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Editorial

Fourth Industrial Revolution of Wastewater Treatment with Adsorption

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1. Background

The fourth industrial revolution of the water sector complies with the objectives of Water 4.0 by employing digital technology for flexible, reliable, and competitive water management [1, 2]. Digitization and automation are used to promote and strengthen the water-human-data nexus, especially to maintain efficient wastewater treatment technologies [3, 4]. The digital support systems allow for collecting a sufficient amount of data with nonexcessive field sampling and monitoring [5, 6]. This advantage would further save time and effort, viz., avoiding workers' exposure to dust, airborne bacteria, and endotoxins, for data collection and assessment [7, 8]. Because the adsorption process has been widely used for removing heavy metals, dyes, turbidity, and organic compounds in wastewater treatment, its performance optimization and prediction by advanced modeling techniques should be comprehensively investigated [9, 10]. Hence, this Special Issue represents the utilization of the adsorption technique to remove various pollutants from wastewater, focusing on the application of artificial intelligence techniques to simulate and forecast the pollutants' removal efficiencies. This Special Issue also attempts to show that applying the advanced and innovative computational tools in various adsorption-based wastewater treatment systems would overcome the drawbacks of conventional modeling and statistical methods.

2. Summaries of Accepted Articles

Reynel-Ávila et al. [11] represented a review of the artificial neural network (ANNs) applications for modeling, simulation, and optimization of the adsorption process for organic and inorganic pollutant reduction. The study demonstrated that ANN had been widely used in more than 250 papers reported in the Web of Science® database to predict the adsorption performance and the related isotherm and kinetic parameters for either batch or dynamic operation. The review concluded that the ANN-based modeling of adsorption systems was efficient for resolving complex engineering problems due to achieving both technical and economic advantages.

Yadav et al. [12] used incense stick ash to prepare Ca-rich zeolite, which was characterized in terms of gismondine ($Ca_2Al_4Si_4O_{16}\cdot 9H_2O$). A computational model was used to estimate the electronic properties and density of states of gismondine ($Ca_2Al_4Si_4O_{16}\cdot 9H_2O$), indicating the successful synthesis of Ca-based zeolites. The Ca-exchanged zeolite was further employed to remove heavy metals and alkali metals from fly ash aqueous phases. The removal efficiencies of these metals were about 27.6% for Cu, 64.1% for Cd, 80.0% for Cr, 20.5% for Co, 23.4% for Ni, 48.8% for Zn, 73.5% for Ba, 27.6% for Ca, 64.1% for Mg, 32.5% for Mn, and 62.6% for Al within 120 min adsorption time.

Kumi et al. [13] represented the application of the pyrolysis process to convert sewage sludge into biochar. The biochar elemental composition was modified by adding eggshell waste, generating an adsorbent suitable for toluene and xylene (TX) removals. The removal efficiencies of T and X reached 79.1% and 86.6%, respectively, at pH = 10, biochar dosage = 2 g/L, and initial TX of 40 mg/L for 1 h adsorption time. The economic feasibility of the proposed adsorption system was estimated, equivalent to a 6.9 yr payback period. Isotherm and kinetic models were used for fitting the adsorption data and suggesting the removal mechanisms.

Alhothali et al. [14] represented the application of artificial intelligence prediction models and statistical methods to simulate and optimize the removals of chemical oxygen demand (COD) and total organic carbon (TOC) via biochar adsorbent. Biochar was prepared from the pyrolysis of tea leaves at 700°C for 2 h under an inert atmosphere (N_2 gas). Each modeling method was composed of 3 inputs (pH, dosage, and adsorption time) and 2 outputs (COD and TOC removals). The highest removal efficiencies of 83.0% for COD and 98.3% for TOC were achieved at biochar dosage = 25 mg/L and pH = 10 within 35 min. The study demonstrated that the highest predictive accuracy was maintained by adaptive neuro-fuzzy interference (ANFIS), followed by artificial neural network (ANN) and response surface methodology (RSM).

Suditu et al. [15] investigated the application of artificial intelligence-related models to optimize and predict the color removal efficiency by adsorption onto activated carbon. The adsorbent material showed a decolorization efficiency of 39.92%, using the RSM method with optimum factors of bromocresol green color = 5.135 mg/L and adsorbent dosage = 1.58 g/L within 62.74 min. An ANN model with 2 hidden layers was employed to optimize the adsorption process, improving the decolorization performance to more than 99%.

Mostafa et al. [16] used the adsorption process to remove organic pollutants (expressed by biochemical oxygen demand; BOD) from wastewater. For this purpose, zero-valent iron nanoparticles were prepared and encapsulated into cellulose acetate, giving CA/nZVI adsorbent. The adsorbent material was characterized for surface morphology, elemental composition, and surface functional groups and used for BOD uptake. The highest BOD removal efficiency was 96.4% at initial concentration = 100 mg/L, 200 rpm agitation, and 3 g/L CA/nZVI dosage. The adsorption system should also be operated at a wastewater pH of around 7 within 30 min. Further, the factors affecting the adsorbent performance toward pollution reduction were optimized by quadratic regression model and ANN. The highest predictive performance (R^2: 0.972 and Adj-R^2: 0.971) was achieved by the ANN model using 10 neurons in the hidden layer and "trainlm" learning algorithm as a back-propagation training function. The proposed models also demonstrated that the highest influential factor was solution pH followed by adsorbent dosage.

We hope that this Special Issue can assist relevant academic and industry researchers in meeting the requirements of the Internet of Things (IoT) and the fourth industrial revolution for wastewater treatment by adsorption.

Conflicts of Interest

The guest editors declare that they have no conflicts of interest regarding the publication of this editorial.

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