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Editorial

Agro-Industrial Wastewater Treatment with Decentralized Biological Treatment Methods

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1. Introduction

Food processing consumes high volumes of water, making agro-industries the third biggest industrial user of water after oil refineries, primary metals and chemicals industries [1]. The overall water consumption in agro-industries is related to the final product's quality and depends on the process, equipment and industry's automation [2,3]. This high water consumption inevitably leads to the production of wastewater in large quantities [4], which differs from domestic wastewater due to high pollutant loads, forming industrial wastewater, as it contains biodegradable and non-toxic substances [5]. Agro-industrial wastewater is mainly characterized by high values of (a) biological and chemical oxygen-demand concentrations (BOD and COD, respectively), due to their high organic loads; (b) dissolved (DS) and/or suspended (SS) solids, including oils, fats and grease; and (c) nitrogen and phosphorus contents [6]. One of the main problems of agro-industrial wastewater is the great variation in its quantity and quality, which depends on the specific type (e.g., fruit, dairy, oil, vegetable, meat) and scale of production (small-scale or local, large-scale or international producer). Furthermore, these facilities are usually scattered throughout the country and produce by-products and waste on a seasonal rate, making their management even more problematic. In Greece, these units are usually small and often cannot bear the cost of waste disposal and fees. Therefore, they struggle to survive and remain competitive in the market and/or in many cases, do not comply with the legislative standards.

Several treatment technologies, including physicochemical systems, biological systems (anaerobic or aerobic), constructed wetlands, electrochemical methods, membrane bioreactors, advanced oxidation processes or hybrid systems including two or more of the above-mentioned methods have been proposed and tested for agro-industrial wastewater treatment [7], which differ on their capital and operation cost and their ability to be used in remote areas. This Special Issue includes seven papers (Table 1), which cover a variety of subjects related to agro-industrial wastewater treatment.

Table 1. Summary of the seven papers published in the Special Issue "Agro-Industrial Wastewater Treatment with Decentralized Biological Treatment Methods" in the Water Journal (https://www.mdpi.com/journal/water/special_issues/water_agro-industrial_wastewater_decentralized_biological_treatment, accessed on 8 March 2021).

Reference	Keywords	Authors	Title	Wastewater Type	Treatment Method
[8]	zeolite; secondary cheese-whey; ammonium removal; adsorption experiments; column experiments	Kotoulas, A.; Agathou, D.; Triantaphyllidou, I.E.; Tatoulis, T.I.; Akratos, C.S.; Tekerlekopoulou, A.G.; Vayenas, D.V.	Zeolite as a Potential Medium for Ammonium Recovery and Second Cheese Whey Treatment	Second Cheese Whey	Adsorption
[9]	zeolite; secondary cheese whey; ammonium removal; column experiments; continuous flow; plant growth experiments	Kotoulas, A.; Agathou, D.; Triantaphyllidou, I.E..; Tatoulis, T.I.; Akratos, C.S.; Tekerlekopoulou, A.G.; Vayenas, D.V.	Second Cheese Whey Treatment Using Zeolite under Continuous Flow Mode and Its Application on Wheat Growth	Second Cheese Whey	Adsorption, biological
[10]	Patent Blue V; Langmuir isotherm; Freundlich isotherm; SEM; removal efficiency	Giri, B.S.; Goswami, M.; Kumar, P.; Yadav, R.; Sharma, N.; Sonwani, R.K.; Yadav, S.; Singh, R.P.; Rene, E.R.; Chaturvedi, P.; Singh, R.S.	Adsorption of Patent Blue V from Textile Industry Wastewater Using Sterculia alata Fruit Shell Biochar: Evaluation of Efficiency and Mechanisms	Textile	Adsorption
[11]	Leptolyngbya; Limnothrix; wastewater treatment; biodiesel; attached systems	Tsolcha, O.N.; Tekerlekopoulou, A.G.; Akratos, C.S.; Aggelis, G.; Genitsaris, S.; Moustaka-Gouni, M.; Vayenas, D.V.	Agroindustrial Wastewater Treatment with Simultaneous Biodiesel Production in Attached Growth Systems Using a Mixed Microbial Culture	Dairy, winery and raisin wastewater	Biological
[12]	orange juice processing waste; biomass valorization; xylanolytic bacteria and yeasts; endo-1,4-β-xylanase activity; 1,4-β-xylosidase activity; hemicellulose hydrolysis; lactic acid bacteria (LAB); acetic acid bacteria (AAB)	Zerva, I.; Remmas, N.; Ntougias, S.	Diversity and Biotechnological Potential of Xylan-Degrading Microorganisms from Orange Juice Processing Waste	Juice Processing Waste	Biological
[13]	formulated diet; integrated multitrophic aquaculture; microbial community; functionality; sustainability	Deng, Y.; Zhou, F.; Ruan, Y.; Ma, B.; Ding, X.; Yue, X.; Ma, W.; Yin, X.	Feed Types Driven Differentiation of Microbial Community and Functionality in Marine Integrated Multitrophic Aquaculture System	Aquaculture	Biological
[14]	constructed in-stream wetland; groundwater inflow; nitrate; non-point pollution; nutrient reduction; phosphate	Kill, K.; Pärn, J.; Lust, R.; Mander, Ü.; Kasak, K.	Treatment Efficiency of Diffuse Agricultural Pollution in a Constructed Wetland Impacted by Groundwater Seepage	Agricultural Pollution	Constructed wetlands

2. Summary of This Special Issue

A variety of agro-industrial wastewaters and treatment methods are presented in the papers discussed in this Special Issue. Two of the papers [8,9] focus on the use of natural zeolite in second cheese whey treatment, aiming to adsorb and recover nitrogen. The first paper [8] presented laboratory-scale experiments using artificial wastewater and second cheese whey. In these sorption experiments, different zeolite granulometries and ammonium concentrations were used. The results indicated that zeolite granulometry had no significant effect on ammonium sorption. Furthermore, column sorption experiments indicated that ammonium removal rates exceeded 96% in the first 120 min of operation, for both artificial wastewater and second cheese whey, while COD removal was approximately 40%. Desorption experiments also showed that ammonium and organic matter were not easily released from zeolite, indicating the potential use of saturated zeolite for soil amendment. The follow-up study [9] included continuous flow column experiments, which also proved the ability of zeolite to adsorb nitrogen from second cheese whey, achieving an adsorption capacity of 15.30 mg NH_4^+-N/g. The saturated zeolite was used in plant growth experiments, which showed a positive effect of saturated zeolite on the plant production. Both studies proved the potential use of zeolite for second cheese whey treatment, either as an adsorption filter, or as potential substrate in biological trickling filters and constructed wetlands. Giri et al. [10] also examined adsorption as a potential treatment method. In their study, biochar prepared from Sterculia alata fruit shells was used to remove dye. The laboratory-scale experiments showed that the produced biochar could succeed a maximum adsorption capacity of 11.36 mg/g when 40 g/L of biochar was used and the dye initial concentration was 500 mg/L. Scanning electron microscopic (SEM) images showed the possible existence of a multilayer-type adsorption.

Dairy, winery and raisin wastewater were treated using cyanobacteria cultures, to examine their treatment efficiency and their ability to produce microbial lipids as biodiesel feedstock [11]. Attached growth biological systems were mainly examined by Tsolcha et al. [11], using a mixed microbial culture dominated by *Leptolyngbya* and *Limnothrix* species. The laboratory-scale experiments showed that, for all three wastewaters types tested, the organic matter removal efficiency exceeded 95%. Furthermore, dairy wastewater recorded the highest attached biomass productivity (5.03 g m^{-2} day^{-1}). Zerva et al. [12] isolated xylan-degrading microbiota from orange juice processing waste to access their biotechnological potential to serve as biocatalysts for citrus biomass valorization. The isolated microbial strains included isolates belonging to *Pseudomonas psychrotolerans* and *P. oryzihabitans*, while Illumina data showed the dominance of lactic and acetic acid bacteria and of the yeasts *Hanseniaspora* and *Zygosaccharomyces*.

The effect of feed types, fresh frozen fish diet (FFD) or formulated diet (FD) on microbial community diversity in integrated multi-trophic aquaculture (IMTA) was examined by Deng et al. [13], as microorganisms affect element cycling, energy flow and farmed-species health. The results showed that cyanobacteria dominated the FFD pond, increasing nitrogen fixation. On the other hand, *Sulfurovum* and *Desulfobulbus* dominated in sediments correlated to sulfur transformation.

Kill et al. [14] used free water surface CWs to treat agricultural runoff. CWs in this study were found to be effective in total phosphorus (TP) and phosphate (PO_4-P) removal as they achieved removal rates of 20.5% and 16.3%, respectively.

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