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Qing Zhao, Chengjun Liu, Tianci Gao, Lei Gao, Henrik Saxén, Ron Zevenhoven. *Remediation of stainless steel slag with MnO for CO2 mineralization*. Pages 1-8.

Mineralization of CO2 using a Ca–rich metallurgical slag is known to be a promising approach to controlling CO2 emissions while converting slag by-products into valuable materials. However, untreated stainless steel slag (SSS) cannot straightforwardly be used for carbon capture and storage (CCS) or rather carbon capture and utilization (CCU) since there is a potential risk of toxic chromium release. For the dual goals of chromium immobilization and calcium recovery of SSS, four principal Ca–bearing phases of glass, dicalcium silicate, merwinite, and melilite were prepared and employed in order to investigate their decomposition behavior. Based on the experimental results, the morphology variations of the studied phases were revealed and the stability order was proposed as follow: glass > melilite > merwinite > dicalcium silicate. A MnO–based modification was conducted, and the effect of MnO content on the phase transformation and element distribution of SSS was investigated. Experimental results indicated that a proper increase of MnO content is beneficial for the calcium enrichment in target phases and chromium stabilization in a spinel phase. The structure and phases modification mechanism induced by added MnO is studied and reported in this work.

- **Keywords:** Carbon capture and storage; CO2 mineralization; Stainless steel slag; Chromium pollution; Hazardous waste remediation

J. Vijayeeswarri, M. Geethapriyai, V. Ramamurthy. *Community level defluoridation of groundwater with limestone derived adsorbent*. Pages 9-15.

Fluorosis is a worldwide, chronic degenerative disease caused by excessive level of fluoride in drinking water, mostly impacting rural, resource poor communities. Success of any technological solution to this problem, by reducing fluoride in water to safe level, is contingent on its feasibility to be implemented under resource limited circumstances for extended periods. Keeping these constraints in mind, we have developed a method to adsorb fluoride using surface modified limestone, using a simple and scalable process. The adsorbent was prepared using crystalline calcium carbonate, calcium chloride and monobasic sodium phosphate as the main ingredients. Surface and elemental analyses showed that fluoride constituted up to 3.8% of the surface of the saturated adsorbent. Kinetic data showed that the diffusional resistance was a rate limiting step to water defluoridation. Pilot scale operation of the process in a rural tenement with local help to

prepare the adsorbent and treat 700 l of groundwater each day for 4 months was demonstrated. During this period the average fluoride concentration of the feed water was 7.1 ppm, and was reduced to 1.0 ppm by the treatment. We also show that the saturated adsorbent could be regenerated by acid wash followed by surface modification.

- **Keywords:** Fluoride; Adsorption; Limestone; Surface modification; Pilot demonstration

Guisheng Qi, Huiyun Ren, Sunjia Zhang, Shaokai Wei, Weiwei Li, Weizhou Jiao, Youzhi Liu. *Dust removal performance in counter airflow shear rotating packed bed*. Pages 16-22.

A new type of rotating packed bed (RPB), counter airflow shear rotating packed bed (CAS-RPB), was proposed to solve the problem of increasingly serious air pollution. To meet the ultra-low emission (ULE) standard (the outlet particle concentration less than 5 mg Nm−3) in a cost-effective way, various operation conditions were conducted in the counter-rotating flow CAS-RPB and the co-rotating flow CAS-RPB, including high gravity factor (β), gas velocity (vg), ratio of liquid to gas (L/G), liquid surface tension (σ) and liquid viscosity (μ). Besides, empirical correlations for the outlet particle concentrations were also established both in the counter-rotating flow CAS-RPB and the co-rotating flow CAS-RPB. Moreover, the dust removal performance in CAS-RPB was also compared with other types of RPB at the similar operation conditions to further illustrate its superior performance. The promising results were indicated that the CAS-RPB, as a new technology for gas advanced purification, showed excellent performance in much lower outlet particle concentration.

- **Keywords:** CAS-RPB; Ultra-low emission; Total dust removal efficiency; Liquid property

Yunhao Li, Juncheng Jiang, Qingwu Zhang, Yuan Yu, Zhirong Wang, Haisen Liu, Chi-Min Shu. *Static and dynamic flame model effects on thermal buckling: Fixed-roof tanks adjacent to an ethanol pool-fire*. Pages 23-35.

Storage tank fires (such as pool-fires) often occur in the petrochemical tank farms. Flame pulsation is an important characteristic of the turbulent flames observed in pool-fires. Current cylindrical solid flame models inadequately predict the thermal radiation of pool-fires because of the ignorance of the flame pulsation effect. In this study, the thermal buckling behavior and fire resistance of a fixed-roof Q345 steel tank with a stepped thickness exposed to a neighboring ethanol pool-fire based on the flame pulsation model is numerically investigated. The influence of smoke generated by the combustion process which can reduce thermal radiation fluxes is taken into account. Geometric and material nonlinearity which considers nonlinear strain-displacement and stress-strain relation respectively is used on finite element analysis. Results show that the thermal buckling mode of the cylindrical tank wall is elastic buckling, and the thermal buckling behavior is non-linear. The fire resistance of the fixed-roof steel tank increases significantly as the vertical fire location increases, and the fire resistance decreases with the burning tank diameter increasing. Moreover, the fire resistance of the fixed-roof steel tank for a cylinder-cone combined flame based on the flame pulsation model is larger than that for a cylindrical flame. The study can be used to optimize the steel structure design of oil tanks for resisting pool-fires, and thus reduce the loss caused by fire accidents in tank farms.

- **Keywords:** Storage tank; Pool-fire; Thermal buckling; Fire resistance; Flame pulsation model

Yi-Ting Chiu, Haitao Wang, Jechan Lee, Kun-Yi Andrew Lin. *Reductive and adsorptive elimination of bromate from water using Ru/C, Pt/C and Pd/C in the absence of H2: A comparative study*. Pages 36-44.

Three typical catalysts of hydrogenation, Ru/C, Pt/C and Pd/C, are compared for the first time to eliminate bromate in water. As Ru/C, Pt/C and Pd/C are comprised of 5 wt% of metals and porous activated carbon, they exhibit similar morphologies and textural properties, as well as surface charges in water. Nevertheless, Ru/C seems more catalytic active than Pt/C and Pd/C based on temperature-programmed reduction analyses. When Ru/C, Pt/C and Pd/C are used to eliminate bromate in water, Ru/C successfully eliminates a large fraction of bromate ions present in water via its conversion to bromide and partial adsorption. Nevertheless, Pt/C and Pd/C are barely capable of eliminating bromate and converting it to bromide even at elevated temperatures. Regardless of catalyst species, the acidic conditions appears to be more favorable for bromate elimination, but alkaline conditions inhibit bromate elimination by the three catalysts. The presence of other existing anions certainly interferes with bromate elimination, especially, by Ru/C possibly due to the fact that the other existing anions were adsorbed onto the surface of catalyst. In addition, Ru/C, Pt/C and Pd/C are all reusable for bromate reduction; particularly used Ru/C could maintain > 70% of its original capacity for eliminating bromate. These comparisons reveal that Ru/C is certainly a more advantageous catalyst for eliminating bromate via reduction to bromate and adsorption. The findings of this study are valuable and important for developing control technologies of bromate in water.

- **Keywords:** Ru/C; Pt/C; Pd/C; Bromate; Bromide; Reduction

Ping Chang, Guang Xu, Fubao Zhou, Benjamin Mullins, S. Abishek. *Comparison of underground mine DPM simulation using discrete phase and continuous phase models*. Pages 45-55.

Diesel particulate matter (DPM) is carcinogenic to humans. DPM concentrations in underground mines are much higher than other working environments, thus pose substantial health threats to miners due to overexposure. Computational fluid dynamics is commonly used to study the DPM dispersion and assess the concentration distribution in various working environments. However, most such studies for underground mines treated DPM as a continuous phase (gas phase) in the model. DPM is a solid discrete phase, and its behaviours could be quite different from that of gaseous contaminants. This study compared DPM concentration distributions by using three modelling methods: the Eulerian-Lagrangian method and the Eulerian-Eulerian method that treats DPM as discrete phase particles, and the species transport method that treats DPM as a continuous phase gas. The model was based on a typical underground mine development face with a forcing auxiliary ventilation setup. It was found that the general DPM concentration distribution for the three numerical methods was similar for simple geometry with more uniform flow regions. However, large discrepancies existed in the development heading with complex geometry and flow features. The findings suggest that when simulating DPM, although the species transport method can provide relatively accurate results with much less computational time, the parameters of the modelled gas need to be carefully calibrated to get a better simulation result. For key areas where the diesel machinery and miners are usually located, the Eulerian-Lagrangian method should be used for more accurate analysis.

- **Keywords:** Diesel particulate matter; Computational fluid dynamics; Underground mines; Eulerian-Lagrangian method; Eulerian-Eulerian method; Species transport method

Baharak Ayoubi-Feiz, Mohsen Sheydaei, Mohammad Karimi. *Visible light photoelectrocatalysis for wastewater treatment using bifacial N-*

***TiO2/Graphene/Ho2O3/Titanium nanocomposite: Artificial neural network modeling and evaluation of ozone addition*. Pages 56-65.**

In this paper, N-TiO2/Graphene/Ho2O3/Titanium bifacial nanocomposite electrode was prepared. First, the effect of Ho2O3 to N-TiO2 wt.% in the nanocomposite preparation matrix was investigated through studying visible light photoelectrocatalysis process in industrial wastewater decolorization. Characterizations of optimum catalyst were performed using DRS, XRD, SEM and EDX analyses. Then, the effect of operating variables i.e. catalyst dosage (electrode number(s)), wastewater pH, applied bias potential, visible light power and contact time on the extent of wastewater decolorization was investigated by the visible light photoelectrocatalysis process. It was observed that almost 80% wastewater decolorization was achieved using the photoelectrocatalysis at the optimum conditions by N-TiO2/Graphene/(10%) Ho2O3. Artificial neural network was used for model the photoelectrocatalysis process and determine the relative importance of investigated operating variables. It was also established that combination of photoelectrocatalysis with ozonation yielded 100% decolorization in 90 min and 96% COD removal in 270 min under the optimized conditions. Moreover, the catalyst sheet was enough stable to be used in all wastewater treatment experiments.

- **Keywords:** TiO2 nanoparticles; Ho2O3; Visible light photoelectrocatalysis; Ozonation; Wastewater treatment; Artificial neural network

Ping Yu, Jie Cao, Veeriah Jegatheesan, Li Shu. *Activated sludge process faults diagnosis based on an improved particle filter algorithm*. Pages 66-72.

Maintaining the discharge standards of biologically-treated wastewater is essential in order to protect receiving water bodies from secondary pollution. If unexpected faults happen in an activated sludge process that is used as biological treatment, it would affect the quality of the receiving water body. Thus, in this paper, an improved particle filter (PF) algorithm, based on a variable frequency mutation (VFM) strategy is proposed for the process faults diagnosis. This is inspired by the frequency conversion for energy-saving application in the industrial process; an adaptive frequency conversion operator has been incorporated into the mutation operation of immune algorithm to reduce the system operating costs. Then, the resampling process of PF algorithm was replaced by particle mutation based on the previously calculated information for securing the diversity and the effectiveness of the particle; lastly, a VFM-based PF algorithm for system states estimation and fault diagnosis was established. This algorithm not only effectively increases the adaptability of the particle to changes of the system state, but also conductively solves the problems of the degeneracy in the traditional PF algorithm and the diversity weakening caused by resampling operation. Simulation results show that the algorithm can effectively improve the estimation accuracy of the nonlinear system states. The application results of faults diagnosis in the activated sludge process show that it can accurately diagnose the occurrence of faults. Therefore, the proposed method has great practical significance in wastewater treatment plants to avoid problems caused by unexpected faults.

- **Keywords:** Activated sludge process (ASP); Adaptive mutation; Faults diagnosis; Particle degeneracy; Particle filter (PF); Variable frequency conversion

Leila Rezig, Moncef Chouaibi, Wiem Meddeb, Kamel Msaada, Salem Hamdi. *Chemical composition and bioactive compounds of Cucurbitaceae seeds: Potential sources for new trends of plant oils*. Pages 73-81.

Studies were conducted on the chemical composition of 'Essahli' pumpkin seeds, 'Ananas' melon seeds and 'Crimson' watermelon seeds varieties. 'Essahli' pumpkin seeds were

found to contain the highest oil (35.53 ± 4.26%) and protein contents (40.00 ± 3.84%). Furthermore, the 'Crimson' watermelon seeds witnessed the highest fiber content (48.26 ± 5.26%). The chemical composition of cold pressed seed oils was investigated. Linoleic acid (C18:2) was the main fatty acid in the seed oil fractions, followed by oleic (C18:1), palmitic (C16:0) and stearic acids (C18:0). Melon seed oil presented considerable amounts of phytosterols in which sitosterol was the major sterol accounting for 3248.48 mg/kg oil and exhibited both highest oxidative stability (3.8 ± 0.41 h) and antioxidant activity (IC50 = 52.55 ± 5.08 μg/g). The chromatographic analysis of phenolic compounds showed that phenolic acids were the most important group in the melon seed oil with predominance of ferulic acid (134.83 μg/g). The obtained results revealed that Cucurbitaceae seeds presented an alternative source of plant oil, which may serve as raw material for food applications.

- **Keywords:** Cucurbitaceae seeds; Cold pressed seeds; Seed oils; Fatty acids; Sterols; Phenoliccompounds

Visva Bharati Barua, Ajay S. Kalamdhad. *Biogas production from water hyacinth in a novel anaerobic digester: A continuous study*. Pages 82-89.

Mixing and the separation of stages in a digester during anaerobic digestion demonstrate enhanced biodegradation efficiency of the feedstock. But two stage anaerobic digesters are difficult to operate and require huge space. Also, continuous high intensity mixing minimises biogas production. Based on these criteria, a novel type of two stage anaerobic digester was designed. The aim of this study was to evaluate the performance of this novel anaerobic digester in continuous mode utilising water hyacinth as the feedstock. Initially, untreated water hyacinth whole plant was fed in the digester followed by hot air oven pretreated water hyacinth and water hyacinth co-digested with food waste. The optimal OLR for untreated and pretreated water hyacinth was observed to be 3.75 kg COD/m3.d whereas for co-digested water hyacinth the optimal OLR was 6.7 kg COD/m3.d; illustrating an average COD removal of 72.5%, 82% and 77% for untreated, pretreated and co-digested water hyacinth respectively.

- **Keywords:** Water hyacinth; Mixing; Two stage; Novel anaerobic digester; Continuous anaerobic digestion; Biogas

Ahmed M.D. Al Ketife, F. Almomani, Muftah EL-Naas, Simon Judd. *A technoeconomic assessment of microalgal culture technology implementation for combined wastewater treatment and CO2 mitigation in the Arabian Gulf*. Pages 90-102.

A technoeconomic assessment (TEA) has been conducted of the feasibility of large-scale application of microalgal culture technology (MCT) to the combined mitigation of CO2 emissions from flue gases and nutrient discharges from wastewater in the Arabian Gulf. The assessment has incorporated the selection of the algal species and MCT technologies, the extent of nutrient removal, and the biomass/biofuel production rate. The cost benefit of the abatement of pollutants (in the form of CO2 and nutrient discharges) was included by assigning appropriate credits to these contributions. The overall economic viability was quantified as the break-even selling price (BESP) of the generated biocrude, taken to be the price at which the product must sell to cover the operating expenditure (OPEX). Based on available information and optimal operational conditions, the BESP was calculated as being $0.544 per kg biomass, equating to $0.9 L−1 for the extracted biocrude, the credited items contributing ˜14% of this figure. The BESP was found to be most sensitive to the algal growth rate μ, the BESP changing by ±24% in response to a ±20% change in μ. Whilst the terms of reference of the study are limited to OPEX contributors, the potential for sustainability associated with the innately reliably high levels of natural light in the Gulf region appear to provide auspicious circumstances for large-scale implementation of MCT. For emerging economies with a comparable climate

but without a mineral oil-based economy a greater financial benefit from the proposed scheme would arise.

- **Keywords:** Technoeconomic analysis; Microalgae culture technology; Break-Even selling price; Large-Scale implementation; Carbon dioxide biofixation; Nutrient removal

Chunshan Zheng, Bingyou Jiang, Sheng Xue, Zhongwei Chen, He Li. *Coalbed methane emissions and drainage methods in underground mining for mining safety and environmental benefits: A review*. Pages 103-124.

Coalbed methane (CBM) drainage in underground coal mining is of significance to guarantee mining process safety and bring valuable environmental benefits, as the drainage could help to eliminate methane-related accidents, reduce greenhouse gas (GHG) emissions and provide a source of clean energy. Due to the manifold benefits, extensive investigations have been conducted on methane emissions and drainage methods. However, few review studies have been reported in analysing and summarizing those previous investigations. Therefore, in this paper, a broad review on CBM emissions and drainage methods is conducted. First, the methane emissions in underground coal mines are reviewed, including methane generation, storage and migration characteristics, emission sources, emission estimation, and the factors influencing emissions such as coal properties, geological conditions and mining-process parameters. Then, based on the borehole trajectory, three methane drainage methods for reducing methane emissions are categorized: surface to inseam (SIS) methane drainage, underground to inseam (UIS) methane drainage and cross-measure borehole methane drainage. Each drainage method is analysed from perspectives of borehole design and application function. Particularly, the popular UIS drainage borehole design and sealing for preventing ventilation air leakage are emphasized. Finally, summary and conclusions on previous works are provided. Outcomes of this review work are expected to provide relevant researchers and mining engineers with effective contents on methane emissions and drainage methods in underground coal mines. Based on the site-specific methane conditions in their coalmines, mining engineers could determine the most appropriate methane-drainage methods to increase the drainage efficiency and reduce methane emissions for a safer and more efficient mining process.

- **Keywords:** Coalbed methane emissions; Methane drainage methods; Mining safety and environmental benefit; UIS methane drainage

Peyvand Valeh-e-Sheyda, Aryan Afshari. *A detailed screening on the mass transfer modeling of the CO2 absorption utilizing silica nanofluid in a wetted wall column*. Pages 125-132.

The low CO2 absorption in water is a major issue for the water-based CO2 capture technology. The current study focuses on augmentation effect of silica nanoparticles in a water-based nanofluid system on CO2 absorption experiments, carried out in a wetted wall column (WWC). Central composite design (CCD) and response surface methodology (RSM) have been applied to predict the individual and possible interaction influences of the most important operating variables, including absorption temperature, (25–45 °C), nanofluid flow rate, (100–300 mL/min), and concentration (0–1 %w) under atmospheric pressure. The propriety of the RSM model has been confirmed through R-squared and adjusted determination coefficients (R2 = 0.9757, and Adj-R2 = 0.9605). The combination of temperature and liquid flow rate, as well as liquid flow rate and concentration, has been proved to be highly effective for CO2 absorption in gas-liquid mass transfer experiments. The findings further have revealed that the impact of temperature at low flow rates is sensible on the gas-liquid mass transfer. Moreover, low absorption

temperatures and high flow rates of silica nanofluid can dramatically enhance the liquid-side mass transfer coefficient. It was found that under the optimal operation condition, the enhancement ratio of the predicted kl in the presence of silica nanoparticles can be over 1.37.

- **Keywords:** Absorption; Carbon dioxide; Central composite design; Liquid-side mass transfer; Silica nanoparticle; Wetted wall column

Muhammad Adnan, Sher Jamal Khan, Kamran Manzoor, Nicholas P. Hankins. *Performance evaluation of fertilizer draw solutions for forward osmosis membrane bioreactor treating domestic wastewater*. Pages 133-140.

The reverse solute flux (RSF) of draw solute ions towards the bioreactor is one of the main issues for concern during the forward osmosis membrane bioreactor (FO-MBR). This RSF can be significantly reduced with fertilizer-based draw solutes with anions of relatively large hydrated diameter. The individual performance of three such fertilizer-based draw solutes, ammonium sulfate (SOA), potassium hydrogen phosphate monobasic (MKP) and mono ammonium phosphate (MAP) was investigated in a forward osmosis membrane bioreactor (FO-MBR) integrated with direct contact membrane distillation (DCMD) process. During FO operation, results demonstrated that use of MAP significantly reduced the RSF (0.113 g/m2/hr (gMH)) towards the bioreactor, in contrast with that of SOA (0.568 gMH) and MKP (1.17 gMH). MKP exhibited the shortest filtration run of 12 days because of increased buildup of draw solute inside the bioreactor. On the other hand, SOA showed relatively prolonged filtration runs of 17 days, followed by 15 days for MAP. It was also found that MKP and SOA exhibited inhibitory effects on the mixed liquor characteristics in contrast with MAP in terms of biomass growth, particle size distribution and sludge filterability. Based upon these findings, MAP was found to be the most viable draw solute for the FO-MBR.

- **Keywords:** Forward osmosis membrane bioreactor; Membrane distillation; Fertilizer draw solute; Reverse solute flux; Salt accumulation

Jéssica Stefanello Cadore, Daniel Assumpção Bertuol, Eduardo Hiromitsu Tanabe. *Recovery of indium from LCD screens using solid-phase extraction onto nanofibers modified with Di-(2-ethylhexyl) phosphoric acid (DEHPA)*. Pages 141-150.

The main objective of this work was to develop a nanomaterial able to selectively extract and recover indium (In) from obsolete cell phone LCD screens. For this, Nylon 6 nanofibers were produced and modified with di-(2-ethylhexyl)phosphoric acid (DEHPA) for application in the solid-phase extraction of In. The best extraction conditions for concentration of In were 30% DEHPA, pH 0.5, 7.5 min contact time, and S:L ratio of 1:300. In this step, an In extraction efficiency of around 74% was obtained. In stripping steps, an efficiency of 92% was achieved using 1.5 M HCl, S:L ratio of 1:20, and 5 min contact time. Under the best extraction and stripping conditions, it was possible to obtain up to 6-fold concentration of In, compared to the initial concentration. In addition, the nanofibers were evaluated in terms of their stability and capacity for reuse, which showed that there was no significant loss of DEHPA and that the extraction efficiency remained almost constant. The findings demonstrated the possibility of using the Nylon 6/DEHPA nanofibers in a highly efficient extraction/stripping procedure for the selective recovery of In and Sn, with reduced environmental impacts.

- **Keywords:** Polymeric nanofibers; Solid-phase extraction; Indium; Centrifugal spinning; Wastes recycling

Nasim Zare, Babak Bonakdarpour, Mohammad Ali Amoozegar, Mahmoud Shavandi, Narges Fallah, Sara Darabi, Negar Basereh Taromsary. *Using enriched water and soil-based indigenous halophilic consortia of an oilfield for the biological removal of organic pollutants in hypersaline produced water generated in the same oilfield*. Pages 151-161.

The idea at the core of the research reported in the present paper is the use of indigenous halophilic consortia of an oilfield for treatment of the produced water (PW) generated in the same oilfield. To test this idea water and soil-based microbial sources obtained from desalination units of two oilfields were enriched in PW obtained from the same oilfield and supplemented with either yeast extract (YE) or Mueller-Hinton medium containing crude oil. Enriched soil-based microbial consortia (termed EVPS) gave a meaningfully higher maximum achievable biomass concentration, and amount of COD removed when grown on PW supplemented with YE compared to enriched water based ones. The supplementation of PW with inorganic nitrogen and phosphorous sources resulted in around 35% COD removal whereas supplementation with YE increased the PW COD removal to 62%. Microbial analysis of EVPS with Illumina HiSeq/MiSeq showed that bacteria had higher richness and diversity than archaea. The dominant bacteria genera were Chromohalobacter, Idiomarina, and Marinobacter, whereas Haloterrigena, Haloferax, and Methanohalophilus were the dominant genera amongst the archaea. Based on previous reports, the identified genera in EVPS have a wide salt tolerance range and are collectively capable of biodegrading most of the organic compounds prevalent in PW.

- **Keywords:** Produced water; Halophilic consortium; Enrichment; Microbial community structure; Biological treatment

Michael Lim, Rizwan Ahmad, Jing Guo, Fida Tibi, Minseok Kim, Jeonghwan Kim. *Removals of micropollutants in staged anaerobic fluidized bed membrane bioreactor for low-strength wastewater treatment*. Pages 162-170.

This study applied a laboratory-scaled, staged anaerobic fluidized bed membrane bioreactor (SAF-MBR) added with granular activated carbon (GAC) as fluidized media to treat a synthetic wastewater containing 0.1 mg/L of three different pharmaceutical micropollutants. Diclofenac, ibuprofen, and sulfamethoxazole were selected as target micropollutants to investigate their removal efficiency during SAF-MBR operation. More than 96% of overall COD removal efficiency was achieved at 8.7 h of total HRT with 288 mg/L of bulk VSS concentration. Transmembrane pressure (TMP) from membrane remained less than 0.3 bar during operational period. After the SAF-MBR was introduced with the micropollutants at 5 $Lm^{-2}h^{-1}$ of permeate flux, they were removed completely within 3 days of operation. Our batch experiments supported that the removal of micropollutants in reactor bulk was immensely pronounced by adsorption to GACs, sorption and biodegradation due to the biofilm formed on GACs fluidized in SAF-MBR system.

- **Keywords:** Anaerobic fluidized bed membrane bioreactor; Granular activated carbon; Micropollutants; Biodegradation; Sorption

S.M. Al-Salem. *Thermal pyrolysis of high density polyethylene (HDPE) in a novel fixed bed reactor system for the production of high value gasoline range hydrocarbons (HC)*. Pages 171-179.

Pyrolysis is a promising thermolysis technique to recover valuable oils and light hydrocarbons (HC) with high yields from plastic solid waste (PSW). In this work, thermal pyrolysis of high density polyethylene (HDPE) with the aim of producing gasoline range

hydrocarbon oils, has been carried out in a novel fixed bed (batch) reactor. The pyrolysis of HDPE has been conducted between 500 to 800 °C in the presence of nitrogen as an inert carrier gas media to produce liquid fuel oil, gaseous products and solid char. The optimum temperature of obtaining maximum oil product yield (70%) was 550° C. A comprehensive gas chromatography (GC) analysis of the liquid and gaseous products was conducted to quantify high molecular weight individual HC components. Moreover, light molecular weight HC constituting the gaseous fraction were identified. A chemical kinetic analysis of the cracking reactions, was performed to investigate the reaction mechanism of yielding the maximum oil product. The oil product recovered had a high proportion of aliphatic HC especially in the range of C8 to C12, whilst aromatic HC were of lower proportion. The carbon number of the pyrolysis oil was noted to increase proportionally with the increasing operating temperature. The gaseous product had a high percentage (> 70%) of C2 to C4 HC, which was attributed to the high activity of carbon/carbon (C-C) chain scission reaction.

- **Keywords:** Pyrolysis; Plastic waste; Aromatics; Hydrocarbons; Naphthenic compounds; Reclaimed waste

Jung Eun Kim, Juliette Kuntz, Am Jang, In S. Kim, Joon Young Choi, Sherub Phuntsho, Ho Kyong Shon. *Techno-economic assessment of fertiliser drawn forward osmosis process for greenwall plants from urban wastewater*. Pages 180-188.

Pressure-assisted osmosis (PAO) has been suggested to integrate with fertiliser driven forward osmosis (FDFO) to improve the overall efficiency of simultaneous wastewater reuse and fertiliser osmotic dilution. This study aims to demonstrate the techno-economic feasibility of pressure-assisted fertiliser driven forward osmosis (PAFDO) hybrid system compared to the existing ultraviolet and reverse osmosis (UVRO) process. The results showed that coupling FDFO with PAO (i.e. PAFDO) could help fulfill the water quality required for greenwall fertigation. An economic analysis on capital and operational costs for the PAFDO showed that the PAO mode application at a lower FDFO dilution stage could significantly reduce the costs. However, when considering the different applied pressures in PAO (i.e. 2, 4, and 6 bar), the increase in the total water cost was not significant. This indicates that the dilution stage for applying PAO is more sensitive to the total water cost of the PAFDO than the applied pressure. A coupling of higher average water flux (>10 L/m2h) and lower draw solution (DS) dilution factor (DF < 60) is recommended. Therefore, this could make the PAFDO system economically viable compared to the benchmark for the UV-RO disinfection system.

- **Keywords:** Forward osmosis; Fertigation; Pressure assisted osmosis; Wastewater reuse; Techno-economic assessment

Gaimei Guo, Gang Cheng. *Mathematical modelling and application for simulation of water pollution accidents*. Pages 189-196.

Water pollution accidents occur frequently and cause severe damage in recent years. The objective of this study is to build a model for simulating spatial-temporal change of pollutants after water pollution accidents. A Simulation System of Water Pollution Diffusion is developed in this study. A water pollution accident in Yuncheng City, China is used as an example. The results indicate that the pollutant moves from upstream to downstream with an increasing pollution area but a decreasing concentration. Moreover, spatial-temporal changes of the pollutant concentrations show the inverted-V tendency, where the concentration at a point in space increases then decreases through time. Finally, on the basis of the comparison of simulated concentrations of benzene with monitoring concentrations of it, Mean Absolute Deviation and Mean Deviation are computed to measure model error. The results show that Mean Deviation is -0.028 mg/L

and Mean Absolute Deviation is 0.255 mg/L, whereas the data range from 0.001 mg/L to 28.104 mg/L.

- **Keywords:** Water pollution accident; Diffusion simulation; Spatial-temporal change; Mean absolute deviation; Mean deviation

Wenying Guo, Sihai Zhang, Nengwu Zhu, Deliang Luo, Pingxiao Wu. *Recovery of high purity secondary silver from waste Ag/Cu electrical contacts*. Pages 197-205.

In this study, a strategy was developed to directly recover high-purity Ag and other metals (especially Cu) from WECs to reduce the leaching of precious metals and promote the leaching of Cu and other metals. The results of SEM, EDS, XRD and ICP-OES clearly suggested that Ag and Cu were effectively released from WECs below 0.15 mm size, which contributed to the regulation of metals crystal types. The zero-valent copper from WECs was changed by roasting to form CuO and Cu2O, and the suitable samples of roasting at 400 °C for 3 h were confirmed experimentally. After the leaching processing under H2SO4 (1 M) and H2O2 (30%), the roasted particles were directly obtained, including Ag with 99.53 wt.% purity and more than 99.99% recovered, and Cu, Sn, Ni and Zn extracted by 99.67%, 90.71%, 73.05% and 99.32%, respectively. However, the unroasted particles would generate lower grade of Ag because other metals (e.g. Cu, Sn, Ni and Zn) were difficult to be leached from WECs. The leaching solution primarily included Cu ions (98.3%) and a little of the nickel (0.83%) and tin (0.86%) ions, which could recover copper by evaporation crystallization to form CuSO4 (99.48 wt. %). The reaction mechanism of the process could be concluded that the copper state was transformed by mechanical separation and roasting to promote the leaching of various metals from Ag.

- **Keywords:** Waste electrical and electronic equipment; Electrical contact; Silver; Metal recovery

Karen Daly, Owen Fenton, S.M. Ashekuzzaman, Anna Fenelon. *Characterisation of dairy processing sludge using energy dispersive X-ray fluorescence spectroscopy*. Pages 206-210.

The dairy processing industry generates significant volumes of dairy sludge and recycling onto land could provide a source of nutrients for crop production. This work assessed the feasibility of energy dispersive X-ray fluorescence spectroscopy (XRF) for the direct, elemental analysis for land application. XRF intensities were calibrated using fundamental parameters (FP), matching libraries (ML) and empirical (EMP) standards. For major nutrients phosphorus (P), potassium (K), magnesium (Mg), sulphur (S) and aluminium (Al) each calibration method provided an excellent fit to conventional analysis. Agreement statistics computed the Concordance Correlation Coefficient (CCC) that expresses agreement in which a value of 1 represents perfect agreement and a value of 0 represents no agreement. The CCC values for FP calibrations fell between 0.8820 and 0.9925 representing excellent agreement with ICP values, and outperformed other calibration methods in XRF. Copper (Cu), manganese (Mn), zinc (Zn) and nickel (Ni) recorded R2 between 0.8037 and 0.9868, for FP and ML calibrated values with empirical calibrations showing moderate agreement (R2 0.6510 to 0.8855). Trace elements fell within narrow limits of agreement with negligible bias with CCC values between 0.8335 to 0.9930. XRF can provide rapid and accurate analysis of dairy sludge without the need for empirical standards.

- **Keywords:** X-ray fluorescence spectroscopy; Acid digestion; Dairy sludge; Elemental analysis

Sapna Raghav, Sapna Nehra, Dinesh Kumar. *Adsorptive removal studies of fluoride in aqueous system by bimetallic oxide incorporated in cellulose*. Pages 211-225.

Fluoride adulteration in drinking water has been established as one of the solemn problems across the world because it causes severe diseases like fluorosis. This study demonstrates fluoride adsorption using aluminium and lanthanum impregnated cellulose matrix (ALIC) prepared by ultrasound assisted technology (ALIC(U)) and co-precipitation (ALIC(P)) method. The ultrasonication technology is much faster than conventional methods. It enhances the surface area due to the cavitation effect and enhances the trapping of metal ions in the cellulose matrix by increasing the collision rate of metal ions and the biopolymer molecules. The surface areas of ALIC(U) and ALIC(P) were 196.91 and 130.93 m2/g, and the adsorption capacities of ALIC(U) and ALIC(P) were 88.67 and 33.33 mg/g, respectively. The adsorption mechanism is based on the participation of hydroxyl groups of cellulose and cationic metal hydroxide via H-bonding, ion-exchange, and ion-pair complexation. The equilibrium adsorption and kinetics studies have been performed to understand the mechanism and rate of adsorption of both ALIC (U and P). The rate constant of adsorption process for ALIC(U) and ALIC(P) is 0.135 g mg−1 min−1 and 0.04 min−1, respectively. The Gibbs free energy and entropy of ALIC (U and P) ensure the spontaneous and feasible nature of adsorption.

- **Keywords:** ALIC; Ultrasonicator; Cavitation effect; Adsorption capacity; Fluoride; Pseudo-second-order

Jingde Li, Hong Hao. *Numerical and analytical prediction of pressure and impulse from vented gas explosion in large cylindrical tanks*. Pages 226-244.

This paper presents an extension of previous study on estimating the internal and external pressure and impulse from vented gas explosion in large cylindrical tanks. Unlike the small-medium scale explosion from cylindrical tanks in previous work, explosion pressure and impulse from large-scale explosions are numerically and analytical investigated in this study. CFD simulations are conducted and validated by using experimental data. Sensitivity study on grid selection for large-scale explosion simulations is performed. By adopting two scale-up factors for the analytical correlations, the internal pressure and external pressure on adjacent tanks from vented gas explosion in a tank are accurately predicted. Parametric study of the effectiveness of separation gap between adjacent tanks on pressure and impulse mitigation is also carried out. Influences of the venting size, tank diameter and tank height on the effectiveness of separation distance for pressure and impulse mitigation from large-scale vented gas explosion in an adjacent tank are studied.

- **Keywords:** Large-scale gas explosion; Vented gas explosion; External pressure; Far field; CFD; Safe separation gap

Hao Wu, Deyang Wu, Jinsong Zhao. *An intelligent fire detection approach through cameras based on computer vision methods*. Pages 245-256.

Fire that is one of the most serious accidents in petroleum and chemical factories, may lead to considerable production losses, equipment damages and casualties. Traditional fire detection was done by operators through video cameras in petroleum and chemical facilities. However, it is an unrealistic job for the operator in a large chemical facility to find out the fire in time because there may be hundreds of video cameras installed and the operator may have multiple tasks during his/her shift. With the rapid development of computer vision, intelligent fire detection has received extensive attention from academia

and industry. In this paper, we present a novel intelligent fire detection approach through video cameras for preventing fire hazards from going out of control in chemical factories and other high-fire-risk industries. The approach includes three steps: motion detection, fire detection and region classification. At first, moving objects are detected through cameras by a background subtraction method. Then the frame with moving objects is determined by a fire detection model which can output fire regions and their locations. Since false fire regions (some objects similar with fire) may be generated, a region classification model is used to identify whether it is a fire region or not. Once fire appears in any camera, the approach can detect it and output the coordinates of the fire region. Simultaneously, instant messages will be immediately sent to safety supervisors as a fire alarm. The approach can meet the needs of real-time fire detection on the precision and the speed. Its industrial deployment will help detect fire at the very early stage, facilitate the emergency management and therefore significantly contribute to loss prevention.

- **Keywords:** Fire detection; Loss prevention; Computer vision; Convolutional neural networks

Huosheng Li, Jingfang Xiong, Tangfu Xiao, Jianyou Long, Qimin Wang, Keke Li, Ximing Liu, Gaosheng Zhang, Hongguo Zhang. *Biochar derived from watermelon rinds as regenerable adsorbent for efficient removal of thallium(I) from wastewater*. Pages 257-266.

Discarded watermelon rinds were used to prepare porous biochars, which act as regenerable adsorbents for treating both synthetic and real Tl-containing wastewater. The primary biochar prepared under pyrolysis temperature of 500 °C was found to be the most effective for Tl(I) removal. The primary biochar had the best Tl(I) removal efficacy over a wide pH range (4–12), followed by the KOH-modified and HCl-modified biochar. Maximum Tl(I) adsorption capacity reached 178.4 mg/g, which is superior to that of other biochar. Strong resistance to the interference from co-existing cations and organics on Tl(I) removal was also observed during treatment of complex synthetic and real industrial wastewater. Characterization techniques such as X-ray diffraction (XRD), Fourier transform infrared (FT-IR) spectra, high resolution transmission electron microscope (HRTEM), and X-ray photoelectron spectroscopy (XPS) reveal that the K- and Cl-rich primary biochar acts as regenerable amphibious ion exchange resins to perform reversible adsorption and desorption of Tl(I). The biochar derived from watermelon rinds exhibits effective Tl(I) removal performance and strong regenerability, and is a promising adsorbent for Tl(I) removal with excellent application prospects.

- **Keywords:** Thallium; Biochar; Heavy metals; Watermelon rinds; Adsorption; Ion exchange

Sang-Gil Lee, Kyu-Sang Kwon, Bong-Ju Kim, Nag-Choul Choi, Jae-Woo Choi, Soonjae Lee. *Detection of oil leakage in soil by monitoring impedance using time domain reflectometry and hydraulic control system*. Pages 267-276.

Monitoring of petroleum contamination in soils surrounding underground storage tanks is an important issue for the effective remediation of soil and groundwater. In this study, a method for the detection of oil leakage from underground storage tanks was developed using time domain reflectometry (TDR), which has a sensible capacity for soil resistance, and a hydraulic control system. Without the hydraulic control system, TDR-measured impedance was not sensitive to the input of oil. The ability of the new system to detect diesel leakage in a sandy soil was verified by conducting leakage detection experiments. Impedance changes measured by TDR installed in the cylinder are useful as a sign of oil leakage. The sensitivity of oil leakage detection was dependent on the configuration of the hydraulic control system. The applicability of the sensor system in subsurface

environment was validated by conducting oil release detection test in the sand tank. Results indicate that TDR, combined with a hydraulic control system, can be used for the detection of oil leakage from the storage tank.

- **Keywords:** Oil leakage detection; Soil; Impedance; Time domain reflectometry; Hydraulic control system

Mohanakrishnan Logan, Masihullah Safi, Piet Lens, Chettiyappan Visvanathan. *Investigating the performance of internet of things based anaerobic digestion of food waste*. Pages 277-287.

A pilot scale decentralised Continuously Stirred Tank Reactor (CSTR) was designed, developed and installed, with 675 L working volume, to treat food waste generated from the Asian Institute of Technology (AIT) campus community. The reactor was operated in mesophilic, anaerobic and wet condition with feedstock as food waste of 10% Total Solids (TS) content. This study aims for performance evaluation of food waste anaerobic digestion and development of remote monitoring system suitable for centralised monitoring of decentralised anaerobic digestion plants. The performance of the reactor was remotely monitored with the installation of pH, Temperature and Oxidation Reduction Potential (ORP) electrodes connected with the Programmable Logic Controller (PLC). The quality of biogas produced was monitored by online biogas analyzer system. The CSTR was operated with three different Organic Loading Rates (OLR) viz., 1, 2 and 3 kg of volatile solids per cubic meter of digester per day (kg VS/m3.d) to evaluate performance of the food waste digestion and biogas production. The average biogas yield was 0.75, 0.62 and 0.52 cubic meter per kilogram of volatile solids (m3/kg VS), with average methane yield of 0.42, 0.33 and 0.27 m3/kg VS at OLR of 1, 2 and 3 kg VS/m3.d respectively. Furthermore, it was observed that the average reduction in total solids was 70.7, 66.5 and 54.98% and average reduction in volatile solids was 78.3, 72 and 67% at OLR of 1, 2 and 3 kg VS/m3.d respectively. Internet of Things (IoT) enabled remote monitoring on real time basis and aided the centralised operator to improve the process performance resulting in better operation and maintenance of the decentralised anaerobic digestion systems.

- **Keywords:** Sustainable waste management; Food waste; Mesophilic; Wet anaerobic digestion; Online monitoring; Decentralisation; IoT

Samirys Sara Rodrigues Cirqueira, Eduardo Hiromitsu Tanabe, Mônica Lopes Aguiar. *Experimental investigation of particle deposition in filter media during filtration cycles with regeneration by pulse jet cleaning*. Pages 288-298.

The objective of this study was to experimentally evaluate the influence of particle deposition on gas filtration with pulse jet cleaning. Filtration experiments were performed using dolomitic limestone particles, with polyester and polypropylene filter media. A total of 100 filtration tests were performed with a surface velocity of 4 cm/s. The stipulated maximum pressure drop was 1000 Pa, the pulse time was 200 ms, and the pulse pressure was 200 kPa. After 100 filtration cycles, the polyester filter presented higher cleaning efficiency, higher collection efficiency, lower particle retention, higher permeability, lower residual pressure drop, and lower mass retained after reverse air pulse cleaning, compared to the polypropylene filter. The results confirmed that the polyester filter presented excellent operational performance when pulse jet cleaning was used. Furthermore, surface filtration was more pronounced for the polyester filter, due to lower deposition of particles inside the filter.

- **Keywords:** Particle deposition; Fibrous filter regeneration; Gas filtration; Pulse jet cleaning; Filtration efficiency; Cleaning efficiency

Wenwei Tang, Yunying Liu, Jiemin Gong, Shichao Chen, Xinping Zeng. *Analysis of manganese oxidase and its encoding gene in Lysinibacillus strain MK-1*. Pages 299-305.

Manganese (Mn) is one of the most abundant transitional metals in the crust of the Earth and Mn contamination is occurring in groundwater worldwidely. The removal of manganese is mainly achieved by catalytic oxidation of manganese-oxidizing bacteria. As a result, biological Mn-removal technology has attracted increased attention due to its high efficiency and convenience. Several species of bacteria, including Bacillus and Pseudomonas, have the ability to oxidize Mn. A bacterial strain MK-1 from Lysinibacillus, capable of oxidizing 98% of Mn under optimal conditions (1mmol/L of Mn(II), pH 7.0, 3days), was obtained from a mine located in Hunan province, and a gene, mokA, putatively encoding a manganese oxidase, was identified. The MokA enzyme produced by mokA is a CotA-like multicopper oxidase (MCO) that exhibited significantly different expression profiles in medium with and without Mn(II). Sequence analysis of MokA revealed that it is structurally similar to previously reported manganese oxidases. The results of this study broaden the taxonomic range manganese-oxidizing bacteria. Based on these results, our findings suggested that MK-1 might be applied for the treatment of Mn(II)-contaminated water.

- **Keywords:** Bacteria; Enzymes; Gene; Manganese oxidation; Multicopper oxidase

Jongmun Cha, Kenneth H. Carlson. *Biodegradation of veterinary antibiotics in lagoon waters*. Pages 306-313.

The occurrence and fate of veterinary antibiotics in lagoon water and animal manure are an emerging area of interest due to the potential impact of these compounds on the aquatic environment. The objective of this study was to evaluate the degradation of oxytetracycline (OTC), sulfamethoxazole (SMX), tylosin (TYL), and monensin (MON) in dairy lagoon waters under aerobic and anaerobic conditions. Biodegradation of OTC, SMX, TYL and MON occurred at both 20 °C and 4 °C under aerobic and anaerobic conditions. More than 88% of all antibiotics were degraded at 20 °C under aerobic treatment. Concentrations decreased at 4 °C, but none of these compounds completely biodegraded in either treatment within 242 days at 4 °C. Calculated first-order degradation half-lives of OTC, SMX, TYL and MON at 20 °C were 12, 6.5, 16, and 9.2 days, respectively, under aerobic treatment and 17, 59, 19, and 71 days, respectively, under anaerobic treatment. At 4 °C, half-lives were 80, 204, 46, and 128 days, respectively, under aerobic treatment and 110, >242, 103, and 193 days, respectively, under anaerobic treatment. Therefore, these results show that degradation of antibiotics, in general, is faster under aerobic conditions, compared to anaerobic conditions. It was found that lower temperature (4 °C) reduced the biodegradation rate of antibiotics.

- **Keywords:** Veterinary antibiotics; Biodegradation; Lagoon water; Aerobic; Anaerobic

Mahesh Kodoth, Tadahiro Shibutani, Yehia F. Khalil, Atsumi Miyake. *Verification of appropriate life parameters in risk and reliability quantifications of process hazards*. Pages 314-320.

Failure frequency estimation is one of the important measures of risk quantification. In traditional reliability assessment, mean time to failure (MTTF) is one of the most common life parameter to field failure data analysis. However, it is critically important to use correct life parameter for accurate reliability estimation. One of the uncertainties in reliability assessment is the inappropriate life parameter and how they could be selected. The scope of this study is to select an appropriate life parameters for hydrogen refueling stations (HRS). Field failure data of HRS is used as a case study to compare failure

analysis based on two life parameters i.e. survival time vs. number of fillings at the station. A non-parametric estimator is used to estimate cumulative failure function based on number of fillings. The cumulative hazard using the Nelson-Aalen estimator showed a linear relationship with the number of fillings. A parametric estimator using 2-values (β and η) Weibull distribution function is employed to estimate cumulative probability of failure with the survival time. The present study demonstrates that the failure rate can vary by a small to large margin based on the life parameter and estimator chosen for reliability predictions. This shows the importance and need of verification of life parameter in QRA to reduce uncertainty associated with the risk calculation.

- **Keywords:** Hydrogen refueling station; Reliability prediction; Nelson-Aalen estimator; Weibull analysis; Leak frequency

Mohammad Sheikhalishahi, Maryam Karimi, Raha Raghebi. *Combinatorial optimization of petrochemical plants by asset integrity management indicators*. Pages 321-328.

This paper proposes an integrated approach to evaluate and optimize performance of petrochemical plants based on asset integrity management criteria. The proposed approach consists of analytic network process (ANP) and data envelopment analysis (DEA). Asset management criteria are identified by surveying related standards and literature and categorized into three levels. First level criteria which are major criteria are based on plan-do-check-act (PDCA) cycle, second level criteria are sub sets of the first level criteria and third level criteria are quantitative and qualitative indicators derived from the literature. ANP is used to calculate relative importance of the second level criteria which enables decision makers to calculate the final score of each decision-making unit. Constant return to scale (CRS) and variable return to scale (VRS) DEA models in both input and output oriented forms are applied and the preferred model for measuring DMUs' efficiency is selected via normality test. The proposed approach is applied to a set of real time petrochemical plants. Sensitivity analysis is performed to find significant factors affecting DMUs' efficiency scores. The proposed approach would improve overall performance and could reduce operational loss, safety issues and incidents.

- **Keywords:** Asset management; Combinatorial; Optimization; Analytic network process (ANP); Data envelopment analysis (DEA); Petrochemical plants

Yuan Sun, Xuewen Cao, Fachun Liang. *Investigation on underwater spreading characteristics and migration law of oil leakage from damaged submarine pipelines*. Pages 329-347.

Great threats and damages to natural ecosystem and marine environment will be caused once oil and gas leakage occurs. It is crucial to develop a quick response strategy, including the accurate prediction of oil and gas migration path, oil droplet size distribution and other parameters. Volume of fluid (VOF) model and realizable k-ε turbulence model are employed to investigate the underwater spreading characteristics and migration law of oil leakage. Influencing factors such as wave length, leakage direction, current speed, wind speed, oil density, and leaking rate are analyzed by numerical simulation. The calculation results indicates that wave length affects both the underwater spread and drift process, while current speed and wind speed mainly influence the drift process. Leakage direction, oil density and leaking rate have significant influence on underwater spread process but limited effect on drift process. A formula is proposed to predict the oil diffusion distance at certain time. The results of investigation can offer a valuable guidance for formulation of emergency response.

- **Keywords:** Leakage; Underwater spread; Oil migration; Volume of fluid

Larissa Pinheiro Souza, Cátia Alexandra Leça Graça, Maria Elena Santos Taqueda, Antonio Carlos S.C. Teixeira, Osvaldo Chiavone-Filho. *Insights into the reactivity of zero-valent-copper-containing materials as reducing agents of 2,4,6-trichlorophenol in a recirculating packed-column system: Degradation mechanism and toxicity evaluation*. Pages 348-358.

The presence of toxic chlorinated compounds in drinking water, generated during the disinfection step in water treatment plants is of great concern for public health. Therefore, special attention has been given to the development of effective organochlorine-removal techniques. The reductive degradation via zero-valent-metals is recognized as a promising alternative. In this study, the capacity of zero-valent-copper (ZVC) containing materials to degrade 2,4,6-thichlorophenol (TCP) was investigated, using a bench-scale recirculating packed column system. The results indicate that this metal is effective for TCP degradation and dechlorination, even when derived from scrap. The kinetic model that better suits the degradation profiles is a second-order model, with an average normalized surface area rate constant (kSA') of (2.44±1.27)×10−3 L² min−1m−2 for ZVC-containing materials. The ZVC scrap-derived material was found attractive for field applications due to its reusability and low leachability, despite its performance being affected in the presence of water natural constituents. The degradation by-products elucidated confirm that dechlorination is the main degradation pathway, leading to the formation of totally dechlorinated by-products such as phenol-like compounds and cyclohexanone. However, these may still pose a threat to aquatic organisms as revealed by toxicity assays and activity-structure relationship model (ECOSAR USEPA) predictions. Further investigation is therefore required aiming at following by-products formation with degradation time in order to find the best residence time that generates innocuous and/or adequate effluents for environmental disposal.

- **Keywords:** 2,4,6-Trichlorophenol; Zero-valent-copper; Zero-valent-metal reduction; Scrap-Derived metals; Water treatment