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Perseverance Dzikunu, Emmanuel Kwesi Arthur, Emmanuel Gikunoo, Elike Bleppony, Frank Ofori Agyemang, Kwadwo Mensah-Darkwa. *Successive selective leaching procedures for valorization of spent pot lining carbon*. Pages 1-12.

Spent pot lining (SPL) is a hazardous by-product obtained during the decomposition of carbon cathodes in the electrolytic cells used in aluminium smelting. The carbon cathode lining materials degrade over time thereby affecting the performance of the electrolytic cell. Fluoride contents of up to 20 wt% and cyanides up to 1 wt% have been reported as the main environmental concerns in SPL. This study investigated the effect of successive selective leaching (SSL) of pollutants from the SPL in obtaining suitable carbon for use in energy storage applications. Compositional and microstructural analyses were performed on the leached and as-received SPL samples using X-ray fluorescence spectroscopy (XRF), transmission electronic microscopy – energy dispersive X-ray (TEM-EDX), scanning electron microscopy (SEM) and X-ray diffraction (XRD) techniques. In this study, the XRD analysis revealed that fluoride ions in the SPL exist as sodium fluoride (NaF) and calcium fluoride (CaF2). The results indicated that the SSL of SPL is dependent on pH, temperature, types of lixiviant used for the selective leaching and number of washings. It was established that increasing the number of washings with steady stirring rate reduced electrical conductivity and fluoride concentration in the filtrate. Furthermore, high ion removal was achieved at 100 ℃. The current study therefore demonstrated successful removal of pollutants such as CaF2, SiO2, NaF, Al2O3 and Na3Al11O17 while providing insight into the chemical structure and morphology of the treated and untreated SPL.

- **Keywords:** Spent pot lining carbon valorization; Ions removal; Successive selective leaching; And energy storage

Gang Zhou, Qi Wang, Shuailong Li, Qiming Huang, Zhen Liu. *Effect of a newly synthesized anionic Gemini surfactant composite fracturing system on the wettability of coking coal*. Pages 13-23.

To improve the wetting effect of the fracturing fluid on coal, a sulfonate Gemini surfactant (Gemini-3OH) was synthesized from nonyl phenol through a double ether and sulfonation reaction. It was mixed with an appropriate amount of cationic cellulose (JR400) to form a fracturing fluid composite system (Gemini-3OH/JR400). The optimum concentration ratio of the composite system was determined using a surface tension test. The mechanism of action of water, Gemini-3OH and Gemini-3OH/JR400 composite

system on the coal surface was analyzed by means of FTIR, XPS, industrial analysis, and SEM, along with microscopic observations, contact angle measurements, and molecular dynamics simulations. The results showed that Gemini-3OH/JR400 had a lower critical micelle concentration and surface tension, and had the greatest impact on the coal structure and functional group content. The contact angles of Gemini-3OH/JR400 at the moment of contact with coal and at 60 s were 33.12° and 19.76°, respectively. Finally, molecular dynamics simulations further verified that Gemini-3OH/JR400 had a better wetting effect on coal. This study provides a new concept for wetting coal bodies by water injection and fracturing in coal seams, and hence, can help in the prevention and control of mining accidents and disasters.

- **Keywords:** Coal seam water injection; Compound fracturing fluid; Anionic Gemini surfactant; Wettability; Coking coal

Abdul Waheed, Umair Baig. *Exploiting phase inversion for penta-amine impregnation of ultrafiltration support matrix for rapid fabrication of a hyper-cross-linked polyamide membrane for organic solvent nanofiltration*. Pages 24-33.

For the sake of recovery of precious organic solvents from industrial organic solvent waste stream or alternatively for recovery of active principle ingredient (API) synthesized in pharmaceutical companies, organic solvent nanofiltration (OSN) membranes have recently been emerged. A thin film composite (TFC) membrane was fabricated by using rapid membrane fabrication technique. The PA(TEPA-TCL)@PSU/PETP membrane was fabricated by penta-amine (TEPA) impregnation of polysulfone (PSU) matrix during phase inversion which in turn was reacted with terephthaloyl chloride (TCL) through interfacial polymerization (IP). The PA(TEPA-TCL)@PSU/PETP membrane was characterized by scanning electron microscopy (SEM), water contact angle (WCA), energy dispersive X-ray (EDX) analysis, ATR-FTIR and elemental mapping. The PA(TEPA-TCL)@PSU/PETP membrane was applied for OSN by using water, methanol, ethanol and isopropanol as solvents. When methanol was used as feed, it showed a permeate flux of 28 L m−2 h−1 (LMH) at 20 bar. An inverse relationship was found between viscosity and flux of the solvents. A feed composed of methanol and dyes (dyes were used as model pollutants) was used to evaluate the OSN performance of the membrane. Apparently, size exclusion mechanism was found to be responsible for rejection of dyes as EBT was rejected up to > 92 % and Congo red (CR; M.W. = 696.6 g mol−1) rejection reached > 96% while it stayed at ≈ 88 % for Methylene blue (MB; M.W. = 319.8 g mol−1). The UV-Visible analysis of feed and permeate was conducted which confirmed the rejection of CR and MB. Hence, the PA(TEPA-TCL)@PSU/PETP membrane was found to be efficient for the purification of organic solvents contaminated with organic dyes.

- **Keywords:** Polyamide membrane; Polysulfone support; Rapid fabrication; Organic solvent nanofiltration; Solvent viscosity

Haoran Leng, Zhiying Lv, Haili Tan, Yuhong Jia, Hong You. *Degradation of nitrobenzene in 3D stack Z-scheme photoelectrocatalytic system: Degradation condition, pathway analysis and synergistic mechanism*. Pages 34-47.

As a representative pollutant with carcinogenesis, mutagenicity and teratogenicity, nitrobenzene (NB) has devastating harm to human health. Herein, a unique three-dimensional (3D) stack Z-scheme photoelectrocatalytic (PEC) system was built by self-assembled different photoelectrodes for efficient NB removal. The effect of initial NB, bias potential, pH and electrolyte concentration on NB removal efficiency were investigated. The intermediates and oxygen-active radicals were determined and analyzed by high performance liquid chromatography (HPLC), gas chromatography-mass spectrometry

(GC-MS), density functional theory (DFT) and electron paramagnetic resonance (EPR) to propose the NB degradation pathways and mechanism. The results showed that holes were utilized to produce ·OH to oxidize NB on the photoanode surface, the electrons excited from photocathode could reduce NB under UV irradiation; thereafter, the reduction product (aniline) was oxidized to phenol to achieve mineralization by the synergistic effect of anode (oxidation) and cathode (reduction). 3D stack Z-scheme PEC system exhibited a high NB degradation efficiency of 98.18% after 90 min reaction and a mineralization efficiency of 75.08% at 150 min. With ECOSAR software, the system toxicity was speculated. This study has advantages in NB removal and provides direction for other refractory organics.

- **Keywords:** 3D stack Z-scheme PEC system; Nitrobenzene removal; Degradation pathway; Toxicity evaluation; Synergistic mechanism

Xiang Li, Yang Qin, Huajing Song, Wei Zou, Zhigguo Cao, Linjie Ding, Yuwei Pan, Minghua Zhou. *Efficient removal of bisphenol A by a novel biochar-based Fe/C granule via persulfate activation: Performance, mechanism, and toxicity assessment*. Pages 48-60.

Fe–C microelectrolysis is an efficient wastewater treatment technology for biorefractory pollutants. However, the poor stability and complicated separation mechanism of microelectrolytic materials hinder their application in advanced oxidation processes. Thus, herein, catalytic Fe–C microelectrolysis granules (FeBCGs) were prepared using Fe powder and sawdust and were used as persulfate (PS) activators for bisphenol A (BPA) removal. The effects of the calcination temperature, Fe/sawdust mass ratio, FeBCG concentration, PS concentration, initial pH, and initial BPA concentration were investigated. Under optimal conditions ([FeBCG]0 = 0.5 g/L, [PS]0 = 1 mM, without pH adjustment), the BPA removal efficiency reached 100% within 20 min. The FeBCGs presented numerous functional groups and a porous structure, which are beneficial for PS activation and BPA removal. The BPA degradation mechanism was elucidated via radical capture experiments, electron paramagnetic resonance spectroscopy, electrochemical analysis, density functional theory calculations, and high-performance liquid chromatography–mass spectrometry, which revealed that SO4•−, •OH, O2•−, 1O2, and electron transfer contributed to BPA removal. Additionally, the ecotoxicity of the intermediates was evaluated. The FeBCGs exhibited high stability and resistance to inorganic anions and natural organic matter. These findings may provide guidelines for the design and development of integrated microelectrolysis materials coupled with advanced oxidation processes for water treatment.

- **Keywords:** Biochar-based Fe/C; Persulfate activation; Removal mechanism; Theoretical calculation

Kárlia D.S. Amaral, Julio A. Navoni. *Desalination in rural communities of the Brazilian semi-arid region: Potential use of brackish concentrate in local productive activities*. Pages 61-70.

Desalination permits the use of brackish and saltwater for different activities. This work aimed to characterize the desalination systems of 31 rural communities in the Brazilian semi-arid region, evaluating the potential of using brackish waters. The physical-chemical characteristics of the groundwater and the concentrate were used to determine the quality indexes for irrigation and animal watering. Most (58 %) of the wells had chlorinated sodium water with corrosive tendencies. Among the parameters evaluated, conductivity, sulfate, and magnesium were more related to changes in water quality for animal watering. Chloride, sodium, and conductivity were the parameters that most distanced themselves from the recommended limits for irrigation. A high percentage of the well waters (51 %) and brackish waste (65 %) it's classified with a bad quality for

plant cultivation. Conversely, most of the groundwater (87 %), and the brackish waste (71 %), integrated the best quality classes (excellent and good) for animal production. Despite the high variability of the quality of brackish waters in the region, it is possible to use this resource, as well as the by-product of desalination, by applying adequate management and appropriate technologies.

- **Keywords:** Reverse osmosis; Wastewater reuse; Water quality; Agricultural

Sh. Deylami, M. Hosseini Sabzevari, M. Ghaedi, M.H. Ahmadi Azqhandi, F. Marahel. *Efficient photodegradation of disulfine blue dye and Tetracycline over Robust and Green g-CN/Ag3VO4/PAN nanofibers: Experimental design, RSM, RBF-NN and ANFIS modeling*. Pages 71-81.

The g-CN/Ag3VO4/PAN nanofibers (NFs) is prominent from various nanophotocatalysts (NPCs) due to their higher surface to volume ratio, mechanical strength and recyclable characteristics. In this study, g-CN/Ag3VO4/PAN NFs were obtained through in situ method by immobilizing Ag3VO4 on g-CN/PAN NFs. Compared to g-CN/PAN and Ag3VO4/PAN, the g-CN/Ag3VO4/PAN NFs revealed excellent photocatalytic performance toward disulfine blue dye (DB). Also, the g-CN/Ag3VO4/PAN NFs showed highly activity over some interference of inorganic cations/anions and excellent cycling stability. Furthermore, the batch experiments designed by central composite design (CCD) were employed for remove of tetracycline (TC). Afterward, response surface methodology (RSM), Radial basis function artificial neural network (RBF ANN) and an adaptive neuro-fuzzy inference system (ANFIS) have been used for modeling of photocatalyst dose, concentration of TC and irradiation time. Due to strong influence of pH on the photocatalytic degradation, the pH was optimized as one at a time variable. For all three models, the values of the statistical parameters were calculated. The obtained results reveal that the ANFIS models is more accurate to predict the degradation of TC. Furthermore, the effective factors were optimized by employing the Desirability function (DF) and genetic algorithm (GA) approach and then used for real water samples. At this optimum condition, the removal percentage was obtained ~97% by DF and GA approach, respectively. At the end, the LC-Mass method was employed to detect the intermediates of photodegradation of TC molecules.

- **Keywords:** Tetracycline; Disulfine blue dye; Nanofibers; Modelling; Optimization

Carmen Padilla-Rascón, Juan Miguel Romero-García, Inmaculada Romero, Encarnación Ruiz, Eulogio Castro. *Multicompound biorefinery based on combined acid/alkaline-oxidative treatment of olive stones*. Pages 82-92.

Olive stones (OS) constitute the main solid by-product of the olive oil industry, whose main application is direct burning. As an alternative, this work proposes an integrated multiproduct OS biorefinery, to produce furfural, lignin, antioxidants and sugars. A combination of pre-treatments, i.e. dilute acid pre-treatment followed by alkaline peroxide delignification, was assessed in order to improve on the previously limited results reported for the same raw materials. The operational conditions were optimised through experimental design and response surface methodology, to produce the highest recovery of sugars (xylose) from the liquid fraction plus glucose from the enzymatic hydrolysis (EH) of the pre-treated solids. This resulted in 70% and 41% recovery, respectively, while delignification yields reached 51% at 7% H2O2, increasing EH yields up to 70.3%. Phenolic compounds of potential interest were detected in the liquors, up to 25.3 mg gallic acid equivalent/g OS. Solubilised lignin was recovered by acid precipitation, with a yield of 76.3%, representing 11 g lignin/100 g OS, with a calorific value of 21,733 kJ/kg. 26.5 g/L of furfural was obtained from the xylose-rich hydrolysate

with a yield of 45.7%. Consequently, OS can be considered to be a promising raw material for a multiproduct biorefinery.

- **Keywords:** Olive stones; Xylose; Glucose; Alkaline peroxide treatment; Lignin; Furfural

Fadl A. Essa, Mohamed Abd Elaziz, Mohammed Azmi Al-Betar, Ammar H. Elsheikh. *Performance prediction of a reverse osmosis unit using an optimized Long Short-term Memory model by hummingbird optimizer*. Pages 93-106.

The accessibility to freshwater suitable for human use is a modern problem in many countries of the world. One of the well-known methods to overcome this problem is the reverse osmosis (RO). The performance of a reverse osmosis unit integrated to a recovery energy system was experimentally investigated under various operating system pressures (10, 15, 20, 25, 30, 35, 40, 45, 50, 55, and 60 bar) and recovery ratios (10%, 20%, 30%, 40%, and 50%). Moreover, a hybrid machine learning model composed of Long Short-term Memory (LSTM) neural network optimized by artificial hummingbirds' algorithm (AHA) was developed to predict permeate flow and power saving of the investigated RO unit. The inputs of the models, in case of power saving, were recovery ratio and system pressure; while system pressure was the input of the models in case of permeate flow. AHA was employed to optimize the performance of pure LSTM via determining the optimal values of the model parameters. A considerable enhancement in prediction accuracy of the optimized model was observed compared with pure model. The coefficient of determination during testing phase of power saving prediction was 0.997 and 0.981 for LSTM-AHA and LSTM, respectively. While it was 0.992 and 0.97 for LSTM-AHA and LSTM, respectively, in case of permeate flow prediction. Furthermore, the saving in consumed power of the RO unit was declined with increasing the recovery ratio. Therefore, the best saving in consumed power was obtained for the recovery ratio of 10%, where it reported more than 85%.

- **Keywords:** Reverse osmosis; Energy recovery system; Long Short-term Memory; Artificial hummingbirds algorithm

Bablu Alawa, Jitendra Choudhary, Sankar Chakma. *Discernment of synergism in co-pyrolysis of HDPE and PP waste plastics for production of pyro-oil: Mechanistic investigation with economic analysis and health risk assessment*. Pages 107-131.

Plastic waste is a major environmental challenge globally as it can hazard the soil, groundwater, marine, and land creatures. It also emits several toxic gases in open environment when heated up. The ceaseless demands for plastic materials due to wide applications generated a high volume of plastic waste which can impact sustainability development. The present study reports synergism in co-pyrolysis of mixed waste plastic for production of value-added products with economic analysis and health risk assessment. The characterization results of mass spectroscopy and NMR revealed that the product contains different types of hydrocarbons such as paraffins, aromatic, cyclic olefins, and lower hydrocarbons. The physicochemical characterization of pyro-oil showed similar fuel properties to that of commercial diesel (CD). Blending of pyro-oil obtained from HDPE:PP (20:80) improved the fuel quality that results in high brake thermal efficiency (BTE) and reduced brake-specific fuel consumption (BSFC). At the maximum load condition, ~19.17% and 29.43% enhancement in BTE were observed with 10% and 20% PO blending, respectively. Also, ~23.4% of fuel consumption was reduced when 20% PO blend was used with CD. The results showed that the maximum CO emission of 30.93% could be reduced by blending 10% PO. The engine performance and combustion characteristics revealed that PO blended fuels emit low percentage of CO, NOx, CO2, and

HC – which essentially suggest a better life style by minimizing the health risks via reduction in greenhouse gas emission that may cause cardiovascular collapse, seizures, coma, and sometimes death. Thus, the present study will help in valorization and mitigation of generated waste plastics through energy conservation and boost the circular economy. The economic analysis based on the present investigation showed that ~₹9.73 (0.12$) profit per litter can be achieved in the first year itself, while the profit in the 2nd and 5th year could be increased up to ₹54.43 (0.68$) and ₹67.73 (0.85$), respectively.

- **Keywords:** Pyrolysis; Alternative energy; Thermochemical conversion; Engine performance; Risk assessment

Alberto Maria Gambelli, Federico Rossi. *Re-definition of the region suitable for CO2/CH4 replacement into hydrates as a function of the thermodynamic difference between CO2 hydrate formation and dissociation*. Pages 132-141.

The replacement of methane with a theoretically equal quantity of carbon dioxide, probably represents the most promising solution for natural gas hydrate exploitation. However, the real efficiency is far from the ideal value. This article aims to focus the attention on the thermodynamic area considered suitable for replacement. Because the formation and dissociation of hydrates always show differences between each other and, in particular, the formation always requires more severe conditions to occur, the region effectively suitable for replacement is still more narrow than what currently believed and consists of the area between the dissociation curve of methane hydrates and the formation curve of CO2 hydrates. The present hypothesis was confirmed by carrying out the replacement process both above and below this latter curve. It was found that the methane recovery was more than one order of magnitude higher in the first case: 43.32 against 4.19 vol%.

- **Keywords:** CO2 capture; Natural gas hydrates; CO2/CH4 replacement; Phase equilibrium; Process efficiency

Yongkui Li, Suqin Li, Xin Zhao, Xiaodong Pan, Penghui Guo. *Separation and purification of high-purity quartz from high-silicon iron ore tailing: An innovative strategy for comprehensive utilization of tailings resources*. Pages 142-148.

High-silicon iron ore tailing is typically regarded as abundant mining waste of little use; it occupies a vast area of land and is harmful to human health and the ecological environment. Nevertheless, high-silicon iron ore tailing contains abundant quartz resource. In this study, a superconducting high gradient magnetic separation (S-HGMS) coupling fluorine-free mixed acid leaching technology was used to prepare high-purity quartz from high-silicon iron ore tailing. The S-HGMS technology was applied to separate and extract quartz from high-silicon iron ore tailing. Subsequently, the obtained quartz concentrate was subjected to an acid mixture leaching procedure to extract its impurities and obtain high-purity quartz. The optimal conditions determined for the magnetic separation process were a solid concentration of 4% and slurry flow velocity of 0.12 m/s. Under these conditions, the SiO2 grade of the quartz concentrate reached 98.56 ± 0.13%, and the SiO2 recovery was 60.59 ± 0.13%. The optimal conditions of the leaching process were a solid–liquid ratio of 1:4, leaching temperature of 80 °C, reaction time of 10 h, and acid mixture of HNO3, HCl, and H2SO4 (molarity ratio of 1:4:1). Under these conditions, the SiO2 purity reached a maximum value of 99.92 ± 0.01% in the high-purity quartz. Furthermore, we proposed a process for evaluating the recovery potential of Fe from iron-rich substances and recycling the leaching solution. The applied technology achieved a comprehensive utilization of high-

silicon iron ore tailing and no waste discharge, meanwhile provides a theoretical basis and data support for its industrialization.

- **Keywords:** Iron ore tailing; High-purity quartz; S-HGMS; Fluorine-free mixed acid leaching

Chen Yang, Xinxi Duan, Xiufeng Zhang, Sohrab Rohani, Hongli Wu, Minyu He, Yuxiang Gao, Qingcai Liu, Jian Yang, Ming Kong, Weizao Liu. *Acid-free extraction of manganese from pyrolusite tailings by in situ redox interaction with waste copperas*. Pages 149-158.

Pyrolusite tailings (PTs) is a solid waste discharged from the mining of high grade pyrolusite, and is also regraded as an important secondary resource of manganese. However, its extraction requires an expensive reductant used for the reduction of Mn(IV) to low valence. In this paper, an innovative process using in situ redox interaction of PTs with waste copperas (as reductant and sulfating agent) followed by water leaching for efficient manganese extraction was proposed. The in situ redox interaction mechanism was investigated systematically. At lower temperatures (< 500 °C), Fe(II) was the main reductant by direct solid-to-solid reaction. In the temperature range of 500–650 °C, the Mn(IV) in PTs was reduced to Mn(II) due to the synergistic effect of Fe(II) and SO2, and then Mn(II) was sulfated into water-soluble MnSO4. The reduction of Fe(III) into Fe(II) by SO2 occurred i.e. the Fe(II)⇌Fe(III) redox cycle. And the generated FeSO4 continued to react with PTs, indicating that the Fe(II)⇌Fe(III) redox cycle facilitated the extraction of manganese. Furthermore, high roasting temperatures caused MnSO4 to decompose into insoluble Mn2O3, inhibiting the extraction.

- **Keywords:** Pyrolusite tailings; Copperas; Redox interaction; Extraction; Manganese

Raphael Santana Almeida, Flávio Vasconcelos da Silva, Sávio S.V. Vianna. *Combining the bow-tie method and fuzzy logic using Mamdani inference model*. Pages 159-168.

As a hybrid tool, Bowtie might be effective as a qualitative tool. However, when the quantitative contribution is considered, it relies on databases, and as such, the analysis is affected by the subjective judgment of the specialist, data variability, or lack of data which may lead to vagueness and imprecise information. Fuzzy logic can help to shed light on this matter as it is capable of resembling human reasoning. The approach offers various mechanisms to overcome these uncertainties. This paper proposes a combination of Bowtie and fuzzy logic, using a case study concerning the rupture of isobutane storage tank. The Mamdani inference method is investigated. Additionally, the Fussel-Vasely equation was used to calculate the critical importance for each basic event, which brings a complementary understanding of the system. Six tests were performed to analyse the frequencies and fussel-vasely numbers of the five basic events: "PI" (Pressure Indicator), "LIAH" (Level and Indicator Alarm High), "HE" (Human Error), "SV" (SAFE VALVE) and "DS" (Disposal System). The analysis showed that the basic event "SV" as the most critical event, followed by "LIAH" and "Human Error".

- **Keywords:** Process safety; Bowtie technique; Fuzzy logic

A.S. Abdullah, Wissam H. Alawee, Suha A. Mohammed, Ali Majdi, Z.M. Omara, Fadl A. Essa. *Increasing the productivity of modified cords pyramid solar still using electric heater and various wick materials*. Pages 169-176.

One of the problems that the world is increasingly facing day by day is the problem of lack of potable water. Solar stills are one of the ideal solutions for places far from urbanization and unprepared civilly. The main aim of this present study is to investigate the effect of utilizing various burlap wicks of jute cloth, cotton cloth, plush cloth, and silk cloth on the performance of cords pyramidal solar still (CPSS). In addition, three electric heaters that derive their energy from a solar panel were used to raise the water temperature of pyramidal solar still basin to improve its productivity. The experimental tests were performed under the environment of Kafrelsheikh University, Egypt. Results revealed that CPSS had a total yield of 8000 mL/m².day compared to 3550 mL/m².day for PSS. So, the incremental improvement of CPSS yield was 125 % rather than that of the PSS. In addition, the highest values for the increase in productivity were for the distiller CPSS supplied with jute (125 %), then cotton (115 %), then plush (88 %), then silk (60 %), respectively. Also, the daily yields of CPSS with heaters and PSS were 10750 and 3650 mL/m².day, respectively with a productivity improvement of 195 %. Besides, the CPSS with jute wick and electric heaters had a thermal efficacy of 63.5 %. While, the CPSS with jute wick and electric heaters has an exergy efficiency of 6.1 %.

- **Keywords:** Pyramid solar still; Heater; Wick; Cotton wick; Jute cloth

Mojtaba Hedayati Marzbali, Ibrahim Gbolahan Hakeem, Kalpit Shah. *In-situ production of magnetic char via rapid subcritical hydrothermal carbonisation of paunch waste.* Pages 177-185.

The conventional hydrothermal carbonisation (HTC) is mainly tied to the high capital investment of the reactor and low product quality. In a novel approach, the rapid subcritical HTC of paunch waste (at 240 °C for only 5 min) was proposed to enhance the quality of products and their utilisation via in-situ production of magnetic hydrochar. Magnetite nanoparticles were found on the surface of hydrochar with size of 10–20 nm and crystal lattice spacing of 0.25 nm, XRD characteristic peaks of magnetite, and strong FTIR peak at 580 cm−1 assigned to Fe-O stretching in the crystalline lattice of magnetite. Magnetic hydrochar could adsorb Congo Red at a capacity of 59.9 mg g−1. An organic-rich process water with a high COD of 43 g L−1 was co-generated along with magnetic hydrochar and assumed to be anaerobically digested. The estimated theoretical methane yield was found sufficient to run the HTC plant in an energy-neutral mode. After developing a process model in Aspen plus, the discounted cash flow analysis revealed a net present value of US$13.04 MM for 30 years of operation, which can increase to $34.79 MM if the iron precursors are sourced from locally available iron-rich sludge.

- **Keywords:** Hydrothermal carbonisation; Magnetic hydrochar; Paunch waste; Sustainability; Techno-economic analysis

Xiaoliang Li, Heyun Yang, Hao Ma, HeGang Zhi, Dongfei Li, Xing Zheng. *Carbonaceous materials applied for cathode electro-Fenton technology on the emerging contaminants degradation*. Pages 186-198.

Emerging contaminants (ECs) are concerned worldwide due to their ubiquitous, persistence, high toxicity and low treatment efficiency in conventional processes. Meanwhile, the electro-Fenton (EF) technique has gained significant attention owing to its high efficiency and environmental compatibility for the degradation of ECs. Nevertheless, the EF process has suffered low Faraday efficiency, high cost and poor mass transfer, mainly in the low efficiency of Fe3+/Fe2+ cycle, insufficient capacity of oxygen reduction and limitation of low pH. The ways to improve EF efficiency include adding catalysts, optimizing electrode materials, and coupling other technologies. Among them, cathode material is the key factor affecting EF efficiency. In recent years, researchers have carried out a large number of related studies, among which carbonaceous materials (CMs) have become one of the most promising EF cathode materials due to their excellent performance advantages. Many works on the preparation and modification of

novel carbon materials have been paid attention to, but lacks a systematic review report summarizing carbon cathode in EF process. Aiming at this issue, this paper summarizes the modification of CMs to improve H2O2 electrogeneration, strengthen Fe3+/Fe2+ cycle efficiency, and broaden pH window, respectively. Besides, the development of biochar materials is summarized, and the existing shortcomings and future development directions in the field of cathode EF are briefly discussed.

- **Keywords:** electro-Fenton; Emerging contaminants; Carbonaceous cathode; H2O2 electrogeneration; Fe3+/Fe2+ cycle; pH window

Ruitong Lv, Jia Kang, Xing Fan, Jian Li. *Performance of integral polypropylene packing coated with polydimethylsiloxane in biotrickling filter for toluene elimination*. Pages 199-211.

Biotrickling filters (BTFs) for volatile organic compounds (VOCs) have attracted tremendous research attention in the field of environmental engineering. However, the problem of clogging occurred during the long-term operation limits their practical applications. To alleviate the clogging, an integral polypropylene (PP) packing coated with polydimethylsiloxane (PDMS) was prepared, and in combination with fungus, its performance was investigated for toluene elimination. Two laboratory-scale BTFs were started at low toluene concentrations of 200–900 mg·m−3. Subsequently, a series of experiments were conducted at toluene concentrations of 47–2906 mg·m−3, with empty bed residence time (EBRT) values of 50 and 40 s. Toluene removal efficiency reached 100 % at the inlet toluene concentration of 296–560 mg·m−3 for EBRT of 50 s. The maximum elimination capacity (EC) of 98 g·m−3·h−1 was obtained at an inlet toluene load of 117.67 g·m−3·h−1. Clogging was relieved by manual cleanup, and the BTFs were operated steadily for nearly 8 months. CO2 production was monitored during the whole operation, and toluene mineralization was evaluated simultaneously. Furthermore, the biofilm structure and microbial diversity were analyzed.

- **Keywords:** Integral packing; Polydimethylsiloxane; Clogging; Biotrickling filter; Mineralization

Mi Yan, Yayong Yang, Tianchi Shen, Nurak Grisdanurak, Agamuthu Pariatamby, Mohammad Khalid, Dwi Hantoko, Haryo Wibowo. *Effect of operating parameters on monomer production from depolymerization of waste polyethylene terephthalate in supercritical ethanol*. Pages 212-219.

Waste plastic presents a high risk for environment and ecosystem, and it is essential to recycle the discarded plastic. In this study, supercritical ethanol depolymerization (SCED) is used to recover monomer from waste polyethylene terephthalate (PET). The effect of reaction temperature (230–350 °C), reaction time (2–60 min), and liquid/solid (ethanol/waste PET) mass ratio (L/S ratio = 8:1, 10:1 and 12:1) on depolymerization of waste PET in supercritical ethanol (SCE) were investigated by experiments. The solid residue after depolymerization process was characterized by FTIR, TG-DSC, and SEM. It was found that the main components of liquid product include diethyl terephthalate (DET), and ethylene glycol (EG), etc. The optimum depolymerization efficiency (100%), DET yield (98%), and EG yield (89.8%) could be obtained from SCED of transparent waste PET at 310 °C, 60 min, and L/S ratio= 10:1. Such optimal condition was also applied for depolymerization of various waste PET. When recycled ethanol from preceding depolymerization was reused in subsequent depolymerization, the yield of DET and EG decreased by 6.0–7.5% and 3.5–4.0%, respectively. The potential reaction pathway of waste PET in SCE was also proposed. Generally, SCED is potential technology for monomer recovery from waste PET.

- **Keywords:** Waste PET; Supercritical ethanol; Depolymerization; Diethyl terephthalate; Ethylene glycol

E. Gholamian, A.S. Mehr, M. Yari, J.G. Carton. *Dynamic simulation and techno-economic assessment of hydrogen utilization in dual fuel (Hydrogen/biogas) micro gas turbine systems for a wastewater treatment plant*. Pages 220-237.

Due to the commitments of many governments, electrical power production from renewables hopefully continues to become widespread at a rapid rate to revolutionize energy infrastructures. Nevertheless, this green power seems to be wasted due to seasonal power swings, grid restrictions, and curtailment. The present research investigates the practicability of hydrogen injection into biogas from anaerobic digestion to generate electricity for a deployed wastewater treatment plant. A Polymer electrolyte membrane electrolyzer powered by Photovoltaic panels would produce hydrogen. An array of commercialized micro gas turbines has been suggested to create electrical power and thermal demand. Transient modeling was carried out using TRNSYS software to analyze the plant's performance from the thermodynamics and techno-economic perspectives. It is found that when biogas mass flow rate fluctuates, hydrogen could be effectively injected into biogas to fuel micro gas turbines. The results revealed that injecting hydrogen into biogas results in up to a 30% reduction in CO2 emissions, with two micro gas turbines producing more than 265 kW of electrical power at full load. LCOH and payback time would be 8.3 $/kg H2 and 6.5 years, respectively, for a hypothetical scenario in which electrolyzer size is anticipated to supply the maximum necessary hydrogen. Also the results indicate that electrical power and thermal energy of 70kWe-400kWe and 120kWth-500kWth could be reached annually, and the highest efficiency for the power generation, CHP, and the overall system becomes 37.5%, 83%, and 78%, respectively.

- **Keywords:** Biogas; Dynamic simulation; Hydrogen; Techno-economic; Micro gas turbine

Yuming Shou, Jinyue Chen, Xiaoxue Guo, Jiping Zhu, Long Ding, Jie Ji, Yifeng Cheng. *A dynamic individual risk management method considering spatial and temporal synergistic effect of toxic substance leakage and fire accidents*. Pages 238-251.

Actual chemical industrial park accidents usually involve multi-hazard accidents. Synergistic effect of accidents could lead to serious casualties. In order to reduce the individual risk of accidents, this work proposes a method for managing the dynamic individual risk when toxic substance leakage and fire accidents occur concurrently, in which spatial and temporal synergistic effect of above two accidents is considered. The synergistic effect may reduce individual escape ability, and is modeled by quantifying the relationship between escape ability and toxic substance dose. In addition, the method analyzes dynamic individual risk of a person receiving the thermal radiation dose and toxic substance dose when escaping along a certain route. The casualty degree is described by the injury degree based on dose thresholds and the total fatality probability based on Probit model. Combined with the accident scenario, the critical safety escape distance is obtained. The model is proposed to plan the individual escape route based on the risk assessment results. The critical values of toxic substance concentration and thermal radiation intensity are defined as the basis for planning alternative escape routes. Finally, the optimal escape route is obtained according to the total fatality probability of each route. The range of safe escape direction can be used when wind direction information is inaccurate. A case study demonstrates the effectiveness of the proposed method and risk management strategy.

- **Keywords:** Individual risk; Synergistic effect; Individual escape ability; Critical dose threshold; Critical safety escape distance; Optimal escape route

Alba Santamaría-Herrera, F. Javier Hoyuelos, Carlos Casado-Marcos. *Characterization of the explosiveness of wood dust*. Pages 252-259.

Factors that influence the explosiveness of wood dust, like particle size distribution, moisture content and microscopic structure, have been characterised. Sawdust flammability has been tested in a Hartmann tube. The Minimum Explosive Concentration and Minimum Ignition Temperature of dust clouds and layers have also been measured. Dust granulometry linked to the regularity of its structure and moisture are the essential parameters to generate or not an explosive atmosphere. Smaller particle size dust with a lower moisture content is much more likely to create an ignition and/or explosion risk. The samples have been classified into two groups, those collected from cutting processes and those found in the ventilation ducts or deposited in the facilities. The most dangerous samples are those from Group 2. In some cases, dust samples up to 35 % moisture or with particle size greater than 500 μm at maximum dryness are able to produce an explosion.

- **Keywords:** Explosion characteristics; Sawdust; Biomass dust; Explosive atmospheres; Minimum ignition temperature

Ruijie Hou, Yongxing Song, Jingting Liu, Linhua Zhang, Mingyang Zhang, Xun Sun. *Experimental and numerical investigation on the disinfection characteristics of a novel rotor-radial groove hydrodynamic cavitation reactor*. Pages 260-269.

Hydrodynamic cavitation was considered as a new efficient and green water treatment technology, which doesn't produce any disinfection by-products. In the present paper, the disinfection characteristics of a novel rotor-radial groove hydrodynamic cavitation reactor were evaluated. The effects of various rotor speeds, flow rates, and initial bacterial concentrations on the removal of Escherichia coli were analyzed on the basis of experimental research and numerical simulation. The possible mechanism of hydrodynamic cavitation disinfection was explained. 93.3% disinfection rate of Escherichia coli can be obtained at 3900 rpm and 2 m3/h in 20 min for 15 L water of simulated effluent. With the increase of flow rate, the disinfection effect of the reactor was improved based on the cavitation effect and the exposure time of bacteria in the bubble collapse area (passing times). The disinfection of Escherichia coliis based on the micro jet, shock wave, and shear stress generated by hydrodynamic cavitation. The findings of the present study can provide support for the application development of hydrodynamic cavitation disinfection and the theoretical development of rotational hydrodynamic cavitation reactors.

- **Keywords:** Water disinfection; Hydrodynamic cavitation reactor; Flow field; Disinfection mechanism; Computational fluid dynamics

Peizhen Chen, Weimin Cheng, Shaopeng Li. *Optimization strategies for mitigating nitrogen loss in the aerobic composting of pig manure and microbial changes revealed by metagenomic analysis*. Pages 270-284.

In this research, comprehensive optimization strategies for mitigating nitrogen loss in pig manure compost was screened out and nitrogen cycle microbial changes revealed by metagenomic technology. Results showed the optimum combination of process conditions as C/N ratio of 25, turning frequency of twice/day, addition of biochar and inoculation with nitrogen retaining microbial agent. The nitrogen loss rate of the optimized group was 14.67%, which was 45.33% significantly lower than that of the traditional group.

NH3, N2O, and NO emission significantly decreased by 42.74%, 48.93%, and 69.95%. Metagenomic analysis revealed that process optimization could change the microbial community, functional genes and metabolism pathways of the nitrogen cycling in the composting process. Nitrogen loss was mainly mitigated by increasing the enzyme activities in nitrogen assimilation (increased by 11.80%), nitrification (increased by 39.35%), and nitrogen fixation pathways (increased by 74.72%) and reducing the enzyme activities in denitrification pathways (decreased by 35.20%). The findings provided reference markers for further exploration of compost nitrogen loss. This comprehensive optimization strategies method for mitigating nitrogen loss was recommended in aerobic composting of pig manure.

- **Keywords:** Comprehensive optimization strategies; Nitrogen loss; Composting; Metagenomic

Zhi-Hao Wu, Yao Wu, Yan Tang, Jun-Cheng Jiang, An-Chi Huang. *Evaluation of composite flame-retardant electrolyte additives improvement on the safety performance of lithium-ion batteries*. Pages 285-292.

Safety requirements for lithium-ion batteries (LIBs) have become increasingly stringent with the rapid development of LIBs. We synthesize composite flame-retardant electrolyte additives (pentafluoroethoxy cyclotriphosphazene and dimethylacetamide) for LIBs to improve the safety performance of LIBs during use. The study tests the electrochemical performance of LIBs whose electrolytes contain the aforementioned additives using an electrochemical workstation and a LIB parameter tester. An experiment on self-extinguishing time is conducted to test the flame retardancy and ionic conductivity of the prepared composite flame-retardant electrolytes. Differential scanning calorimetry (DSC) and thermogravimetry are conducted to test the cathode materials of the LIBs after cycling at different heating rates. Various nonisothermal thermodynamic models are used to analyze the experimental DSC data, and the cathode materials' apparent activation energy and thermodynamic parameters are obtained. Finally, multivariate linear fitting is conducted to simulate the thermal decomposition reaction of the cathode materials.

- **Keywords:** Flame-retardant electrolyte; Pentafluoroethoxy cyclotriphosphazene; Dimethylacetamide; Electrochemical performance; Nonisothermal thermodynamic model

Fei-fei Liu, Yu-xue Zhang, Tong Lu. *Performance and mechanism of constructed wetland-microbial fuel cell systems in treating mariculture wastewater contaminated with antibiotics*. Pages 293-303.

Mariculture wastewater has raised great concerns owing to its potential impact on the sustainability of coastal environments and aquaculture practices. In this study, constructed wetlands coupled with microbial fuel cells (CW-MFCs) were constructed to evaluate their ability to treat mariculture wastewater that has been contaminated with antibiotic sulfadiazine (SDZ). The results showed that both open- and closed-circuit CW-MFCs (R1 and R2) had comparable removal efficiencies for NH4+-N, total inorganic nitrogen (TIN), chemical oxygen demand (COD), and total phosphorus (TP). Compared with R3, which had no SDZ, R2 was less efficient at removing NH4+-N and TP, and also presented inhibited electricity generation. R2 in closed-circuit mode was more efficient at removing SDZ than R1 in open-circuit mode. However, R2 also had a higher relative abundance of antibiotic resistance genes (ARGs) in the anode region and cathode effluent than R1, indicating that the closed-circuit CW-MFC system was inferior to the open-circuit system in controlling ARGs. High-throughput sequencing analysis suggested that the presence of SDZ and being in closed-circuit mode both increased the diversity of the microbial community, which in turn led to changes in the removal efficiency of SDZ and

the system's ability to generate electricity. The potential hosts of the three ARGs at the phylum level were mainly from Proteobacteria, Desulfobacterota, Patescibacteria, Firmicutes, Actinobacteriota, and Spirochaetota. Notably, some genera related to sulfur transformation in Desulfobacterota showed strong positive correlations with ARGs. This study is beneficial to expand the application of CW-MFCs in the treatment of antibiotic-contaminated mariculture wastewater.

- **Keywords:** Constructed wetland; Microbial fuel cell; Mariculture wastewater; Sulfadiazine; Antibiotic resistance genes

Hui Tao, Lingqin Zhou, Yiting Qi, Yiyang Chen, Zongshuo han, Tao Lin. *Variation of microplastics and biofilm community characteristics along the long-distance raw water pipeline*. Pages 304-312.

The massive accumulation of microplastics (MPs) in aquatic environments and water treatment plants and their potential threat to human health have attracted widespread attention. The water quality indices, occurrence characteristics of MPs, and changes in the pipe wall biofilm structure along long-distance raw water pipelines in Jiangsu were studied, and the key factors influencing the variation in microbial community structure were revealed. The results demonstrated that the types of MPs detected in long-distance raw water pipelines were mainly polypropylene (PP), polyethylene (PE), polystyrene (PS), polyethylene terephthalate (PET), and polyvinyl chloride (PVC). The total abundance of MPs decreased significantly with an increase in the conveying distance, from 1570.8 n·L−1 at water intake to 377.0 n·L−1 at the end of the pipeline network. Small-scale MPs were the most abundant, maintaining the highest concentration of 300–700 n·L−1. The decrease along the pipeline was more obvious for MPs with larger densities and particle sizes. Physical sedimentation and biosorption by extracellular polymeric substances may be the means by which MPs are removed. The diversity of bacterial communities in the pipe wall biofilms changed significantly along the pipeline, but the predominant bacterial groups at each sampling point were similar at different taxonomic levels. RDA showed that the effects of DOC (41.6 %), CODCr (33.5 %), and MPs abundance (30.1 %) were comprehensive and were the top three key factors affecting the variation in the biofilm community characteristics along the pipeline.

- **Keywords:** Long-distance raw water pipeline; Microplastics; Pipe wall biofilm; Bacterial community; Redundancy analysis

S.V. Alekseenko, A.A. Dekterev, L.I. Maltsev, V.A. Kuznetsov. *Implementation of a three-stage scheme for the co-combustion of pulverized coal and coal-water slurry in an industrial boiler to reduce NOx emissions*. Pages 313-327.

In this paper, the co-combustion process of coal-water slurry (CWS) and pulverized coal fuel (PCF) in E500 pilot boiler when using staged afterburning scheme, was investigated based on numerical simulation. A complex three-dimensional mathematical model and numerical methodology was used to describe the CWS and PCF co-combustion, as well as subprocesses in the combustion chamber. The proposed mathematical model was tested based on data obtained from a full-scale experiment. A good compliance was shown between the computational results and the experimental data. A detailed comparative analysis of the effect of changes in the design of a pilot boiler when using a three-stage combustion scheme and the flare-drip combustion technology for CWS on the physical-chemical processes in the combustion chamber and environmental indicators was carried out for the first time. The change of circulation zones depending on the method of coal fuel supply during three-stage combustion was investigated. Calculations have shown that the implementation of the proposed changes reduced the underburning of solid carbon from 1.9% to 0.51%. It was revealed that using CWS as a reducing agent

diminishes the amount of harmful NOx emissions by more than 40% compared to the basic version.

- **Keywords:** Pilot-industrial boiler; Pulverized coal; Stage combustion; Coal-water slurry; NOx reduction; CFD

Jinshan Zhao, Pu Yang, Yuye Lin, Xiaoyao Zhu, Jiaxin Wang, Xinyu Gan, Xiangyong Zheng, Min Zhao, Chunzhen Fan, Linna Du, Huanyi Miu. *The effect of underwater supplemental light on the growth of V.spinulosa Yan and the restoration process of water*. Pages 328-336.

Submerged plants are often used in the ecological restoration of polluted water, and they have good water purifying effect. In the process of water restoration, submerged plants are faced with insufficient light due to high turbidity or water depth. Therefore, we proposed a new model of artificial light assisted submerged plants to purify water nutrients. In this paper, we investigated the effects of locations and light intensities on the growth of V.spinulosa Yan and its water purification effect. The results showed that the light location of the underwater supplemental light was more important than the light intensity. The top supplemental light may provide an excellent environment for algae on the water surface. Excessive algae or epiphytic microorganisms might prevent the V.spinulosa Yan from obtaining light. When the PAR= 109 μmol m−2 s−1, V.spinulosa Yan had a higher biomass (145.39 dw/m2) than before (65.2 dw/m2). When the PAR > 280 μmol m−2 s−1, the clonal reproduction of V.spinulosa Yan was reduced. The main effect of supplemental underwater light on the water restoration process was enhancing the photosynthesis of V.spinulosa Yan by changing ETRmax and Fv/Fm of V.spinulosa Yan leaves. It significantly increased V.spinulosa Yan biomass and improved dissolved oxygen. Improvement of the water environment possibly altered the microbial environment and promoted the removal of water nutrients.

- **Keywords:** Underwater LED light; Growth of V.spinulosa Yan; Water restoration

Mahmoud Samy, Andy Gyamfi Kumi, Eslam Salama, Marwa ElKady, Kenneth Mensah, Hassan Shokry. *Heterogeneous activation of persulfate by a novel nano-magnetite/ZnO/activated carbon nanohybrid for carbofuran degradation: Toxicity assessment, water matrices, degradation mechanism and radical and non-radical pathways*. Pages 337-351.

We investigated for the first-time the fabrication of zinc oxide/water hyacinth-based activated carbon (ZnO/AC) and nano-magnetite (NM) (NM/ZnO/AC) nanohybrid for the utilization in photo-Fenton-like system. Response surface analysis showed that the optimal operating conditions for complete carbofuran degradation were pH 3, initial carbofuran concentration of 5.0 mg/L, PS concentration of 0.0923 mM and NM/ZnO/AC catalyst dose of 0.9 g/L. The degradation efficiencies declined to 46% and 28.8% after adding hydroxyl and sulfate radicals' quenchers, respectively compared to 92.8% in the case of no scavenger confirming the major role of sulfate and hydroxyl radicals. The degradation percentages of carbofuran were 100%, 95.7%, 51.8%, 67.8% and 21.6% for distilled, tap, sea, lake and drain water matrices showing the inhibitory effect of dissolved organic matter, turbidity and inorganic ions on the degradation performance. The degradation efficiencies and mineralization ratios of carbofuran in the case of suspended NM/ZnO/AC were higher than that of immobilized mode in five succeeding runs. The by-products generated after carbofuran degradation were primarily produced by cleavage and attack of reactive radicals. The efficient degradation of carbofuran, as well as the reduction of the toxicity of the generated intermediates affirmed the viability of using the synthesized composite for industrial effluents treatment.

- **Keywords:** Carbofuran; Metal leaching; Non-radical pathway; Operating parameters; Photo-Fenton; Photocatalysis

Mohsen Qarajehdaghi, Ali Mehrizad, Parvin Gharbani, Gholam Hossein Shahverdizadeh. *Quaternary composite of CdS/g-C3N4/rGO/CMC as a susceptible visible-light photocatalyst for effective abatement of ciprofloxacin: Optimization and modeling of the process by RSM and ANN*. Pages 352-362.

Ciprofloxacin (CIP) is an antibacterial agent extensively used to treat acute infections. This antibiotic is frequently excreted in an incompletely metabolized form and ultimately enters the environment through wastewater. This study aims to design and optimize an efficacious photocatalytic process to abate CIP from aqueous media. To this end, a novel carboxymethyl cellulose (CMC) based nanocomposite containing CdS, g-C3N4, and rGO (CdS/g-C3N4/rGO/CMC) was synthesized via a hydrothermal route and used as a visible-light-driven photocatalyst to degrade CIP. The photocatalytic process was designed and optimized through two effective approaches: response surface methodology (RSM) and artificial neural networks (ANNs). The removal efficiency of CIP and TOC achived 81.93% and 68.87%, respectively, under RSM-based optimal conditions (8 mg L−1 CIP, 0.6 g L−1 catalyst, at pH= 6.1 within 35 min). Based on the ANN analysis, the relative importance of process-influencing parameters was: catalyst dosage (34%), pH (30%), irradiation time (26%), and CIP initial concentration (10%). Evaluation of the process mechanism revealed that the principal active species in the photocatalytic degradation of CIP were hydroxyl radicals and holes. The kinetic studies demonstrated that the photocatalytic degradation of CIP through CdS/g-C3N4/rGO/CMC followed the pseudo-first-order model with a rate constant of 0.0469 min−1. Furthermore, the catalyst's reusability was confirmed under optimal conditions. Consequently, the synthesized nanobiocomposite could render a prominent photocatalytic activity to remove stubborn pollutants from wastewater.

- **Keywords:** Photocatalyst; CdS/g-C3N4/rGO/CMC; Ciprofloxacin; RSM; ANN

Zahra Hajimohammadi Tabriz, Leyla Khani, Mousa Mohammadpourfard, Gülden Gökçen Akkurt. *Biomass driven polygeneration systems: A review of recent progress and future prospects*. Pages 363-397.

Biomass is the most widely used renewable energy source which is highly appreciated due to its high availability and non-intermittent nature. Considering problems such as reduction of fossil fuels, global warming, and emission of greenhouse gases, lack of attention to the existing situation may cause irreversible damage to the future of the planet. In addition to using renewable energy sources, improving the efficiency of systems will also be helpful. Polygeneration systems play an important role in increasing efficiency and reducing pollution. So, the use of biomass in polygeneration systems seems to be a great approach for sustainable development. Recent studies on biomass-based polygeneration systems have focused on how to use biomass and integrate diverse subsystems to achieve the best performance from energy and exergy viewpoints. The present paper reviews biomass-based systems, and the parameters affecting the performance of these systems. The literature review shows that the high exergy destruction rate in the gasifiers is the most frequent problem among recent articles. In addition, despite the advantages of anaerobic digestion process, the number of studies conducted on the use of this method for biomass conversion is small. In the end, results, limitations, and future outlooks of these systems are discussed.

- **Keywords:** Biomass-based polygeneration system; Gasification; Anaerobic digestion; Thermodynamic analysis; Energy; Exergy

Peng Chi, Li Qingfeng, Fu Jianhong, Yang Yun, Zhang Xiaomin, Su Yu, Xu Zhaoyang, Zhong Chengxu, Wu Pengcheng. *An intelligent model for early kick detection based on cost-sensitive learning*. Pages 398-417.

Kick detection is crucial for ensuring process safety of drilling operation. Detection of a kick at early stage leaves more time for the drilling crew to take necessary actions. In this work, a novel intelligent model is proposed for early kick detection, which incorporates feature transformation, cost-sensitive dataset construction, and ensemble learning. It applies 7 wellhead feature parameters as input. The model is trained and tested with the field data of a shale gas reservoir in Sichuan. The model performances under different data dimensions and misclassification costs are evaluated. It is found that when the data dimension is 6 and the misclassification cost is 3, the model has the best classification ability (Total Cost=0.9, Accuracy=0.998, Recall=0.990, Precision=0.986). The low false alarm rate helps to minimize wastage of drilling time. The ablation experiment and the comparison with conventional sampling methods unanimously prove the superiority of the proposed model. Datasets with various sizes and imbalance ratios are tested and the model shows satisfactory accuracy. The formula of the optimal misclassification cost is derived for the instruction of field application. The early kick detection performance of the proposed model is better than the existed methods.

- **Keywords:** Drilling safety; Kick detection; Machine learning; Cost-sensitive learning; Generative adversarial networks

Yanli Fu, Ying Zhu, Hao Dong, Jing Li, Weiyi Zhang, Yingying Shao, Yanqiu Shao. *Effects of heavy metals and antibiotics on antibiotic resistance genes and microbial communities in soil*. Pages 418-427.

With rapid developments in livestock and poultry farming, antibiotics and heavy metals are entering the soil environment as feed additives. However, their relationships with antibiotic resistance genes (ARGs), microorganisms, and environmental factors are unclear. In this study, cadmium (Cd) and sulfadiazine (SD) were selected as representative heavy metal and antibiotic substances, respectively, to investigate the relationships among environmental factors, microorganisms, mobile genetic elements (MGEs), and ARGs. Addition of Cd and SD, both individually and in combination, increased the abundances of total ARGs and MGEs. The abundance of total ARGs increased by 0.89-fold and 1.06-fold in C2 and C8 (only-Cd-added groups), 1.61-fold and 6.53-fold in S10 and S100 (only-SD-added groups), and 7.29-fold, 7.62-fold, 2.32-fold, and 6.80-fold in C2S10, C2S100, C8S10, and C8S100 (groups with Cd and SD in combinations), respectively. Proteobacteria and Bacteroidetes were the most abundant bacterial phyla. MGEs (especially intI1) had the greatest impact on ARGs and played a crucial role in their propagation and expression. Exploring the effects of heavy metals and antibiotics in soil on ARGs is important for comprehensively assessing their ecological and environmental risks to ARGs.

- **Keywords:** Cadmium; Sulfadiazine; Antibiotic resistance genes; Microbial community

Keli Linghu, Qixin Wu, Jue Zhang, Zhuhong Wang, Jie Zeng, Shilin Gao. *Occurrence, distribution and ecological risk assessment of antibiotics in Nanming river: Contribution from wastewater treatment plant and implications of urban river syndrome*. Pages 428-436.

To study the occurrence and spatial distribution of antibiotics in the Nanming River in Guiyang, China, 27 water samples were collected. Twelve antibiotics were analyzed by solid phase extraction (SPE) combined with ultra-performance liquid chromatography-tandem mass spectrometry (UPLC-MS/MS), among which a total of eight antibiotics were

detected with a maximum frequency of 91.2%, indicating the prevalence of antibiotics in the study area. The total antibiotic concentrations ranged from 2.3 to 1097.4 ng/L and were dominated by fluoroquinolones according to wide spatial distribution. The least contaminated sites were located in suburbs, while the most severe contamination occurred in sites affected by urban areas. The spatial distribution is vulnerable to human activities such as wastewater treatment plants (WWTPs). The self-organizing map (SOM) atlas showed that antibiotics were mainly divided into three components: sulfonamides (SAs), tetracyclines (TCs), and fluoroquinolones (FQs), and the sampling sites were divided into four categories. Ofloxacin (OFX) was the dominant contributor to ecological risk with the risk quotient (RQ) > 1 at 23 sampling points. The good positive correlation between FQs and Na+/ (Na+ +Ca2+) implied that FQs could be used as a symbol of urban river syndrome. By combining traditional indicators and emerging pollutants (co-tracers), this study provides a more accurate representation of anthropogenic pollutants in urban rivers.

- **Keywords:** Antibiotic residues; Human activities; Urban River; Source apportionment; Risk evaluation

Siqi Zhong, Jing Pan, Ke Tian, Jingxi Qin, Taiping Qing, Junfeng Zhang. *Efficient degradation of p-chlorophenol by N,S-codoped biochar activated perxymonosulfate*. Pages 437-446.

The easy preparation of low-cost, highly active, and environment-friendly carbon-based catalysts for wastewater treatment remains a challenge. In this study, we fabricated a biochar codoped with nitrogen and sulfur (NS-BC) as a low-cost and efficient catalyst for peroxymonosulfate (PMS) activation and p-chlorophenol degradation. NS-BC was synthesized by the pyrolysis of sawdust with urea and sulfur powder serving as the nitrogen source and sulfur source, respectively. Due to the large surface area and high defect degree of NS-BC, its catalysis performance for PMS (Kobs=0.8104) was better than those of single-doped (Kobs=0.4177 and Kobs=0.3132) and undoped (Kobs=0.1265) biochar, and it can completely degrade p-chlorophenol within 5 min. The main active substances in the activation process of PMS were elucidated by free radical burst experiments and electron paramagnetic resonance analysis. Superoxide radical and singlet oxygen were the main active species of the system. These catalysts achieve rapid removal of a wide range of organic contaminants over a wide pH range. This work mainly emphasizes that the use of nonmetal-doped biochar to activate PMS to degrade p-chlorophenol, thereby avoiding the environmental harm of metal leaching during catalyst degradation.

- **Keywords:** Metal-free catalysts; Peroxymonosulfate; p-chlorophenol; N,S-codoped biochar; Active species

Filiz Uğur Nigiz, Betül Karakoca. *Pervaporative desalination using MIL 140 A loaded polylactic acid nanocomposite membrane*. Pages 447-457.

In this study, freestanding asymmetric MIL 140 A loaded polylactic acid (PLA)-based membranes were prepared and tested for pervapoative desalination. Membranes were characterized using different chemical and physical techniques. Desalination test was carried out with NaCl-water solution. The effects of MIL 140 A concentration (0, 1, 2, 3, 4 wt%), feed temperature (40, 50, 55, 60 ℃), NaCl concentration (2, 3, 4, 5, 6 wt%), and the downstream pressure (10, 15, 20, 25, 30 mbar) on the flux and the rejection were determined. As a result, MIL 140 A incorporation improved the hydrophilicity, durability, and the mechanical strength of PLA membrane. According to the results, a flux of 12.2 kg/m2.h with the rejection of 99.92 % was achieved by 3 wt % of MIL 140 A filled membrane at 60 ℃ with 10 mbar downstream pressure. A real sea water separation was also made with the 3 wt% of MIL 140 A loaded membrane and it was observed that the ion concentrations of the permeate were in drinking water standards. The prepared

membrane was tested more than 160 h and no flux and salt rejection decrease was observed except for experimental errors.

- **Keywords:** MIL 140 A synthesis; Pervaporative desalination; Polylactic acid

Matteo Pietraccini, Peter Badu, Theo Tait, Pierre-Alexandre Glaude, Anthony Dufour, Olivier Dufaud. *Study of flash pyrolysis and combustion of biomass powders using the Godbert-Greenwald furnace: An essential step to better understand organic dust explosions*. Pages 458-471.

An organic dust explosion is a heterogeneous system on a space and time scale. Predicting the parameters characteristic of its severity needs experimental and theoretical approaches to find the optimal compromise between consistency with reality and modelling time. A hybrid method is proposed to study flash pyrolysis and combustion of several organic powders (cellulose, wheat starch, oak wood, Douglas fir and olive pomace). A Godbert-Greenwald furnace was employed to perform the experiments to mimic the fundamental characteristics of a dust explosion: high particle heating rate, high reaction temperature and short residence times. At 973 K, the residence time is a critical parameter: the large particles of cellulosic compounds (wood, cellulose) do not reach their pyrolysis temperature and only fibres smaller than 20 or 30 μm are fully converted. As the particle size distribution of starch is smaller, heat transfer is not directly the limiting phenomenon but rather the strong tendency for powders to agglomerate during pyrolysis. At higher temperatures, secondary reactions of primary tars are evidenced, stressing the influence of the pyrolysis stage and leading to heterogeneous combustion. The composition of the pyrolysis gases as a function of the nature of the powder and the temperature was also determined. A lumped-kinetic model adapted to dust explosion was developed and validated for cellulose. The kinetics constants corresponding to levoglucosan to permanent gases and cellulose to char and water reactions are significantly different from those proposed by the literature, demonstrating that dust explosion kinetic parameters must be obtained under conditions consistent with such phenomenon.

- **Keywords:** Pyrolysis; Oxidation; Organic powder; Dust explosion

Yu-Chi Cheng, Sheng-Wei Liao, Mohammad Alauddin, Paul Amyotte, Chi-Min Shu. *Redefining of potential dust explosion risk parameters for additives in the petrochemical manufacturing process*. Pages 472-480.

Petrochemicals are an indispensable part of our everyday life, necessitating large-scale production facilities. Additive aids play a pivotal role in the petrochemical production process, which are required for the final product to have certain desired properties. The additives used are prone to ignition and combustion, but are frequently overlooked as a source of potential hazard. This study examines the hazard profile of five common powder additives in the petrochemical manufacturing process. The inherent combustion and explosion characteristics were investigated in detail. Each sample's potential to produce a dust explosion was evaluated based upon the parameter test results, e.g., minimum ignition energy (MIE), minimum ignition temperature (MIT), and minimum explosible concentration (MEC). MIT of all five samples was between 350 and 390 °C, and MEC was less than 45 g/m3. Two of the powders had a KSt explosion rating of "extremely strong" (St-3). After a comprehensive evaluation of dust explosion sensitivity and dust explosion severity, all five additive samples were categorised as high-level potential dust explosion risks. Process safety staff and engineers working with petrochemical production should be aware of the risks posed by dust additives and be prepared to implement more stringent loss prevention measures to curtail the likelihood of dust explosions.

- **Keywords:** Inherent combustion and explosion characteristics; Minimum ignition temperature; Minimum explosible concentration; Dust explosion sensitivity; Dust explosion severity

Abdulla Y. Ghjair, Ali H. Abbar. *Applications of advanced oxidation processes (Electro-Fenton and sono-electro-Fenton) for COD removal from hospital wastewater: Optimization using response surface methodology*. Pages 481-492.

This study investigates the feasibility of applying electro-Fenton (EF) and sono-electro-Fenton (SEF) processes for the removal of chemical oxygen demand (COD) from the hospital wastewater generated by the Al-Diwaniyah hospital located in Iraq. The effect of various operational parameters on COD removal was studied based on the response surface methodology (RSM). The optimal conditions for maximum removal of COD using EF were found to be a current density of 19.293 mA/cm2, an H2O2/COD ratio of 1.4, and a time duration of 46.67 min, in which 96.27% COD removal was obtained at a specific energy consumption rate of 7.325 kWh/kg COD. In the EF process, results showed that the H2O2/COD ratio has the most effect on COD removal, with a 61.76% contribution, followed by the current density, which contributed 22.78%. The suitability of the model equation was confirmed by its high R2 value (98.90%). For the SEF system, the best operating conditions were found to be a current density of 10 mA/cm2, an H2O2/COD ratio of 0.2, and a time duration of 46.67 min, in which 88.31% COD removal was obtained at a specific energy consumption of 2.082kWh/kg COD. Adopting the SEF process showed that the specific energy, H2O2, and iron consumptions are lowered by 1/3.5, 1/7, and 1/2, respectively, compared to those observed at the optimum conditions for maximizing EF alone. Results revealed a significant improvement in the EF system when combined with the ultrasonic (US) technique, wherein a considerable amount of COD removal with a final value of COD less than 100 ppm was observed at a lower cost in terms of energy consumption and the chemicals used, thus confirming the role of SEF for treating hospital wastewater using a more efficient and cost-effective approach.

- **Keywords:** COD removal; Electro-Fenton (EF); Sono-Electro-Fenton (SEF); RSM; Hospital wastewater

Wei Chen, Mingxiang Liu, Mingmei Ding, Lei Zhang, Shibao Dai. *Advanced thin-film composite polyamide membrane for precise trace short-chain PFAS sieving: Solution, environment and fouling effects*. Pages 493-503.

Membrane separation technology has been favorably applied to acquire non-polluting permeate in conditions of contaminative aqueous environment. However, some emerging contaminants with critical impacts on human health and environmental safety such as poly- and perfluoroalkyl (PFAS) compounds composed of various molecular chains are frequently found in water treatment process steps. Especially, short-chain PFASs remain poorly understood in nanofiltration membrane. A thin-film composite membrane with a hyaluronic acid interlayer (TFCi) had been finely tailored to simultaneously gain ameliorative permeate and rejection. Experiments were performed on a small-scale installation to investigate the correlation between operating parameters and short-chain PFASs removal performances. Results showed effectual trace short-chain PFASs rejection during various pressure, temperature, pH, concentration and fouling conditions. Alginate fouling micelles increased PFAS retention and generated a rapid flux decline; nevertheless, the pollutant could be largely removed by washing. Furthermore, molecular dynamics simulations were utilized to reveal the mechanism of the trace short-chain PFASs rejection competence. The hyaluronic acid interlayer was able to suppress the diffusion rate toward the reaction boundary, facilitating the formation of fast water transport pores with good rejection performance for PFAS in polyamides. These results

provide important insights into the mechanism of trace hydrophobic contaminants removal system and the interlayer design approach for efficient short-chain PFAS removal using nanofiltration membranes.

- **Keywords:** Thin-film composite; Perfluoroalkyl substances; Polyamide membrane; Nanofiltration; Membrane fouling

Zizhen Wang, Guanlin Chen, Rui Zhang, Weidong Zhou, Yitao Hu, Xunjie Zhao, Pan Wang. *Early monitoring of gas kick in deepwater drilling based on ensemble learning method: A case study at South China Sea*. Pages 504-514.

Gas kick monitoring is of great significance for prevention of blow-out accidents, especially in deep drilling and deep-water drilling. In this study, a machine learning (ML) model for early-monitoring of gas kick is developed using the ensemble learning algorithms based on 7363 lines of drilling logging data at South China Sea. The selected input parameters based on mechanism analysis of gas kick are six fast engineering parameters, including hook load (WHO), weight on bit (WOB), torque (TOR), flow rate (FLW), rate of penetration (ROP) and stand-pipe pressure (SPP), and two slow mud property parameters, i.e. electrical conductivity (CON) and mud outlet density (DEN). The model is constructed using RUSboosted, Subspace-KNN and Bagged Trees algorithms, and is compared with the neural network algorithm. We propose a comprehensive error to quantitatively evaluate the performance of the gas kick monitoring models. The models for early-monitoring of gas kick are applied for a single well and multiple wells, respectively. The results indicate that: (i) The optimal combination of input parameters is made up of six fast engineering parameters and two slow mud parameters. When there is a higher requirement on timeliness, only use of the six fast engineering parameters is also acceptable. (ii) The ensemble learning models work well when the input data expand from single well to multiple wells in the same block. For most cases, the prediction error of the optimal model is below 10%. The RUSboosted algorithm performed best in most data sets. (iii) Gas kick identification from lots of drilling logging records is mathematically a small-sample problem. The output labelling of a potential gas kick should be based on the field practical requirement. The recommended positive length of continuous-point labelling method is 5 m for the studied area, which can effectively reduce the average error from 8.02% to 5.48%.

- **Keywords:** Gas kick; Logging parameters; Ensemble learning; Comprehensive evaluation

Fang Gao, Lingyun Li, Yanwei Shi, Xiaofei Xue, Jianhua Mao, Linlin Xing, Xiaoyan Yao. *Interaction mechanisms of fouling and cleaning protocol for A/O-MBR treatment of coal-to-hydrogen wastewater*. Pages 515-525.

The anoxic/aerobic membrane bioreactor (A/O-MBR) was conducted to investigate pollutants removal in coal-to-hydrogen wastewater at the pilot experiment. Results showed that the system exhibited effective removal of chemical oxygen demand (~90%), ammonia nitrogen (>95%), and total phenols (>95%). Moreover, the Extended Derjaguin–Landau–Verwey–Overbeek (XDLVO) approach was used to predict the MBR system's membrane fouling and chemical cleaning mechanisms in the MBR system. The results indicated that the initial stage dominated membrane fouling by the acid-base (AB) interaction energy. With aggravated membrane fouling, the determinate role was the van der Waals (LW) interaction energy. Furthermore, the cleaning agent NaClO obtained the highest trans-membrane pressure recovery (104.7% of the virgin trans-membrane pressure) in CGW treatment, compared with HCl or NaOH cleaning. It was attributed to the higher LW interaction energy between foulants and the NaClO-cleaned membrane than those between foulants and the HCl-/NaOH-cleaned membrane. Meanwhile, it could

effectively restrain AB interaction energy decline between them. The findings of this study confirmed successful development of A/O-MBR for bio-refractory CGW treatment with NaClO chemically enhanced backwash. It also provided an in-depth understanding on the fouling and cleaning mechanisms of the MBR system.

- **Keywords:** Coal gasification wastewater; AO-MBR; Membrane fouling; Chemically enhanced backwash; XDLVO theory

Lanmei Zhao, Jian Liu, Long Meng, Dong Zhao, Bo Wang. *Different dissolved oxygen levels drive polyhydroxyalkanoate biosynthesis from hydrolyzed polyacrylamide-containing oil sludge*. Pages 526-533.

Hydrolyzed polyacrylamide (HPAM)-containing oil sludge is an available resource for the generation of polyhydroxyalkanoates (PHAs) by native functional microorganisms in the sludge. The impact of dissolved oxygen (DO) as an important factor on these processes is now unclear. Thus, this study established the biosystems involving the full range of DO levels involving anaerobic, anoxic and aerobic conditions by using HPAM-containing oil sludge as both substrates and microorganisms. PHAs, intermediate metabolites, extracellular polymeric substances (EPS) and microbial communities in these biosystems were determined. The associations between different PHAs and metabolites, and EPS, and functional microorganisms were explored. The PHAs produced in these biosystems included poly(3-hydroxyoctanoate-co-3-hydroxydecanoate-co-3-hydroxydodecanoate) (P(3HO-co-3HD-co-3HDD)), poly(3-hydroxydecanoate) (P(3HD)), poly(3-hydroxyoctanoate) (P(3HO)), poly(3-hydroxyvalerate) (P(3HV)) and poly(3-hydroxybutyrate) (P(3HB)). The yield of medium-chain-length (mcl)-PHAs first increased and then remained stable with DO level (0–3.5 mg·L−1). While the yield of short-chain-length (scl)-PHAs first rose and then descended and finally kept steady with DO level. Different PHA production was correlated with volatile fatty acid (VFA) generation, EPS formation and microbial function. The change trend of VFA yield was coincided with that of scl-PHA building blocks. Polysaccharides and tyrosine/tryptophan proteins in EPS were closely related to mcl-PHA biosynthesis. Pseudomonas, Bacillus, Thauera, Aeromonas and Azoarcus as the shared multifunctional bacteria dominated the biosynthesis of mcl- and scl-PHAs. Different DO levels regulated VFA generation, EPS formation and microbial function of HPAM-containing oil sludge, and consequently drove the biosynthesis of different PHAs. This study is expected to achieve a "win-win" for the environmentally friendly treatment and the resource recovery of HPAM-containing oil sludge.

- **Keywords:** Dissolved oxygen; Hydrolyzed polyacrylamide; Polyhydroxyalkanoates; Biosynthesis; Metabolites; Functional microorganisms

Fengjie Zhang, Wei Liu, Yueping Qin, Xiangyu Chu, Hao Xu, Fan Wu, Yahui Li. *Optimization of coalbed methane recovery from extraction borehole using novel plastic spraying material: A field application and evaluation*. Pages 534-546.

High-quality gas extraction is confronting enormous difficulties due to the leakage of air from the roadway through the coal wall into the extraction system, particularly in the boreholes along the coal seam. In this work, a new set of material and technology for coal wall spraying and sealing was developed to block the air leakage channel and enhance the concentration of extracted gas. The material has excellent air-tightness, resilience, and flame retardancy, and the feasibility of the implementation of the technology was demonstrated by the application in Hexi Coal Mine. The results showed that: the gas-extracted concentration was lower than 10% after 70 days under the conventional borehole sealing method. However, the new material and technology could increase gas-extracted concentration by 26.9~43.7% with a maximum increase multiple of 4.090 times. Moreover, the average gas-extracted concentration can be increased to

76.7% and maintain a relatively stable state for 80 days. This technology could not only reduce the air leakage, but also strengthen the internal and external pressure difference of the borehole, so that more gas can be extracted at a high concentration, which is expected to provide a reference for the gas disaster control and high-quality gas source guarantee.

- **Keywords:** Coalbed methane; Gas-extracted concentration; Air leakage; Coal wall; Spray sealing

Qi Tong, Thomas Gernay. *Resilience assessment of process industry facilities using dynamic Bayesian networks*. Pages 547-563.

Facilities in the process industry manufacture, store, and transfer hazardous materials which are explosive, flammable, and toxic. In industrial facilities, units are interdependent and closely located, which makes them vulnerable to cascading accidents. An undesired disruption to one unit might propagate to others, leading to more performance losses and more efforts to repair the damaged facility. For interdependent facilities which might require a lot of effort to rebuild, resilience assessments through quantifiable performance metrics can be used to consider adaptation and restoration during the post-disruption stage and thereby account for the impacts of disruptions on the performance of facilities during both pre-disruption and post-disruption stages. This study proposes a framework to measure the resilience of facilities vulnerable to cascading accidents in the process industry. Dynamic Bayesian network is applied to model the possible spatial and temporal evolution scenarios of cascading accidents. The uncertainties in evolution paths during the escalation of cascading accidents are considered. A case study of a storage tank farm is applied to illustrate the application of the framework. The effects of protection measures on the resilience to fire hazard are evaluated through cost-benefit analysis to determine the optimal protection strategy of the tank farm. A sensitivity analysis based on the case study is conducted to study the influence of critical parameters on resilience assessment.

- **Keywords:** Process industry; Resilience assessment; Dynamic bayesian network; Cascading accidents; Uncertainties; Cost-benefit analysis

Aref Shokri, Mahdi Sanavi Fard. *Techno-economic assessment of water desalination: Future outlooks and challenges*. Pages 564-578.

Over the last decade because of an outstanding technological advancement concerning desalination technology particularly in RO systems which gave rise to a significant reduction in the cost of desalinated water and ever-increasing water demand, desalination capacity has sharply escalated. Regardless of capital and operating costs, other factors like subsidies or local incentives might cause a significant variation in produced water costs between different areas and facilities. Most of the present cost calculation tools offer limited details and their usages are restricted to certain conditions. Site-specific costs associated with raw materials like transportation and tariffs, the local difference in energy costs, plant retrofit, or treatment are particular conditions that have contributed to higher produced water delivery costs. Hence, the precise estimation of ultimate water cost is extremely challenging as it is highly volatile. As a result, the presence of a highly translucent and well-established methodology to cost estimation will greatly assist in the selection of a suitable desalination technology for each site taking to account all cost-related crucial and affecting factors. The present paper takes into spotlight economic assessment and a thorough exploration of major influential factors which contributed to the total water cost using various desalination methods. To decrease complexity of precise cost estimation, a mathematical modeling to estimate the ultimate water cost of the RO system was proposed. Moreover, the authors propose several recommendations to demarcate future research pathways and minimize water final costs. The application of integrated systems using renewable energy sources, and

advancements in material and process design besides increasing unit capacity are current developments that caused a drastic decrease in both cost and energy consumption. The emergence of cutting-edge desalination technologies can have a marked effect on the calculation of cost differences in the future.

- **Keywords:** Cost assessment; Desalination cost; Desalinated water; Capital and investment cost

Ana A. Márquez, Oscar Coreño, José L. Nava. *Abatement of a complex mixture of dyes in the presence of chlorides by electrocoagulation and active chlorine-based photoelectro-Fenton-like processes*. Pages 579-591.

This paper presents an innovative hybrid water treatment process combining electrocoagulation (EC) and active chlorine-based PEF-like (PEF-like) methods to eliminate a complex mixture of tannery dyes. The solution contained Acid Blue 113 (AB 113), Acid Blue 29 (AB 29), and Brilliant Green (BG) dyes in concentrations between 300 and 750 mg L−1 COD in 2000 mg L−1 Cl−, 638 mg L−1 NH4+ and 1700 mg L−1 SO42− at neutral pH (resembling wastewater). The influence of mean linear flow velocity ($0.69 \leq u \leq 3.47$ cm s−1), applied current density ($6 \leq j \leq 22$ mA cm−2), and initial COD on the EC removal efficiency and discoloration was systematically examined. EC removed 32–48% COD; this modest depletion is due to the high load of organic matter. On the other hand, the •OH and HClO produced in the PEF-like process were insufficient to mineralize the organic matter (52–76%) due to the high initial COD. The latter suggested that the PEF-like process requires a previous EC to reduce the COD. The synergy between EC + PEF-like (hybrid process) allowed the COD abatement. The dye removal efficiency followed the order EC < PEF-like < EC + PEF-like. The hybrid process fulfilled the Mexican standard (COD < 210 mg L−1, and 100% discoloration) with total treatment costs of 0.683–0.696 USD m−3. XRF, XRD, SEM-EDS, OEA, and FTIR analyses on iron flocs indicated that AB 29, AB 113, and BG dyes are removed by adsorption. HPLC techniques followed the maleic and malic acids and ammonium and sulfate ions during the incineration of the dyes. The hybrid technology is promising for treating real wastewater containing complex dye mixtures.

- **Keywords:** Persistent organic pollutants; Active chlorine; Fenton-like reaction; Hydroxyl radicals; Water treatment

Guangzhong Yang, Caixia Xu, Liu Yang, Liuliu Wang, Li Guo. *Degradation of Orange IV by UV photolysis in nitrite-containing wastewater: Influencing factors, mechanism, and response surface methodology*. Pages 592-603.

In this study, we examined the ultraviolet (UV) light-induced degradation of Orange IV (O-IV) in an aqueous solution containing nitrite (NO2-). The observed pseudo-first-order rate constants of O-IV (kobs) degradation were assessed based on the effects of different influencing factors, including the initial concentration of O-IV, light intensity, temperature, pH, NO2- concentration, and inorganic anions. The results showed that O-IV was significantly removed with a kobs of 0.05268 min-1 in the UV/NO2- system. Quenching experiments and electron paramagnetic resonance (EPR) spectroscopy determined the possible active species in the UV/NO2- system, including hydroxyl radical (˙OH) and singlet oxygen (1O2). kobs decreased with an increase in the initial concentration of O-IV, possibly because the number of ˙OH produced by NO2- was not sufficient to remove all the dye molecules. kobs increased with an increase in light intensity and NO2- concentration, and the degradation of O-IV under acidic or alkaline conditions was inhibited. The most influential inorganic anions were carbonate ions (CO32-), which reacted with ˙OH and rendered photochemical reactions less efficient.

Additionally, a possible photodegradation mechanism of O-IV was proposed using liquid chromatography-mass spectrometry (LC-MS) analysis. Finally, the response surface methodology (RSM) was performed, the reaction parameters were optimized, the RSM model (R2 =0.9746) was constructed, and the optimal experimental conditions were obtained using the model with an NO2− concentration of 12.91 mmol/L, pH of 7, and light intensity of 32 W.

- **Keywords:** Nitrite; Ultraviolet; Hydroxyl radical; Influence factor; Response surface methodology

Wenhao Zhai, Liming Jia, Ran Zhao, Xiaomeng Chen, Yunxian Zhang, Zimin Wei. *Response characteristics of nitrous oxide related microorganisms to biochar addition during chicken manure composting*. Pages 604-608.

Composting process is accompanied by the emission of greenhouse gases such as nitrous oxide (N2O). Biochar addition effectively reduced the release of N2O. However, the specific impact mechanism of biochar is unclear. Therefore, the aim of this study was to reveal the response of N2O-related microorganisms to biochar addition during chicken manure composting. Results suggested that the addition of biochar reduced the species of N2O-related microorganisms from 22 to 19, and changed the functional roles. Network analysis further revealed that the addition of biochar weakened the transformation relationship between nitrification and denitrification, which effectively inhibited the denitrification rate. Ultimately, Structural equation models verified that the addition of biochar made core microorganism Ornithinibacillus prevail, which weakened the denitrification during composting. This study identified the core microorganisms that regulated the production of N2O during chicken manure composting, and provided a theoretical basis for the targeted regulation of N2O emission.

- **Keywords:** Nitrous oxide; Biochar; Composting; Core microorganisms

Dan Guo, Xinpan Luo, Lu Cai, Ngie Hing Wong, Jaka Sunarso, Nana Li. *Preparation of PVDF composite membrane reinforced by conductive knitted fabric*. Pages 609-618.

Polyvinylidene fluoride (PVDF) membrane prepared by nonsolvent-induced phase separation generally has low mechanical strength and is easily fouled. In this work, the PVDF membranes with enhanced mechanical strength, water flux, and significant electrical conductivity were prepared using conductive knitted fabrics with different stitch densities or construction types as the supporting matrix. The polyester fibers as the sheath yarn increased the peel strength between the composite layers to 3.4 N·cm−1. The interlock stitch fabric with a bending depth of 70 increased the composite membrane's high tensile strength to 12.7 MPa (i.e., 70.6 times higher than that of the original PVDF membrane). Compared to the PVDF membrane, this composite membrane exhibited a rejection rate of 76.1% and a water flux of 194.6 L·m−2·h−1 (i.e., enhanced 27.1 times). After 12-hour, 3 cycles of continuous filtration, the water flux of the composite membrane was reduced slightly by about 1.9%, which compared favorably to that of the PVDF membrane (i.e., reduced by 19.7%). Besides, the stainless-steel as the core yarn also gave the PVDF membrane good electrical conductivity (ρs = 272.7 Ω). This work highlights the potential of developing reinforced hydrophobic membranes using conductive knitted fabric to generate a robust filtration membrane for water treatment.

- **Keywords:** Knitted fabric; PVDF composite membrane; Surface resistance; Tensile strength

Xin Ding, Xiaochun Xiao, Jingzhi Cui, Di WU, Yishan Pan. *Damage evolution, fractal dimension and a new crushing energy formula for coal with bursting liability*. Pages 619-628.

The failure and instability process of surrounding rock in deep engineering is accompanied by energy accumulation and dissipation and results in damage and failure, which play an important role in the inoculation and occurrence of rockbursts. The bursting liability, energy transformation, and total damage evolution during the coal failure process were investigated using uniaxial compression tests. A damage evolution model and constitutive relation were developed in which the initial damage is considered, and the primary fissures of the specimens were also observed from their computed tomography images. Sieve analysis was used to determine the size distribution of the fragments, a crushing energy formula model was developed that is associated with the fractal dimension, which corrects the energy dissipation of coal in the total process of deformation and failure. The relationships among the crushing, surplus energy density, and fractal dimension of coal with different bursting liabilities were explored in detail.

- **Keywords:** Rockbursts; Coal failure; Bursting liability; Damage variable; Energy transformation; Fractal dimension

Kexin Lv, Hengcheng Wan, Qiang He, Yi Li. *Enhanced photocatalytic performance for water purification via oxygen-injected SnS2 nanosheets.* Pages 629-635.

The shortage of fresh water resources has become an unavoidable problem in social and economic development. It is desirable and urgent to deal with the increasingly serious environmental pollution based on sustainable energy. Herein, we developed oxygen-injected SnS2 (SnS2−xOx) nanosheets to acquire enhanced photocatalytic degradation performance on dye-containing wastewater. Mechanism studies proved that O atoms optimize the electronic structure of SnS2, which were further verified by density functional theory (DFT) calculation. As a result, SnS2−xOx nanosheets exhibited that the typical dye removal efficiency reached at ~93%, ~91% and ~85% toward RhB, GR and MB, respectively with worth stability. This work not only exploited a high degradation performance photocatalyst for water purification, but also lay a foundation for the atomic functionalization of photocatalysts.

- **Keywords:** Oxygen-atoms injection; SnS2 nanosheets; Photodegradation; Dye-containing wastewater; Electronic structure

Fatma Betül Özgeriş, Aslı Çilingir Yeltekin, Arzu Ucar, Özge Çağlar, Veysel Parlak, Mehmet Enes Arslan, Hasan Türkez, Muhammed Atamanalp, Gonca Alak. *Toxic releases and exposure assessment: A multi-endpoint approach in fish for ferrocene toxicity*. Pages 636-645.

Fe2+ in ferrocene facilities the oxidation. Based on this phenomenon, increased iron (Fe) level in freshwater ecosystems is thought as an important environmental problem in many geographic regions. In addition to increased mobilization of Fe from sediment due to changes in land use, mining, industrial activity, and elevated acid deposition are also proposed to be possible factors contributing to the increased Fe loading in freshwater environments. Ferrocene is useful in the modern organometallic chemistry industry due to its versatile applications. In this study, the toxicity potential and related toxicity mechanisms of acute ferrocene exposure as well as the protective potential of borax supplementation against ferrocene were investigated in rainbow trout during 96 h under semi-static conditions. In target tissues multiplexed endpoints of hematological indices, genotoxicity, oxidative stress response, DNA damage and apoptosis levels, as well as tumor necrosis factor alpha, and interleukin-6 activities were assessed in blood tissue. In

liver tissue, in addition to the parameters studied in blood tissue (except cortisol), the nuclear factor erythroid-2, which regulates the expression of detoxification enzymes, was investigated. When the results obtained from blood analyzes were examined, ferrocen treatment caused different reactions (increase/decrease) in blood indexes, and these findings were confirmed by MN tests. In ferrocene-induced hematoxicite, the healing effect of borax application has been observed to increase inhibited values and decrease in indexes with increasing tendencies. Besides, this hematoxicity was also supported by cortisol increases. Our findings showed that ferrocene inhibited antioxidant enzyme activities and increased lipid peroxidation, 8-OH-dG, caspase 3, TNF-α, and IL-6 levels in both blood and liver tissues. Similarly, cortisol level (in blood tissue) and Nrf-2 level (in liver tissue) increased with ferrocene application. In the ferrocen+borax group, the MDA level decreased 11 % at the end of the 96th hour compared to the 48th hour, and the Nrf2 level increased 9 %. In general, enzyme inhibitions in blood and liver tissues have shown that ferrocen-mediated toxicity occurs in induced ROS, DNA damage, apoptos activity, and BX applications have a positive effect on the correction of toxicity in the direction of hormesis. In a conclusion, the present study suggested that borax migt exhibite ameliorative potential against ferrocene-induced toxicity in O. mykiss blood and liver via regulating the ROS/TNF-α/Nrf-2 pathway.

- **Keywords:** Hepatotoxicity; Hematological index; Immune system; Fisheries; Food security; Nrf-2

Zhiying Chen, Zhixiang Liu, Linqi Huang, Guoqing Niu, Jingyi Yan, Jiajun Wang. *Research on the effect of ceiling centralized smoke exhaust system with air curtains on heat confinement and plug-holing phenomenon in tunnel fires*. Pages 646-659.

As tunnel fires can easily cause numerous casualties, this paper proposes a combination of ceiling centralized smoke exhaust and air curtain ventilation to study the temperature distribution characteristics and smoke control effects to assist passenger evacuation and firefighting. Dimensionless Froude number was introduced for a theoretical analysis and a series of CFD simulations. The plug-holing phenomenon in the coupling effect between air curtains and ceiling centralized smoke exhaust systems was investigated by changed the parameters of the heat release rate, the smoke exhaust rate, and the jet velocity of the air curtains. The results demonstrate a mutually reinforcing effect of the combined ceiling centralized smoke exhaust system and air curtains in terms of smoke control. The optimal distance between the ceiling exhaust port and the air curtains is 30 m. The blocked holes in the coupled system are mainly located at the downstream edge of the exhaust port, which directly reduces the smoke exhaust efficiency. The smoke exhaust efficiency is more affected by the smoke exhaust rate variation than by the air curtains velocity. A model was built to predict the smoke exhaust efficiency of the coupled system when the fire source power is 20 MW. We propose a new modified critical Fr number (3.69), which can be used to predict the phenomenon of smoke plug-holing in the coupled system. These results allow the design of a fire protection system for tunnel fires with a high barrier and high smoke exhaust effect, facilitating the safe escape of people and efficient fire rescue in the event of a fire.

- **Keywords:** Tunnel fires; Air curtain; Ceiling centralized smoke exhaust; Froude number; Plug-holing

Sebastián Campos, Javier Lorca, Jorge Vidal, Wendy Calzadilla, Carla Toledo-Neira, Mario Aranda, Sara Miralles-Cuevas, Alejandro Cabrera-Reina, Ricardo Salazar. *Removal of contaminants of emerging concern by solar photo electro-Fenton process in a solar electrochemical raceway pond reactor*. Pages 660-670.

This work proposes the degradation of different contaminants of emerging concern (CECs) present in a secondary effluent from a municipal wastewater treatment plant in a solar electrochemical raceway pond reactor (SEC-RPR), applying the solar photo electro-Fenton (SPFE) process. Tap water and a secondary effluent were enriched with 100 μg L−1 of 7 CECs to study the degradation of these compounds by the SPEF process in a SEC-RPR. Among the results obtained, an elimination over 96% and 90% of 5 CECs (progesterone, estradiol, ibuprofen, diclofenac and estrone) was achieved, while sulfamethazine and carbamazepine were eliminated by 73, 37% and 80, 66% after 1 h of treatment, respectively. In turn, a secondary effluent that already achieved the minimum organic load standards established by Chilean regulations was treated in a SEC-RPR by applying different electrochemical advanced oxidation processes (EAOPs). However, regardless of the applied treatment (SPEF, electro-Fenton and electro-oxidation/H2O2), it was possible to further reduce the organic content and even mineralize it. These experiments were performed at pH 3, with Na2SO4 0.05 mM, Fe2+ 0.05 mM and applying a current density of 20 mA cm−2. The SPEF process implemented in a SEC-RPR is presented as an excellent alternative for the treatment of municipal wastewater, due to the large contact area between the effluent and UV radiation, in addition to the continuous and homogeneous generation of H2O2, which allows for the production of hydroxyl radicals in solution, favoring the degradation and mineralization of pollutants.

- **Keywords:** Contaminants of emerging concern; Solar electrochemical raceway pond reactors; Solar photo electro-Fenton; Secondary effluent; Pharmaceutical compounds; Endocrine disruptors

Dongsheng Wang, Xinyu Gan, Zhiquan Wang, Shunfeng Jiang, Xiangyong Zheng, Min Zhao, Yonghua Zhang, Chunzhen Fan, Suqing Wu, Linna Du. *Research status on remediation of eutrophic water by submerged macrophytes: A review*. Pages 671-684.

The issue of eutrophication of water bodies has attracted worldwide attention. Ecological restoration is a promising method to prevent and control eutrophic water bodies. Submerged macrophytes are widely used in the restoration processes. It can not only provide abundant food and habitat for zooplankton, but also inhibit the growth of algae through allelopathy or nutrient competition. This article provides a comprehensive review on research status on the remediation of eutrophic water by submerged macrophytes, with emphasis on the main affecting factors for their growth, including nutrients, light, water depth, sediment, temperature, biochar, transparency, and water flow. The optimum growth conditions of submerged macrophytes are further analyzed to provide guide for further studies and rear applications on the remediation of eutrophic water by submerged macrophytes.

- **Keywords:** Submerged macrophytes; Growth; Influencing factors; Eutrophication; Remediation

Jonghun Lim, Yuchan Ahn, Junghwan Kim. *Optimal sorting and recycling of plastic waste as a renewable energy resource considering economic feasibility and environmental pollution*. Pages 685-696.

This work suggests an optimal strategy to sort and recycle plastic waste as a renewable energy resource with maximizing economic feasibility and mitigating environmental pollution. To derive the optimal sorting and recycling strategies of plastic waste, a novel optimization model is developed; it calculates the overall profit by subtracting the profit of recycling plastic from the total annualized cost. Then the model is used to identify the optimal strategy to sort and recycle plastic waste as a renewable energy resource in mixed-integer nonlinear programming that maximizes the overall profit. In the derived optimal sorting and recycling strategy, high-density polyethylene is recycled to produce downgrade plastic; low-density polyethylene, polypropylene, and polystyrene are recycled as pyrolysis oil; and polyethylene terephthalate is recycled to produce refuse plastic fuel. The derived optimal case can significantly increase the overall profit by about 3,137% (i.e., 35 US$/1 kg of recycled plastic), and 492% (i.e., 29 US$/1 kg of recycled plastic) compared to conventional case in South Korea and Japan respectively.

- **Keywords:** Plastic waste; Sorting; Recycling; Optimization

Yaoyao Cao, Hongmei Jin, Ning Zhu, Zhumeng Zhou. *High-efficiency fungistatic activity of vegetable waste-based humic acid related to the element composition and functional group structure*. Pages 697-705.

Vegetal foods are one of the most consumed commodities globally, accounting for more than 40 % of total food wastage. Hydrothermal conversion is an innovative transformation method towards effective utilization for vegetal waste to generate value-added products which are more eco-friendly and sustainable. In this study, the vegetable wastes of Chinese cabbage (C), broccoli (B) and sweet potato (S) were used to prepare humic acids (HAs) by hydrothermal conversion. The KOH concentration was the key factor affecting the preparation of HA. There was a significant difference in S element ($p < 0.05$), which followed the order of S-HA (1.48 %) > C-HA (0.57 %) > B-HA (0.43 %). The proportions of HAh, HAm, and HAl with molecular weights of > 100, 10–100, and < 10 kDa were 49.89–52.62 %, 23.70–27.92 %, and 18.75–21.13 %, respectively. HAs were rich in oxygen-containing functional groups such as CO, CC, and COOH. The fungistatic activities of Botrytis cinerea and Phytophthora capsici Leonian by S-HA were higher than those of other HAs. Through Mantel analysis and redundancy analysis, it was shown that element S and structure of aliphatic compounds had important effects on the fungistatic activity. In summary, hydrothermal conversion provided a new theory and technical guidance for the high-value utilization of vegetable waste.

- **Keywords:** Vegetable waste; Hydrothermal conversion; Humic acid; Physicochemical characteristics; Fungistatic activity

Rongkun Pan, Bang Cui, Xuebo Zhang, Yanming Wang, Ligang Zheng. *Study on pressure wave response and overpressure attenuation law of explosion-proof doors*. Pages 706-717.

In order to evaluate the pressure relief characteristics of the explosion-proof door, experiments were conducted in a self-built small size explosion-proof door experimental platform. The details of pressure changes in the pipeline were monitored in detail through four monitoring points set on the right end of the pipe, horizontal pipe, the main ventilation fan tunnel and below the explosion-proof door. The overpressure attenuation law at different positions and the effect of equivalent ratio on overpressure attenuation were studied when the explosion-proof door was normally opened for pressure relief and failed to open for pressure relief. The results showed that when the explosion-proof door

cannot be opened for pressure relief, the overpressure of the main ventilation fan tunnel and the explosion-proof door will increase dramatically. Compared with the normal pressure relief by opening the explosion-proof door, it increased by 130.69 % and 100.36 % respectively. Through the explosion-proof door pressure relief, the overpressure attenuation at the main ventilation fan tunnel and the explosion-proof door exhibited a linear. However, the overpressure attenuation at the main ventilation fan tunnel was the most obvious when the $\phi = 0.94$, and the overpressure attenuation at the position of the explosion-proof door was the most obvious when the $\phi = 1$. With the increase of ϕ, the time interval between two overpressure peaks at each monitoring point showed a downward trend, and the decreasing trend was more obvious at the main ventilation fan tunnel compared to other monitoring points. It was also noted that the trend of the time interval between the two overpressure peaks at the four monitoring points will gradually stabilize with the increase of the equivalence ratio. Additionally, the peak overpressure decline rate at the explosion-proof door position was always greater than that in the main ventilation fan tunnel. This indicates that the overpressure attenuation effect at the explosion-proof door is stronger than that at the main ventilation fan tunnel.

- **Keywords:** Explosion-proof door; Gas explosion; Peak overpressure; Pressure relief characteristics

Victor R. Moreira, Thais Girardi Carpanez, Natalie C. Magalhães, Yan F.X. Ladeira, Lisete C. Lange, Míriam C.S. Amaral. *Ultrafiltration as a pre-treatment technology to improve vinasse biomethanation*. Pages 718-724.

Vinasse is a residue that remains after the fractional distillation of fermented juice to obtain ethanol. Intended to extend the opportunities for by-product recovery, vinasse could be used as feedstock for biomethane production, departing from the linear focus of vinasse production, treatment, and disposal, to vinasse production and reuse. However, the high concentrations of sulfate and its inhibitory effect on biological activity could lower the yield of biomethane production. To overcome that, it was studied the potential of ultrafiltration membranes to alleviate the concentrations of sulfate from vinasse and concentrate the organic matter, intended to enhance the biomethane production potential. Raw vinasse, ultrafiltration concentrate, and ultrafiltration permeate were subjected to anaerobic digestion experiments and the cumulative biomethane yield was monitored over 70 days. The ultrafiltration concentrate presented the highest degradation rate (μm: 2.83 ± 0.24 mL/g-VS.d.mL-sample) and longest lag-phase time (λ: 12.31 ± 0.83 d) compared with raw sugarcane vinasse (μm: 1.44 ± 0.11 mL/g-VS.d.mL-sample; λ: 6.57 ± 0.93 d) and ultrafiltration permeate (μm: 1.14 ± 0.04 mL/g-VS.d.mL-sample; λ: 2.92 ± 0.74 d). The potential for biomethane recovery was complemented by an energetic analysis involved in biomethane production and processing. The biomethane recovery from ultrafiltration concentrate presented the lowest specific energy consumption (3.34 MJ/Nm³-CH4), followed by raw sugarcane vinasse (3.51 MJ/Nm³-CH4) and ultrafiltration permeate (3.64 MJ/Nm³-CH4). The remaining digested streams could still be potentially applied to soils for better use of their nutrients, however without an excessive load of organic matter already consumed during anaerobic digestion. Overall, the study demonstrated an effective alternative to salinity relief in raw sugarcane vinasse by ultrafiltration membranes and an alternative of higher vinasse valorization.

- **Keywords:** Anaerobic digestion; Biomethane; COD/SO42-; Wastewater valorization; Sugarcane molasse

Hanlu Xu, Hui Dong, Liang Zhao, Menghui Zhang, Daokuan Cheng. *Isoconversional kinetic analysis of the pyrolysis of Salt Lake industrial waste bischofite with isothermal reaction time predictions*. Pages 725-735.

Extracting magnesium resources from Salt Lakes industrial waste bischofite by pyrolysis technology has become a feasible waste utilization method. High-temperature corrosion has become a safety issue during bischofite pyrolysis. Thus, pyrolysis behavior and kinetic analysis are essential to control pyrolysis reactions. In this study, a thermogravimetric analyzer was used to understand the pyrolysis behavior of bischofite. TG-DTG curves show that the bischofite pyrolysis includes dehydration and coexistence stages. Thermal hazards caused by corrosive gases appear in the temperature range of 174.8–202.3 °C. The kinetic parameters were calculated using three model-free methods (FWO, KAS, and FR) and a master plots method. The results show that the activation energy of the dehydration stage is smaller than the coexistence stage. The reliability of the master plots method was also investigated. The results show that the reaction models for the dehydration (II-1, II-2, and II-3) and coexistence stages (IV-3) were credible. In addition, the isothermal method was used to predict the reaction time under different temperature programs. The results show that controlling the reaction temperature at 700–800 ℃ can improve the conversion efficiency and product quality. This work provides basic data for promoting the development of bischofite pyrolysis technology.

- **Keywords:** Bischofite; Thermogravimetric analyzer; Kinetic parameter; Isothermal method; Reaction time

Boqiang Lin, Yicheng Zhou. *How do economic growth targets affect energy consumption? The role of Chinese-style fiscal decentralization*. Pages 736-745.

The strategic formulation of economic growth targets (TAR) plays an essential role in economic development, but it may also affect energy consumption. Using China's provincial data from 2000 to 2018, this study empirically analyzes the impact of TAR on energy consumption. The results show that the local TAR significantly increases energy consumption, and this effect is significant in the eastern and midwestern regions, but there are differences in different development stages. Meanwhile, the unreasonable industrial structure and extensive urbanization mode are the important influencing mechanisms that TAR affects energy consumption. More importantly, Chinese-style fiscal decentralization is an important factor in explaining the relationship between TAR and energy consumption. As the degree of fiscal decentralization increases, the promotion effect of TAR on energy consumption becomes more obvious. In conclusion, the theoretical and empirical evidence of this study indicates that deepening the reform of government target-based management system is helpful to stimulate the motivation of local governments in energy conservation.

- **Keywords:** Economic growth targets; Energy consumption; Chinese-style fiscal decentralization; Influencing mechanisms

Jinjuan Xue, Meng Yuan, Jiamin Gao, Zewu Zhang, Mingxin Wang, Shuaishuai Ma. *Photo-Fenton catalyst Fe(III)@PCN-222 grafted on PVDF membrane for multitasking applications: Oil/water separation, aromatic pollutants degradation and bacterial inactivation*. Pages 746-756.

In this work, a novel PCN-222 metal−organic framework based multitasking membrane was developed for separation of emulsified oils as well as photo-Fenton degradation of refractory aromatic pollutants and inactivation of pathogenic bacteria in water.

Fe(III)@PCN-222 nanorods were prepared via impregnation method and subjected to amino-modification, and then robustly anchored on polydopamine (PDA) decorated PVDF membrane via catechol-amine reaction. The as-prepared N-Fe(III)@PCN-222/PDA/PVDF composite membrane exhibited underwater superoleophobicity, and showed high separation efficiency (above 99.4 %) as well as relatively favorable permeation flux (874.9–1592.3 Lm−2h−1) in the separation of emulsified oils ranged from nanoscale to microscale from water. Meanwhile, the membrane serving as a recyclable photo-Fenton platform showed an extensive degradation capacity towards aromatic contaminants and high inactivation activity against bacteria under visible light. The grafted Fe(III) is used as an electron acceptor to promote the separation of photo-generated charge carriers, adjusted the band structure to shorten the bandgap value, and can be reduced to Fe(II) by photo-generated electrons as a Fenton-like catalyst. The photo-Fenton mechanism was studied in detail from the aspects of photoelectric properties, band structure and reactive oxygen species. This work could promote the application of PCN subclass MOFs based superwetting membrane as a recyclable platform for complex wastewater treatment.

- **Keywords:** Superwetting membrane; Emulsion separation; Photo-Fenton; Degradation; Sterilization

Shan-shan Guo, Heng-bo Liu, Jia-li Li, Jin-yan Yang. *Migration characteristics of chromium and organic compounds released from waste leather fragments in soil under rainfall*. Pages 757-765.

The environmental issues caused by chrome-tanned leather could not be overlooked, and the high concentration of chromium (Cr) in the waste leather fragments was a major factor in limiting its resource utilization. Few studies have reported the contamination of soil and groundwater by discarded leather fragments. Soil column and static leaching experiments were conductive to exploring the release and transport of organic compounds and Cr from waste leather fragments with various types and sizes. The findings revealed that the 1 cm2-sized leather fragments of cowhide released more organic compounds into the leachate than the pigskin with same size, whereas leather fragments of the pigskin released more Cr than those of the cowhide, and this phenomenon was more prominent under rainfall condition at pH 4.68 than at pH 5.86. The Cr concentration increased at first and then decreased in the leachate, while the concentrations of soluble protein (SP), free amino acid (FAA), and total organic carbon (TOC) increased with the leaching event. After leaching, the concentrations of SP and FAA in each soil layer were nearly three times higher in the leather treatment groups than in the leather absent groups. Cr(III) was the primary species existed in the deep soil layer. The impact of leather fragment type and size on the release of Cr and organic compounds into soil was assessed, which helped to guide waste leather fragment reuse, landfill procedures, and impermeability measure design.

- **Keywords:** Leather fragment; Leaching; Soil column; Chromium; Organic compounds

Feifei Chen, Dan Wei, Lei Ni, Juncheng Jiang, Gang Fu. *A modified inherent thermal runaway hazard index (m-ITHI) for risk assessment of chemical processes based on cloud model*. Pages 766-775.

Microreactors have been applied in chemical processes to prevent thermal runaway. However, the assessment method comparing thermal runaway hazards of chemical processes in microreactors and stirred-tank reactors is hardly reported. Therefore, in order to evaluate and compare the comprehensive thermal runaway hazard of chemical processes using stirred-tank reactors and microreactors under the unified evaluation index system, a modified inherent thermal runaway hazard index (m-ITHI) was proposed. Damage radius (DR), which was a function of process inventory and reaction

heat, was introduced to characterize the thermal runaway severity of materials and reactions. Moreover, cloud model theory was applied to deal with the fuzziness and randomness of thermal runaway hazard indicators. The method was illustrated by processes in microreactors and stirred-tank reactors. Then, it was compared with Quantitative Index of Inherently Safer Design (QI2SD) and inherent thermal runaway hazard index (ITHI). Overall, m-ITHI can provide a way to compare thermal runaway hazard of chemical processes in different scale reactors.

- **Keywords:** Thermal runaway hazard assessment; Stirred-tank reactors; Microreactors; Cloud model theory

Vinitha Mariyappan, Naveen Karuppusamy, Tse-Wei Chen, Shen-Ming Chen, Joefranklin Jesuraj, Muthumariappan Akilarasan, Bih-Show Lou, Jaysan Yu. *Detection of flufenamic acid based on affordable inorganic SrFe2O4 nanorods decorated sulfur atoms substituted graphitic carbon nitride nanocomposite*. Pages 776-787.

Generally, the nanoparticle along with the nanosheet architecture has excellent physiochemical properties at the interface of electrode and electrolyte. In this work, the SrFe2O4 nanorod was prepared through the simple hydrothermal method, as well as the S-GCN prepared (urea + thiourea) by thermal polymerization, and using the solvent evaporation process SrFe2O4 nanorod was decorated on the S-GCN nanosheet, which is used for the electrochemical detection of flufenamic acid (FFA). The electrocatalytic activity of the bare GCE was enhanced by the SrFe2O4/S-GCN because SrFe2O4 has more active sides and S-GCN has a large surface area which is confirmed by the EIS and CV analysis. Moreover, the synergistic effect between SrFe2O4 nanorods and the S-GCN nanosheet provides the fast electron transfer property and enhanced electrocatalytic activity towards the FFA. Our proposed sensor exposed the lower level of the detection limit of 0.004 μM and the linear range of 0.01–384 μM with the LOQ of 0.015 μM. Furthermore, satisfactory recovery results were obtained while using the SrFe2O4/S-GCN modified electrode in the human urine and blood serum samples. Hence further development of our proposed SrFe2O4/S-GCN sensor will reduce the human health risk from FFA.

- **Keywords:** Non-steroidal anti-inflammation drugs; Flufenamic acid; Hydrothermal; Graphitic carbon nitride; Differential pulse voltammetry

Mehmet Ali Topçu, Aydın Rüşen. *Simple and selective copper recovery from valuable industrial waste by imidazolium based ionic liquids with BF4- anions*. Pages 788-796.

In this study, copper was recovered selectively with hydrometallurgical routes (leaching and cementation) from copper anode slime which is a valuable industrial waste. The use of 1-butyl-3-methylimidazolium tetrafluoroborate (BmimBF4) ionic liquid as a novel solvent has been systematically investigated. As a result of the leaching experiment, 98.4% of copper was leached at the optimum leaching conditions; ionic liquid concentration as 40%, temperature as 95 ºC, time as 12 h solid/liquid ratio as 1/25 g/mL and, addition of 20% HBF4 as an oxidant. Also, the experimental results revealed that the other elements in the copper anode slime were not soluble in BmimBF4/HBF4. Moreover, the copper was extracted from the leach solution as in metallic form with the cementation. The highest copper extraction rate was achieved as 93.3% at 45 ºC and 120 min using a scrap aluminum sheet. After all, 91.8% of copper was recovered from copper anode slime as metallic form by leaching and cementation processes in BmimBF4/HBF4. Also, it was found that the leach solution can be reused at least 5 times with low deviations.

- **Keywords:** Anode slime; Selective copper recovery; Cementation; Ionic liquids; Hydrometallurgy

Xiaogang Deng, Xuepeng Zhang, Xiaoyue Liu, Yuping Cao. *Incipient fault detection of nonlinear chemical processes based on probability-related randomized slow feature analysis*. Pages 797-807.

Slow feature analysis (SFA) has achieved the successful applications in the chemical process fault detection field. However, the basic SFA omits the process nonlinearity and lacks the sufficient mining of the features' probability information so that the incipient fault monitoring performance is unsatisfactory. To alleviate this problem, this paper proposes an improved SFA method, referred to as probability-related randomized SFA (PRSFA), to enhance the detection of incipient faults. Different from the current nonlinear SFA version based on the kernel function, which results in the huge computation complexity, the proposed method uses random Fourier mapping to deal with the data nonlinear transformation more efficiently. By combining the random Fourier mapping and SFA, a randomized SFA model is developed to capture the nonlinear slow features. Furthermore, in order to mine the probability distribution information hidden in these slow features, the Kullback Leibler divergence (KLD) is introduced to measure the changing of the slow features' probability distributions. The original nonlinear slow features are converted into the corresponding KLD features, which are more sensitive to the incipient faults. Considering the random property of KLD features resulted from the random Fourier mapping, multiple randomized SFA sub-models are developed and all the sub-models are integrated through Bayesian inference mechanism to construct the global statistics for the whole system monitoring. The simulation results on a continuous stirred tank reactor (CSTR) system show that the proposed method has better incipient fault detection performance than the traditional SFA and kernel SFA methods.

- **Keywords:** Slow feature analysis; Random Fourier mapping; Kullback Leibler divergence; Bayesian inference

Md Galal Uddin, Stephen Nash, Azizur Rahman, Agnieszka I. Olbert. *Performance analysis of the water quality index model for predicting water state using machine learning techniques*. Pages 808-828.

Existing water quality index (WQI) models assess water quality using a range of classification schemes. Consequently, different methods provide a number of interpretations for the same water properties that contribute to a considerable amount of uncertainty in the correct classification of water quality. The aims of this study were to evaluate the performance of the water quality index (WQI) model in order to classify coastal water quality correctly using a completely new classification scheme. Cork Harbour water quality data was used in this study, which was collected by Ireland's environmental protection agency (EPA). In the present study, four machine-learning classifier algorithms, including support vector machines (SVM), Naïve Bayes (NB), random forest (RF), k-nearest neighbour (KNN), and gradient boosting (XGBoost), were utilized to identify the best classifier for predicting water quality classes using widely used seven WQI models, whereas three models are completely new and recently proposed by the authors. The KNN (100% correct and 0% wrong) and XGBoost (99.9% correct and 0.1% wrong) algorithms were outperformed in predicting the water quality accurately for seven WQI models. The model validation results indicate that the XGBoost classifier outperformed, including accuracy (1.0), precision (0.99), sensitivity (0.99), specificity (1.0), and F1 (0.99) score, in order to predict the correct classification of water quality. Moreover, compared to WQI models, higher prediction accuracy, precision, sensitivity, specificity, and F1 score were found for the weighted quadratic mean (WQM) and unweighted root mean square (RMS) WQI models, respectively, for each class. The findings of this study showed that the WQM and RMS models could be effective and reliable for assessing coastal water quality in terms of correct classification. Therefore,

this study could be helpful in providing accurate water quality information to researchers, policymakers, and water research personnel for monitoring using the WQI model more effectively.

- **Keywords:** Water quality index; Coastal water quality classification; Model uncertainty; Classification algorithm; Cork Harbour

Hao Jin, Shihang Li, Shuda Hu, Jun Hou, Changgeng Gui, Liang Yuan, Fubao Zhou. *Effect of rolling point accounting for 33% on the filtration performance of fibrous filter media*. Pages 829-839.

This study investigates the effect of rolling points accounting for 33% on the filtration performance of filter media, hoping to provide guidances for the selection of filter media for industrial dust removal. The differences in filtration performance between filter media with and without rolling points were compared through experiments. The results show that the initial pressure drop and resistance coefficient of clean filter media with rolling points increase by 31.07% and 45.08%, respectively. And, the pressure drop of loaded filter media with rolling points and the specific resistance coefficient of the dust cake are improved, but the difference in filtration efficiency between the two filter media not exceed 5%. Compared with the rolling points area accounting for about 33% of the physical filtration area, the effective filtration area of filter media without rolling points is 39.52% larger on average. Compared with the filter media with rolling points, the average filtration efficiency of the filter media without rolling points decreased from 91.90% to 89.88%, but the average pressure drop decreased from 128.7 Pa to 85.1 Pa, and the quality factor increased from 0.01637 to 0.02161, an improvement of about 32.01%. In short, rolling points reduce the filtration performance of filter media, and filter media without rolling points have better filtration and energy consumption performance.

- **Keywords:** Filtration performance; Rolling point; Effective filtration area; Pressure drop; Filter media

HE Yinnan, QIN Ruxiang. *Autonomous rectification behavior of coal mine safety hazards under a gambling mind: From an evolutionary game perspective*. Pages 840-849.

Safety supervision is an important approach for urging coal mining enterprises to ensure safe production. However, in the face of safety supervision, different interests have a gambling mind for their own benefit, which leads to a loss of risk identification. Moreover, the literature on the analysis of coal mine safety supervision through game methods mainly focuses on how to improve the intensity of supervision. Additionally, research on evolutionary game analysis that considers a gambling mind and research that distinguishes between levels of supervisory intensity are lacking. Therefore, this paper takes the main stakeholders involved in the mine safety supervision, namely, the government supervision departments and the coal mining enterprises as research objects. An evolutionary game model is established. The gambling mind, supervisory intensity, joint liability and other factors are considered in the proposed model. Moreover, this paper also conducts a numerical simulation of the evolutionary game model to analyze the stability of stakeholder interactions and to propose methods for coal mine safety supervision procedures based on the analytical results. The simulation results show that improving the risk identification ability of coal mining enterprises is the key factor for urging coal mining enterprises to take the initiative to rectify safety hazards and avoid accidents. Increasing the frequency of supervision without increasing the penalties can also make the system stable in the optimal state for a long period of time. Increasing joint liability is not conducive to the game system maintaining stability, and has no impact on the supervisory efficiency of government supervision departments. The

research results hold great theoretical and practical significance for improving the safety and process management of coal mining enterprises.

- **Keywords:** Safety supervision; Evolutionary game theory; Coal mining enterprises; Safety hazards; Gambling mind

Zhenzhen Zhao, Yuntao Liang, Shuanglin Song, Jingyan Wang, Lei Liu, Jieqi Bai. *Study on flame propagation of H2/LPG premixed gas in a tube*. Pages 850-859.

This work aims to is to study the flame propagation characteristics of the hydrogen/liquefied petroleum gas (LPG) premixed gas in a closed tube. With the aid of a self-developed square glass explosion tube and a high-speed camera, the characteristic parameters (i.e., flame structure, flame tip speed, maximum explosion overpressure, maximum rate of explosion pressure rise, deflagration index) were obtained and analyzed the explosion characteristics of the premixed gas. The results show that the time for the flame to reach the end of the pipe decreased, and the maximum explosion overpressure increases as the hydrogen addition ratio increases. However, the explosion overpressure and flame propagation velocity increased slowly when the hydrogen addition ratio was less than 40%, While the explosion overpressure and flame propagation velocity increased drastically in the range of hydrogen addition ratio 40–80%. Therefore, the key turning point for LPG hydrogenation is when the hydrogen volume fraction is 40%. The peak explosion flame propagation velocity and the peak explosion pressure showed the change law of increasing first and then decreasing with the equivalent ratio increasing. The Pmax and Vmax are 6.4 bar and 71.2 m/s respectively. The explosive flame structure of the premixed gas formed a "multiple tulip" structure after the typical tulip flame structure due to the influence of hydrodynamic. In addition, the propagation law of H2-LPG-Air premixed flame in the pipeline was influenced by the interaction of pressure wave and flame front velocity, and Pmax trajectory and Vmax curve showed similar oscillation law. Hence, the study provides crucial data for the prevention and control of H2-LPG-Air gas mixture combustion and explosion accidents.

- **Keywords:** Liquefied petroleum gas; Hydrogenation ratio; Flame structure; Flame tip speed; Maximum explosion pressure

Sisi Ye, Miaoyuan Rao, Wenyan Xiao, Junyu Zhou, Ming Li. *The relative size of microalgal cells and microplastics determines the toxicity of microplastics to microalgae*. Pages 860-868.

Microplastics (MPs), as an emergent pollutant, are causing global attention in terms of water pollution, which poses a great detriment to aquatic organisms, like algae, fish and shellfish. This study aimed to investigate the toxicity of MPs of different particle sizes to microalgae with different cell diameters. Here, we conducted a microcosm batch experiment to investigate the toxicity of four particle sizes (0.2 μm, 0.5 μm, 1 μm and 5 μm) of polystyrene MPs (PS-MPs) to 12 species of microalgae. Our results found that PS-MPs of 0.5 and 1 μm had the highest inhibition rate on the microalgae. By classifying 12 species of microalgae into small, medium and large particles sizes, the inhibition of PS-MPs on algal growth gradually increased with larger cells, indicating that they were more susceptible to inhibition. The inhibition rate of PS-MPs on three phyla was Chlorophyta < Cyanobacteria < Bacillariophyta. The contents of reactive oxygen species and malondialdehyde in microalgae cells increased under PS-MPs exposure, suggesting that PS-MPs caused damage to the antioxidant system of microalgae. Together, these findings identified that the toxicity of MPs to microalgae was correlated with the relative size of each other, contributing to evaluate the risk of MPs for aquatic ecosystems.

- **Keywords:** Microplastics; Microalgae; Particle size; Antioxidant system; Inhibition rate

Linghua Chen, Jingfeng He, Lingtao Zhu, Qingyao Yao, Youbang Sun, Chengjing Guo, Hao Chen, Bin Yang. *Efficient recovery of valuable metals from waste printed circuit boards via ultrasound-enhanced flotation*. Pages 869-878.

Due to the environmental hazard of waste printed circuit boards (WPCBs), there is an urgent need to develop efficient recycling technology of useful metal elements in WPCBs and to promote the efficient use of WPCBs. Therefore, we tried to intensify the efficient recovery of metal elements from WPCBs by introducing ultrasound into the flotation process. Scanning electron microscope (SEM) observation and laser particle size analysis confirmed that ultrasonic treatment was conducive to removing the epoxy resin and fine metal particles on the surface of glass fibers and promoting particle dispersion, which significantly improved metal recovery. In addition, wettability analysis demonstrated that the enhanced hydrophobicity of the non-metallic components caused by ultrasonic treatment improved the flotation performance of non-metallic components, thereby strengthening the reverse flotation separation efficiency of the metal components and the non-metallic components. Consequently, compared with traditional flotation, ultrasonic-enhanced flotation promoted the significant increase of total metal recovery and Cu, Al and Zn recovery from WPCBs, in which the total metal recovery and Cu, Al and Zn recovery from WPCBs increased by 7.20%, 4.82%, 15.41% and 5.58%, respectively. Based on this, our findings will provide an important guide for efficiently recovering valuable metal elements from WPCBs.

- **Keywords:** Waste printed circuit boards; Ultrasonic-enhanced flotation; Process improvement; Metal recovery; Surface cleaning; Dispersion

Paulo Renato dos Santos, Maria Eduarda de Oliveira Dourados, Ignasi Sirés, Enric Brillas, Rodrigo Pereira Cavalcante, Priscila Sabioni Cavalheri, Paula Loureiro Paulo, Diego Roberto Vieira Guelfi, Silvio César de Oliveira, Fábio Gozzi, Amilcar Machulek Junior. *Greywater treatment by anodic oxidation, photoelectro-Fenton and solar photoelectro-Fenton processes: Influence of relevant parameters and toxicity evolution*. Pages 879-895.

In this study, the applicability of factorial design to the treatment of greywater (GW) containing dodecyl-benzene sulfonic acid (LAS) by electrochemical advanced oxidation processes (EAOPs) is demonstrated. At bench scale, anodic oxidation with electrogenerated H2O2 (AO-H2O2) and photoelectro Fenton (PEF) processes were studied following a 23 factorial design with central point insertion, using a first-order mathematical polynomial. In the former process, the combination of a boron-doped diamond (BDD) anode with a carbon-PTFE air-diffusion cathode, both of 3 cm2, yielded a 76% degradation of LAS at 40 mg L−1 along with 52% TOC removal under optimized conditions. The PEF process with 5 mg L−1 Fe2+ at current density of 77.5 mA cm−2 allowed attaining a 63% of LAS degradation and 78% of TOC abatement. The best conditions found for PEF according to the factorial design, in terms of Fe2+ concentration and current density, were applied for the treatment of 10 L of raw GW by solar PEF (SPEF) using a compound parabolic collector (CPC) as solar reactor and a filter-press electrochemical cell. A 70% of LAS removal and a 55% of GW mineralization were attained after 240 min of treatment. Artemia salina toxicity tests were performed with effluents resulting from the different methods under optimum conditions, and the SPEF process was proven to be the most effective and promising EAOP for the reduction of GW toxicity.

- **Keywords:** EAOP; Factorial design; LAS degradation; Toxicity; Wastewater treatment

Reza Shokoohi, Alireza Rahmani, Ghorban Asgari, Maysam Ashrafi, Esmaeil Ghahramani. *Removal of algae using hydrodynamic cavitation, ozonation and oxygen peroxide: Taguchi optimization (case study: Raw water of sanandaj water treatment plant)*. Pages 896-908.

Algal blooms can have both direct and indirect harmful impacts on water quality, resulting in changes in coloration, unpleasant taste and odor, turbidity, and During such blooms, algae cells may produce and release unpleasant algal metabolites such as taste and odor-causing compounds and cyanotoxins, which can have adverse impacts on water quality. The purpose of this study is to remove of dominant algae from water entering the water treatment plant of Sanandaj using Hydrodynamic Cavitation, Ozonation, and Hydrogen peroxide and process optimization using the Taguchi design method. Seven parameters that are effective in Algae Removal, including pH, retention time, Cavitation pressure, flow, The distance of the orifice plate from the beginning of the cavitation tube, Ozone concentration, and Hydrogen peroxide concentration, were selected as the major factors; Each factor has three levels. the optimal conditions for removal of Melosira and Oscillatoria are the Cavitation pressure: 5 bar, the Retention Time: 90 min, pH: 5, the Flow: 1 m3/s, The distance of the orifice plate: 25 cm, the Ozone rate: 3 gr/h, Hydrogen Peroxide: 2 gr/l. Based on the percentage portion of each factor, the Cavitation Pressure was introduced as the most effective factor in the removal of the Melosira and the Oscillatoria (38.16% and 35.76%, respectively). Hydrodynamic cavitation presents great potential to treat eutrophic water bodies due to the high efficiency shown in microalgae inactivation. Moreover, hydrodynamic cavitation represents a sustainable removal technique, since it does not produce secondary pollution.

- **Keywords:** Hydrodynamic cavitation; Algal Removal; Melosira; Oscillatoria; Taguchi

Hichem Tahraoui, Abd-Elmouneïm Belhadj, Zakaria Triki, Nihel Rayen Boudellal, Sarah Seder, Abdeltif Amrane, Jie Zhang, Nassim Moula, Amina Tifoura, Radhia Ferhat, Abla Bousselma, Nadia Mihoubi. *Mixed coagulant-flocculant optimization for pharmaceutical effluent pretreatment using response surface methodology and Gaussian process regression*. Pages 909-927.

Wastewater from the Antibiotical-Saidal pharmaceutical plant (Medéa) was pretreated by coagulation-flocculation using copper sulfate (CuSO4), iron chloride (FeCl3), and mixture of the two salts combined in a 1:1 (v/v) ratio in the present study. Response surface methodology (RSM) was used to optimize pH and coagulant dosage as independent variables, while dissolved organic carbon (DOC), absorbance at 254 nm (UV 254), and turbidity were provided as dependent variables in the central composite design (CCD). Then, the databases of the three treatments were combined in a single database to create a general model valid for the three treatments at the same time, and to predict the reduction rates of DOC, UV254, and turbidity, using the Gaussian process regression coupled with the dragonfly optimization algorithm (GPR-DA). To have the best model obtained between RMS and GPR-DA, an experimental validation was carried out after having had the optimal conditions of each type of coagulant, using the multi-objective optimization technique. The results of the experimental validation show the superiority of the GPR-DA model compared to the RSM model. Also, the results show that the mixed coagulant (CuSO4 + FeCl3) obtain better results than CuSO4 or FeCl3 alone with a treatment efficiency equal to 92.68% at pH = 5 and dosage = 600 mg/L, and the reductions in DOC, UV 254 and turbidity are 97.32%, 82.90% and 96.47%, respectively.

- **Keywords:** Pharmaceutical effluent; Coagulation-flocculation; Response surface methodology; Gaussian process regression; Multi-objective optimization

Runkai Zhang, Guanghui Xu, Baoqian Li, Zhanwu Wang, Jing Gao, Jin Li, Yufeng Sun, Guangyin Xu. *Analysis of the pollution emission system of large-scale combustion of biomass briquette fuel in China*. Pages 928-936.

In order to realize the sustainable development strategy and reduce the air pollution caused by biomass boiler emissions, the current study added a Selective Catalyst Reduction (SCR) external denitration system and a wet electrostatic precipitator to the original "three-stage" dust removal system for biomass briquetting fuel boiler emissions and completed the upgrading of the "five-stage" dust removal system. Taking the soot concentration, Sulfur dioxide (SO2) concentration, and Nitrogen oxides (NOX) concentration in the flue gas as the evaluation indicators, real-time online monitoring of the operating conditions of the system is carried out. The results show that the average concentration of smoke and dust in the flue gas discharged from the "five-stage" dust removal system is 3.47 mg/m3, with 2.49 mg/m3 for the average concentration of SO2, and 25.48 mg/m3 for the average concentration of NOX. The removal rates of soot, SO2, and NOX have increased by 5.8%, 4%, and 48.5%, respectively, which are much lower than the emission standards of biomass boiler flue gas pollutants. The innovation of this system is unprecedented for the large-scale combustion of biomass briquettes in China, which greatly reduces the emission of harmful gases. This upgrading will not only make a certain contribution to environmental protection but also provide a theoretical basis to the biomass briquette fuel industry.

- **Keywords:** "three-stage" dust removal system; "five-stage" dust removal system; Pollutant emissions

Yiming Bai, Jinsong Zhao. *A novel transformer-based multi-variable multi-step prediction method for chemical process fault prognosis*. Pages 937-947.

As the digitalization of process industry deepens, process fault detection and diagnosis (FDD) is an essential tool to ensure safe production in chemical industries. However, FDD may have a long detection delay for some chemical faults. Process fault prognosis methods could predict the occurrence of faults in advance, which would give operators more time and reduce the impact of faults. Nevertheless, many fault prognosis methods still suffer from fixed or insufficient prediction time ahead, which greatly confines their usage in critical scenarios. In this paper, we propose a novel Transformer-based multi-variable multi-step (TMM) prediction method for chemical process fault prognosis. Specifically, Transformer models are trained to predict the change of process variables at the next step, and iterative forecasting is used to predict multi-step changes of process variables. Finally, extensive evaluation of applications in a continuous stirred tank heater (CSTH) system and the Tennessee Eastman process (TEP) demonstrates that the proposed TMM prediction method shows high prediction accuracy and early fault prognosis, compared with representative statistical methods and other advanced deep learning methods.

- **Keywords:** Fault prognosis; Prediction method; Chemical process; Transformer; Multi-variable prediction; Multi-step prediction

Mohit Jain, Ashwani Kumar, Amit Kumar. *Landfill mining: A review on material recovery and its utilization challenges*. Pages 948-958.

Landfill mining (LFM) is excavating and processing legacy waste to recover secondary resources. This study reviews the technologies used for excavation and processing of the buried waste, fractions recovered from LFM, their characterization, and environmental and safety issues associated with LFM. The study first explains the process of literature selection by which publications were selected for inclusion in the manuscript. For waste excavation, the study compiles the technologies for excavation and material processing and the safety issues involved. The fractions obtained from LFM may be divided into four broad categories: (i) soil-like material, (ii) combustible fraction (including plastic, paper, wood, and textile), (iii) inert fraction (stone, glass, ceramic, and metal) and (iv) others consisting of the remaining fraction. For material recovery, the manuscript first summarizes the percentage of various fractions obtained, the cut-off diameter for soil-like fractions, and the effect of age on various fractions recovered. The lab analyses for determining the reusability of these fractions have been explained along with the instruments required. Afterwards, the environmental and safety issues associated with LFM have been discussed. Finally, the challenges and opportunities for reutilization of materials obtained from LFM have been elaborated upon.

- **Keywords:** Landfill mining; Material utilization; Resource recovery; Landfilled waste composition; Waste characterization

Chenxi Li, Gang Luo, Yan Liu. *Comparison of the ability of three advanced oxidation processes (AOPs) converting Cl− to active inorganic chlorine species (AICS)*. Pages 959-969.

Advanced oxidation processes (AOPs) during wastewater treatment oxidise Cl−to active inorganic chlorine species (AICS). AICS can react with organic compounds in wastewater to form toxic and hazardous chlorinated organic compounds, most of which are carcinogenic, teratogenic, and mutagenic. In this study, the abilities of three AOPs, i.e., electrochemical, ozone, and Fenton, to convert Cl− to AICS were compared. The results showed that at an initial Cl−concentration of 710 mg-Cl/L and a reaction time of 120 min, the conversion efficiencies of electrochemical, ozone, and Fenton processes were 74.1%, 21.0%, and 4.1%, respectively. The respective concentrations were 436.44 mg-Cl/L, 2.23 mg-Cl/L, and below detection limit for free chlorine; and 82.29 mg-Cl/L, 65.11 mg-Cl/L, and 6.30 mg-Cl/L for ClO3−. The abilities of the three AOPs to convert Cl−to AICS were in the order, electrochemical≫ ozone ≫ Fenton. In the present study, the potential reasons for the significant differences in theCl− oxidising ability of the AOPs were discussed. The effects of temperature and initial pH on the formation of free chlorine in the ozone and electrochemical processes were also investigated. These results are of great significance for the selection of AOPs for treating wastewater containing Cl− in practical applications.

- **Keywords:** Advanced oxidation; Active inorganic chlorine species; Cl−; Free chlorine; ClO2−; ClO3−

Siyu Zhang, Xiaoping Wen, Zhidong Guo, Sumei Zhang, Wentao Ji. *Experimental study on the multi-level suppression of N2 and CO2 on hydrogen-air explosion*. Pages 970-981.

The multi-level suppression of the hydrogen-air explosion by non-premixed N2 and CO2 in a closed duct was experimentally investigated. The multi-level suppression effect of inert gas on hydrogen-air explosion was discussed by comparing explosion parameters such as explosion pressure, the rate of pressure rise, combustion duration and flame propagation. The results showed that the inert gas adjacent to the explosion zone played

a major role in explosion suppression. Compared to single-level explosion suppression, the multi-level explosion suppression was not obvious for inhibitors on the same side, while the multi-level explosion suppression was most efficient for inhibitors on different sides. Moreover, the turbulent development of the flame would exacerbate the explosive reaction, which could not be avoided. The experiment in this paper had great practical significance, and the experimental results could provide data support and theoretical guidance for the safe utilization of hydrogen and the effective suppression of hydrogen-air explosion.

- **Keywords:** Multi-level suppression; Single-level suppression; N2 and CO2; Hydrogen-air explosion

Elham Abdollahi Saadatlu, Farnaz Barzinpour, Saeed Yaghoubi. *A sustainable municipal solid waste system under leachate treatment impact along with leakage control and source separation*. Pages 982-998.

Over the past few decades, inefficient waste management has caused environmental problems, such as leachate leakage, high pollution in the surface and groundwater, and soil contamination. In this regard, it is essential to adopt proper pre-discharge leachate management and treatment in the case of municipal waste. This study proposes a novel sustainable network design model by determining the optimal combination of transfer stations and separation units equipped with waste compaction and leachate treatment technologies, waste treatment facilities with different efficiencies, and optimal waste and leachate flow allocation along with waste separation at the source for municipal solid waste (MSW) systems. The uncertainty in the generated amount of waste is also considered in different urban areas. Therefore, a two-stage stochastic programming has been developed to minimize the total cost and the leachate pollution potential of MSW network systems, considering leachate types, collection and garbage-bin-cleaning truck types, and recyclable waste quality. Furthermore, the social objective is to maximize the number of job opportunities. The sample average approximation approach and the augmented ε-constraint method have been implemented to address the model uncertainty and solve the proposed multi-objective model, respectively. The results have indicated that considering the leachate treatment in the MSW network and waste separation at the source, despite increasing the total cost, has decreased leachate pollution potential by 41.3% and has created the number of job opportunities by 29.2% compared to the current situation in Tehran as a case study. Moreover, complete waste separation at the source in the proposed model has shown that it can have a positive effect on decreasing the total cost and leachate pollution potential.

- **Keywords:** Municipal solid waste; Sustainability; Leachate pollution potential; Source separation; Sample average approximation; Augmented ε-constraint method