plants in Greece and analyzed for their solid and fat content, as well as their concentration of dissolved organic matter and nutrients, and were subjected to anaerobic digestion treatment for the measurement of their biomethane production potential. The highest potential for biogas utilization was found in screenings collected from a treatment plant receiving wastewater from an area with combined rural and agro-industrial activities. Floatings from grit chambers presented the smallest potential for energy recovery. However, these wastes were found to be potentially suitable for energy production, in secondary sludge co-digestion units. Wastewater treatment plants can benefit from such research approaches, aiming to minimize the energy consumption of the municipal wastewater treatment process, leading even to the production of power in wastewater facilities.

Psaltou et al. (Contribution 6) in "Effect of Thermal Treatment on the Physicochemical Properties of Minerals Applied to Heterogeneous Catalytic Ozonation" examine the effect of thermal treatment on three inexpensive minerals, i.e., zeolite, talc, and kaolin (clay), which present different physicochemical properties as potential catalysts for the removal of para-chlorobenzoic acid (p-CBA), a typical micro-pollutant, commonly used as a model compound to indirectly evaluate the production of hydroxyl radicals in ozonation systems. The addition of an appropriate catalyst can enhance the efficiency of the ozonation process, which is a promising treatment technique, especially for the removal of micro-pollutants found in municipal wastewater treatment plants. Thus, such research is always of interest, and the results presented here are promising, especially regarding the catalytic activity of talc (primarily) and kaolin (secondarily), which are not as widely researched as zeolite, as potential catalysts for enhancing the efficiency of heterogeneous catalytic ozonation, applied to municipal wastewater treatment processes.

Dang et al. (Contribution 7) in their work "Loofah Sponges as Bio-Carriers in a Pilot-Scale Integrated Fixed-Film Activated Sludge System for Municipal Wastewater Treatment"

bring focus on another interesting subject of municipal wastewater treatment, especially for developing countries: the use of natural materials as carriers for the integrated fixed-film activated sludge system (IFAS). The authors apply modified loofah sponges, as bio-carriers, in a pilot-scale IFAS for the treatment of real municipal wastewater. Loofah is an annual herbaceous plant from the cucurbitaceous family, and its fully developed fruit is the source of the loofah scrubbing sponges normally used in bathrooms and kitchens. The results presented here are encouraging and worth being noticed, as modified loofah can serve as a possible replacement to the expensive and environmentally unfriendly polyethylene bio-carriers for municipal wastewater treatment applications in developing countries, where loofah is locally abundant.

The concept of applying hybrid systems of constructed wetlands (CWs) for the treatment of the domestic wastewater of small communities has been studied for many years now. However, this alternative technology has not been widely accepted, mainly because its application has not been accompanied with a parallel effort to gain wider community acceptance of it over the conventional wastewater treatment systems. Lavrnić et al. (Contribution 8) in “Potential Role of Hybrid Constructed Wetlands Treating University Wastewater-Experience from Northern Italy” place their research in the University campus of Bologna (Northern Italy) and attempt to assess the potential of their hybrid CW system to be used in universities for wastewater treatment by incorporating the public’s opinion (students and university staff) in their evaluation. The results, presented in this research, show that the hybrid system met the Italian limits for discharge in natural water bodies and some of the limits for wastewater reuse in Italy and the European Union. The positive attitude towards CWs and wastewater reuse, found among the survey participants, reinforce the belief that hybrid CWs (planted and unplanted) can be considered as a feasible technology for application at universities.

The Special Issue had also the chance to bring together one review and two mini-review articles, which focus on summarizing and presenting, in different perspectives, the current state of research concerning, respectively, the following topics: (a) the history, development and future challenges of urban wastewater treatment in Greece; (b) solar photocatalysis for emerging micro-pollutants abatement and water disinfection; (c) the policies regarding the ocean dumping of treated municipal sewage in the Republic of Korea.

The mini-review of Prochaska and Zouboulis (Contribution 9), entitled “A Mini-Review of Urban Wastewater Treatment in Greece: History, Development and Future Challenges” serves as another example of how the municipal wastewater management of a particular country can be of interest to a wider readership, as it addresses the country’s own wastewater management path in respect to the global thinking around sustainable environmental development. In this review paper, the authors revisit the development history of Greece’s municipal wastewater management, highlight the future needs of sustainable development, explore Greece’s own wastewater management path, and look towards the future from several aspects, including the European Union’s policies and international technological trends, in order to identify wastewater treatment plants not only as sites of pollutant removal, but also as places where energy is efficiently used and environmental sustainability is being practiced. The review refers also to the promising area of ongoing research on COVID-19 which involves using sewage to monitor virus circulation in communities and to detect possible outbreaks, even before clinical cases have been identified. As novel enveloped viruses are expected to emerge in the future, integrating this approach with proper onsite wastewater management could help tackle the problem, at the local scale, and avoid larger-scale virus outbreaks.

As stated by Venieri et al. (Contribution 10), the occurrence of emerging micro-pollutants in the aquatic environment, as well as the presence of various pathogenic microorganisms, impose the application of effective purification methods in order to maintain high hygiene standards and protect public health. Venieri et al. in “Solar photocatalysis for emerging micro-pollutants abatement and water disinfection: A mini-review” give a

clear overview of the recent progress in the field and point out important considerations in the design of such systems. Lab and pilot-scale applications are presented, current trends regarding the elimination of antibiotic resistant bacteria, and resistance genes by means of solar photocatalysis are discussed, with a view to investigating the prospect of using those purification methods for the control resistant microbial populations found in the environment. Understanding the interactions of the various water components (both inherent and target species) is key to the successful operation of a treatment process and its scaling up.

Treated sewage sludge disposal is always a matter of research interest, as policies and regulations worldwide are aiming towards a sustainable sludge disposal strategy, with minimum sludge disposal to landfill, maximum energy recovery, agricultural uses and no ocean dumping. In this context, the review article of Chung et al. (Contribution 11) entitled “Overview of the Policies for Phasing out Ocean Dumping of Sewage Sludge in the Republic of Korea” brings focus to the approach followed in the Korea Republic regarding the evolution of policies for the disposal of treated municipal wastewater sludge into the ocean, which was stopped in the Republic of Korea in 2012. The article helps in understanding how international conventions, such as the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, commonly called the “London Convention”, entered into force in 1972 and replaced in 1996 by the “London Protocol”, can gradually impact the swiftness of local policies towards environmental protection.

Taken the contents of this Special Issue as a whole, it is clear that “Municipal Wastewater Management” is an ongoing field of research with the ability to incorporate current environmental and humans’ health challenges into its analyses. The use of municipal sewage to monitor COVID-19 virus circulation in communities and the estimation of possible outbreaks, even before clinical cases have been identified, is another fact that justifies this.

In light of the coronavirus pandemic, interest in the impact that research on municipal wastewater management can have on improving humans’ health and protecting the environment is being rethought. In respect to this, there is an essential need for scientific publications that present varieties of case studies and discuss best practices, in order for wastewater treatment plants to be seen not only as sites of pollutant removal but also as places where energy is efficiently used and environmental sustainability is being practiced, in close relation to the needs of the community.

Viewed in this way, the papers collected in this Special Issue aim to reach a broad readership that can gain awareness and understanding of their topics and be stimulated into future research and collaborations that would improve all stakeholders’ engagement towards promoting sustainable municipal wastewater management.

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