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V.R.S. De Silva, P.G. Ranjith, M.S.A. Perera, B. Wu, T.D. Rathnaweera. *A modified, hydrophobic soundless cracking demolition agent for non-explosive demolition and fracturing applications*. Pages 1-13.

Soundless Cracking Demolition Agents (SCDAs) are an alternative to the current practices of environmentally detrimental conventional demolition and rock fragmentation methods Although having the potential to produce a dense network of fractures when injected into a borehole, the applicability of SCDA is limited by its susceptibility to dilution in water-saturated conditions and delayed onset of expansive pressure. Such limitations can be eliminated by introducing a Viscousity Enhancing Agent (VEA) to modify the SCDA system. Even though adding a VEA enhances the wash out resistance in the SCDA system, the associated delay in the onset of expansive pressure limits the application of this new technology in the industry. Therefore, this study aims to recover the delayed onset of expansive pressure in modified SCDA by utilising a chemical accelerator (CaCl2) through a comprehensive experimental study. The developed new material was fully characterised by performing mechanical tests (uniaxial compressive strength tests, flowability tests, washout resistance tests), microstructural analysis (scanning electron microscopy) and mineralogical analysis (X-ray diffraction). According to the results, simply increasing the dose of CaCl2 in unmodified SCDA was found to be ineffective to attain an increased rate of expansive pressure generation and the peak expansive pressure development. The increased dose of CaCl2 resulted in an accelerated expansive pressure generation, but also a lower peak expansive pressure. The approach of combining the accelerator and VEA was found to be an effective means to increase the washout resistance and the rate of expansive pressure development of modified SCDA while retaining a reasonable flowability of SCDA. Finally, the study proposes an optimum combination of VEA (welan gum, 0.1%) and the accelerator (CaCl2, 2%) by weight of SCDA to produce an SCDA with enhanced expansive pressure generation in submerged conditions, which can be effectively and safely applied for demolition and rock fragmentation.

- **Keywords:** Soundless cracking demolition agents; CaCl2; Welan gum; Mechanical properties; Microstructure; Mineralogy

Amel Farhat, Nedra Asses, Hajer Ennouri, Moktar Hamdi, Hassib Bouallagui. *Combined effects of thermal pretreatment and increasing organic loading by co-substrate addition for enhancing municipal sewage sludge anaerobic digestion and energy production*. Pages 14-22.

In this work, the thermal pretreatment of municipal sewage sludge (MSS) associated to its anaerobic co-digestion with the olive processing wastewater (OPW) was investigated for increasing complex organic matter disintegration and bio-conversion into energy. The hydrolysis of MSS (47%–49%) was performed at 120°C during 30min of pretreatment, which was confirmed by Fourier transform infrared (FTIR) spectroscopy. Results showed that increasing total solid (TS) from 0.58% to 3.2% has no effect on the suspended volatile solid (VS) disintegration. Anaerobic co-digestion of pretreated MSS (PMSS) mixed with OPW was investigated and the effect of increasing OPW proportion on the bio-methane potentials (BMP) was examined. The anaerobic digestion of better ratios of PMSS/OPW(80%/20% and 70%/30%) was also performed in sequencing batch reactors (ASBRs). The high biodegradation yields of VS and phenols (81% and 92%, respectively) were obtained at PMSS/OPW of 70%/30% corresponding to a methane yield of 0.441L/gVSinlet. Therefore, thermal pre-treatment of MSS and OPW addition improved significantly methane yield (50%–160%) and wastes stability. Furthermore, they increased total energy production from 30.9kWh/ton to 93.5kWh/ton, which would provide 0.56 M€/year net benefits only from the electric power, which is considered interesting. The excess thermal energy should be used for wastes pretreatment and digester heating.

- **Keywords:** Anaerobic co-digestion; Pretreatment; Municipal sewage sludge; Agro-wastewater; ASBR; Energetic benefit

Igor Cretescu, Maria Harja, Carmen Teodosiu, Dorina Nicolina Isopescu, Men Fei Chok, Brindusa Mihaela Sluser, Mohamad Amran Mohd Salleh. *Synthesis and characterisation of a binder cement replacement based on alkali activation of fly ash waste*. Pages 23-35.

This study considers the valorisation of an important amount of fly ash generated as waste in the process of coal burning in a thermal power plant of Iasi municipality (Romania). The waste valorisation is related to the development of a new building material by using the alkaline activated fly ash based on the fact that inorganic polymers with similar properties to ordinary Portland cement may be obtained by alkaline treatment. Three main operating parameters were considered for the synthesis of this material: the liquid/solid ratio, the concentration of alkaline solution and the activation temperature. By minimizing the activation temperature and recycling the hydroxide solution, the synthesis of low-cost materials for partial cement replacement in concrete was possible. The synthesized materials were thoroughly characterised for analysis of chemical composition, morphology, physical and mechanical properties by XRD, SEM, EDX, TGA, FTIR, density and compressive strength. According to experimental results, the synthesized materials have a bigger specific surface area as compared to that determined for fly ash. The XRD and FTIR analysis proved that fly ash waste contains: quartz, mullite, iron oxide and a vitreous phase, while the synthesized materials after the fly ash alkaline treatment contain: quartz, sodalite, chabazite, geopolymer gel.

- **Keywords:** Alkaline treatment; Cement replacement; Chemical composition; Fly ash; Morphology; Physical and mechanical properties

Muhammad Hashim Abbas, Rosemary Norman, Alasdair Charles. *Neural network modelling of high pressure CO2 corrosion in pipeline steels*. Pages 36-45.

The effect of carbon dioxide (CO2) corrosion on pipelines is of great relevance to the petroleum as well as the Carbon Capture and Storage (CCS) industries. CO2 corrosion is responsible for lost production as it brings about the gradual degradation of pipe internals with time. The cost of general corrosion is said to be between 3 to 5% of an industrialised nation's gross domestic product (Schmitt et al., 2009; Popoola et al.,

2013). In the U.S., the cost of corrosion in the production and manufacturing sector was $34.4 billion in 2014, with the oil and gas industry accounting for more than half (Abbas, 2016). The use of neural networks (NN) as an analytic tool for corrosion data has been established however the aim of this paper is to characterise selected Matlab transfer and training functions, and assess their degree of suitability for CO2 corrosion rate prediction. Assessments of the training functions include the evaluation of the correlation coefficient (R2-value) and determination of a cumulative absolute error to indicate the level of precision and the extent of model accuracy. A NN model is developed for predicting CO2 corrosion at high partial pressures by considering the results of the various tests and analyses on the given Matlab functions. The results showed that the model is reliable with all test results falling within the 95% confidence limits. Leave-One-Out Cross-Validation (LOOCV) was implemented as a means for carrying out an additional assessment on model performance as well as for model selection from possible alternatives.

- **Keywords:** Carbon dioxide (CO2) corrosion; Matlab; Neural network; Prediction model; High CO2 partial pressure

Li Xinhong, Chen Guoming, Zhang Renren, Zhu Hongwei, Fu Jianmin. *Simulation and assessment of underwater gas release and dispersion from subsea gas pipelines leak*. Pages 46-57.

Subsea gas release and dispersion can cause safety concerns such as fire, explosion or stability loss of floating installations. This paper presents a Computational Fluid Dynamics (CFD) based approach to describe the behavior of underwater gas release and dispersion from subsea gas pipelines leak. The uniqueness of the present study is the integration of estimating subsea gas release rate and predicting rising gas plume. The proposed approach is comprised of two submodels. An equivalent short pipeline model is established to calculate the subsea gas release rate, considering the change of hole size and environmental pressure. A 3D model based on Eulerian-Lagrangian modeling concept is built to predict the rising gas plume, in which bubbles are treated as discrete particles. The validation is carried out by comparing CFD results against experimental data. The underwater gas dispersion simulations include a matrix of scenarios for different gas release rates, water depths, ocean current speeds and leak positions, to study their effects on the behavior of underwater gas plume. The developed CFD model can provide some valuable outputs, e.g., gas release rate, rise time, horizontal dispersion distance and surfacing area size. These results could help to conduct the risk assessment and the emergency planning for accidental leakage of subsea gas pipelines.

- **Keywords:** CFD simulation; Risk assessment; Underwater gas release; Dispersion; Subsea pipelines

Tomasz Rogoziński. *Pilot-scale study on the influence of wood dust type on pressure drop during filtration in a pulse-jet baghouse*. Pages 58-64.

Experimental filtration processes were carried out to investigate the air flow resistance during separation of three types of wood dusts in a pilot-scale pulse-jet filter. Three types of dust were compared: dust from sanding pine wood, dust from sanding beech wood and dust from working particl,eboard. These dusts are characterized by different particle-size distribution. The resistance coefficient K1 was determined for the filter fabric used in tests. Basing on the results of pressure drop across the filter measured during the experimental processes in condition of three levels of filtration velocity Vf (0.0405; 0.0484 and 0.0583ms−1) the specific dust cake resistance coefficient K2 was calculated. It value depends on the dust type and filtration velocity used. The lowest K2 (20,085s−1) has pine wood dust at filtration velocity 0.0484ms−1. While the highest value (28,925s−1) was calculated at Vf=0.0583ms−1 for dust from working of particleboards.

- **Keywords:** Pulse-jet filter; Wood dust; Air flow resistance; Specific dust cake resistance coefficient

Leslie Meier, Dana Stará, Jan Bartacek, David Jeison. *Removal of H2S by a continuous microalgae-based photosynthetic biogas upgrading process*. Pages 65-68.

The capacity of a biogas upgrading system based on the microalgae Chlorella sorokiniana was evaluated. A system composed of a photobioreactor connected to an absorption column was tested. Two continuous systems were operated with real biogas. One with biogas containing 1800–3500 ppmv of H2S, another one without H2S. The tested system provided 98% and 100% removal levels for CO2 and H2S, respectively. Removal of H2S was the result of oxidation to sulfate, as a consequence of the high concentration of dissolved oxygen. Comparison of both systems showed no signs of inhibition due to H2S presence in the biogas. It is concluded then that a microalgae-based biogas upgrading system would not only provide conditions for CO2 removal, but also for H2S oxidation.

- **Keywords:** Biogas; Upgrading; Microalgae; H2S

Liming Yuan, Richard A. Thomas, James H. Rowland, Lihong Zhou. *Early fire detection for underground diesel fuel storage areas*. Pages 69-74.

With the increased use of mobile diesel-powered equipment in underground mines, the fire risk posed by underground diesel fuel storage areas is a concern. To reduce the risk associated with the storage and transfer of large quantities of diesel fuel in permanent underground mine storage areas, an experimental study was conducted to investigate the responses of different sensors for early detection of diesel fuel fires in a storage area. Fire sensors tested in this study were four carbon monoxide (CO) sensors, two smoke sensors, and one flame sensor. A series of fire tests were conducted in the NIOSH Safety Research Coal Mine, Bruceton, PA, using various fire sizes at different ventilation airflow velocities and fire locations. Response times for different sensors were analyzed, and the results suggest that the flame sensor and smoke sensors resulted in shorter response times in most tests compared to the CO sensors. Based on the test results, the appropriate sensor locations for early fire detection in a diesel fuel storage area were identified. The results of this study can help mining companies to select appropriate fire sensors for underground diesel fuel storage areas and improve the deployment of these sensors to ensure the safety of underground miners.

- **Keywords:** Fire detection; Diesel fuel storage; Carbon monoxide sensor; Smoke sensors; Flame sensor; Ventilation

Bing-huang Wang, Qian Zhang, Jun-ming Hong, Ling Li. *Highly effective iron–carbon–bentonite–alginate beads (Fe°/C-BABs) as catalyst to treat benzalkonium chloride in fixed-bed column systems*. Pages 75-86.

Novel iron–carbon–bentonite–alginate beads (Fe°/C-BABs) were successfully prepared with the ion-gelation method and demonstrated high activities in persulfate activation for benzalkonium chloride (BAC) oxidation. The beads were measured in terms of size, mass, and Fe content and then characterized via scanning electron microscopy, energy dispersive spectrometry, Fourier transform infrared spectroscopy, and thermogravimetric analysis. The performance of Fe°/C-BABs as filler was evaluated in a continuous fixed-bed with paralleled PS and BAC feeding. The effects of initial PS (100 mM) concentration, pH (3–11), fixed bead weight (10–30 g), and flow rate (225-540 mL h−1) were investigated. Results indicated that the Fe°/C-BABs effectively activated PS to treat BAC in the solution. The optimal conditions for the degradation of BAC were pH 7.0, [BAC] = 50 mg L−1, [PS] = 100 mM, bead weight = 30 g, PS flow rate = 25 mL h−1, and

BAC flow rate = 225 mL h−1; the removal rate of BAC reached 93.3%.The economic cost analysis was carried out under the optimal experimental conditions. To deeply understand the degradation mechanism of pollutants, the intermediates of BAC degradation were analyzed via gas chromatography/mass spectrometry analysis, and a degradation path pathway was proposed.

- **Keywords:** Fe°/C-bentonite-alginate hydrogel beads; Persulfate; Fixed-Bed column; Benzalkonium chloride; Advanced oxidation

Hong Chen, Yanxiao Wei, Liang Peng, Jialing Ni, Yan Guo, Jiayuan Ji, Bo Jiang, Guanlong Yu. *Long-term MIBK removal in a tubular biofilter: Effects of organic loading rates and gas empty bed residence times*. Pages 87-95.

A novel gas biofilter, namely the tubular biofilter (TBF) was developed and successfully used for toluene removal from waste gas streams. To furtherly explore its performance for methyl isobutyl ketone (MIBK) removal, the TBF was continuously operated for over 284 days under various organic loading rates (OLRs) (ranging from 20 to 340 g m−3 h−1) and gas empty residence times (EBRTs) (ranging from 15 to 5 s) in this paper. The results show that the TBF could achieve a high MIBK removal efficiency (RE) at a short gas EBRT of 5 s. The mean maximum REs of MIBK were 98.67%, 88.95%, 77.93%, 71.74%, and 55.92% under the OLRs of 19.89, 39.33, 78.96, 160.17, 338.02 g m−3 h−1, respectively. The maximum elimination capacity for MIBK was as high as 200 g m−3 h−1, while the critical load was about 20 - 30 g m−3 h−1. Based on the Michaelis-Menten kinetic model, the biokinetic constants Ks was found to be 8.56 g m−3 and rmax was 0.14 g m−3 h−1. The biomass clogging appeared at the EC of over 80 g m−3 h−1. The TBF showed a high efficient performance for MIBK removal due to the enhancement of highly porous polyurethane sponge and new tubular configurations.

- **Keywords:** Biofilm; Biofiltration; Elimination capacity; Excessive biomass accumulation; VOC

Ghasem Azarian, Ali Reza Rahmani, Mahmoud Masoudi khoram, Zeinab Atashzaban, Davood Nematollahi. *New batch electro-coagulation process for treatment and recovery of high organic load and low volume egg processing industry wastewater*. Pages 96-103.

In this study, a new batch cell with undivided operating and processing units based on electrocoagulation was used for wastewater treatment of egg processing industries. In addition, the influence of operational parameters such as current density, retention time and type of electrode on the amount of chemical oxygen demand (COD), total suspended solids (TSS) and total coliform (TC) removal were investigated. The results showed that COD, TSS and TC removal efficiency increases with increasing current density and retention time. Of course it should be noted that, in the final evaluation of these parameters, the operational costs, electrochemical energy consumption (EEC) and electrode consumption costs should be considered. Maximum removal of COD (99%), TSS (98.5%) and TC (99.99%) were achieved by an aluminum electrode in 10 min retention time and a current density of 6.6 mA cm−2. In addition, the aluminum electrode with EEC of 14.2 kW h m-3 and the anode consumption of 0.53 mg cm−2 is cost efficient as compared with an iron electrode. According to results, treatment of egg processing industry wastewater with a low volume of wastewater and high amount of organic load is carried out easily by electrocoagulation process (ECP) as compared to other common methods. Moreover, the proposed reactor has a high efficiency in the treatment of industries wastewater and produces an effluent with TSS and COD lower than 5 mg L-1 which has a standard quality for discharge in the environment.

- **Keywords:** Electrocoagulation; Cell design; Wastewater treatment; Egg processing industry

Ines Ayadi, Hafedh Belghith, Ali Gargouri, Mohamed Guerfali. *Screening of new oleaginous yeasts for single cell oil production, hydrolytic potential exploitation and agro-industrial by-products valorization*. Pages 104-114.

Microbial lipid production using renewable raw material is considered an alternative for biodiesel production. In this study, several biotopes have been targeted for new oleaginous yeasts isolation. 205 yeast strains were screened to find efficient and more suitable oleaginous yeasts for agro-industrial wastes bioconversion. Using the qualitative fluorometric technique, 12 strains were pre-selected and the morphology of their lipid bodies was studied. The molecular identification showed that our isolates are closely related to six genera of oleaginous yeast. Cultivated on nitrogen limited medium, lipid content of all yeast strains exceeds 20% (w/w), confirming their oleaginous character. The highest lipid yield and content were achieved by Candida viswanathii Y-E4 (3.55 g/L) and Rhodotorula babjevae Y-SL7 (39.17%), respectively. All the lipid profiles analyzed are mainly formed by triacylglycerols of oleic acid. In addition to the lipogenic aptitude, the hydrolytic potential including cellualse and lipase activities was also studied. The highest CMCase (0.11 U/mL) and β-glucosidase (0.55 U/mL) activities were produced by the Trichosporon asahii Y-SL1 strain. However, the highest lipase activity (50 U/mL) was detected in the liquid culture of Yarrowia lipolytica Y-D1P. To minimize the SCO production cost, oleaginous yeasts were evaluated for their capacity to use agro-industrial by-products for lipids and enzymes production. Cultivated on wheat bran acid-hydrolysate, Rhodotorula mucilaginosa Y-MG1 exhibits the highest lipid yield (2.2 g/L). In parallel, a considerable lipid content 64% (w/w) and lipase activity (174.1 U/mL) were achieved by Yarrowia lipolytica Y-D1P and Trichosporon asahii Y-D1 respectively, when the soap stock of pomace olive oil refining was used as carbon source. This study opens up new perspectives in the use of industrial wastes for production of microbial lipids and high-added value products.

- **Keywords:** Microbial lipid; Oleaginous yeast; Waste oil; Lignocellulosic residues; Cellulase; Lipase

Baoyang Ding. *Pharma Industry 4.0: Literature review and research opportunities in sustainable pharmaceutical supply chains*. Pages 115-130.

The exploitation of the emerging technologies of Pharma Industry 4.0 facilitates sustainable value creation, leads to more agile, smart and personalised pharma industry, and thereby, in the long-run, enables pharma companies to obtain competitive advantages. A more sustainable pharmaceutical supply chain (PSC) should be implemented to match future operations and management of the pharmaceutical products across the entire life cycle. The main purpose of this study is to identify the potential sustainability barriers of PSC and to investigate how Industry 4.0 can be applied in the sustainable PSC paradigms. This paper systematically reviews 33 relevant articles concerning sustainable PSC and Industry 4.0, taken from peer-reviewed academic journals over a decade (2008–2018). Based on content analysis, we find that the major challenges that inhibit inclusion of sustainability in the PSCs are: high costs and time consumption, little expertise and training, enforcement of regulations, the paucity of business incentives, ineffective collaborations and coordination across the PSC, lack of objective benchmarks, and poor end-customer awareness. The technologies and innovations based on Industry 4.0 can solve these barriers with regards to four aspects: enhancing the flexibility of the PSC for patient-centric drug supplies; improving the effectiveness of coordination and communication across different entities within the PSC;

mitigating waste and pollution at different stages; and enabling a more autonomous decision-making process for supply chain managers. Our analysis reveals that future research interest should focus on: cross-linking coordination and cooperation, eco-friendly end-of-life products disposal, proactive product recall management, new benchmarks and measurement of sustainable performance, new regulation system design, and effects of incentives for sustainable activities.

- **Keywords:** Pharmaceutical; Sustainability; Supply chain; Industry 4.0; Sustainable operations

Gianmaria Pio, Ernesto Salzano. *Evaluation of safety parameters of light alkenes by means of detailed kinetic models*. Pages 131-137.

The oxidation of light alkenes is the core of the modern chemical industry and a pivotal point for several environmental and safety considerations. However, few works have dealt with the prediction of fire and explosion parameters for the definition of process conditions, for the design and safe handling of such reactive substances. In this work, flammability parameters for light alkenes (ethylene, propylene and the three butylene isomers) have been calculated by adopting the detailed kinetic mechanisms of the University of California, San Diego, integrated with C4 reactions by the Lawrence Livermore National Laboratory mechanism. The new model has been adopted for the definition of flammability limits, adiabatic flame pressure and temperature, maximum rate of pressure rise, gas deflagration index (KG), auto-ignition temperature and minimum oxygen concentration. Flammability regions for nitrogen and carbon dioxide dilution have also been reported.

- **Keywords:** Light alkenes; Laminar burning velocity; Flammability limits; Maximum rate of pressure rise; Safety parameters; Combustion modelling

Sharf Ilahi Siddiqui, Saif Ali Chaudhry. *A review on graphene oxide and its composites preparation and their use for the removal of As3+and As5+ from water under the effect of various parameters: Application of isotherm, kinetic and thermodynamics*. Pages 138-163.

High level exposure of arsenic through water is a calamity for developing countries and is associated with diabetes, hypertension, neurological arteriosclerosis, cardiovascular and cancer along with others severe diseases. The removal of arsenic has become urgent but most of the treatment technologies are costly except adsorption which is inexpensive, simple and safe to handle. Graphene oxide and its composite based membranes, thin films, paper-like materials, and solid composite materials have got attention for water treatment. Because of the unique physicochemical characteristics, magnetic character, oxidizing ability, and structural defects, graphene oxide and its composite provide an advantage for arsenic treatment. This review summarizes the arsenic treatment application of graphene oxide and graphene oxide based materials with selected examples, mostly from the latest literature. The ideas of preparation, characterization of graphene oxide and its composite using fourier-transform infrared spectroscopy, Raman spectroscopy, X-ray diffraction spectroscopy, X-ray photoelectron spectroscopy, scanning electron microscopy, transmission electron microscopy, thermogravimetric analysis and vibrating-sample magnetometer, has been explored in detail. Batch studies of graphene oxide and its based materials for arsenic removal from water have been highlighted in terms of affecting parameters. The adsorption affinity and mechanism have been discussed using kinetics and isotherm models. The implementation and reusability have also been discussed in the review.

- **Keywords:** Arsenic; Adsorption; Graphene oxide; Composite; Arsenic removal

Jitae Kim, Byeong-Kyu Lee. *Enhanced photocatalytic decomposition of VOCs by visible-driven photocatalyst combined Cu-TiO2 and activated carbon fiber*. Pages 164-171.

Volatile organic compounds (VOCs) threaten the environment and human health, as many of them are highly toxic and carcinogenic. For this reason, a larger of VOCs control techniques have developed. This study, Cu-TiO2 combine with activated carbon fiber (Cu-Ti/ACF) was prepared and used as visible light-driven photocatalyst material for removal of toxic VOCs (benzene and toluene) in aqueous solution. The Cu-Ti/ACF was characterized by scanning electron microscopy (SEM), energy dispersive spectrometer (EDS), X-ray diffractometer (XRD), specific surface area (BET), X-ray photoelectron spectroscopy (XPS) and UV–vis spectrophotometer. The adsorption and photocatalytic degradation of benzene and toluene was test under different condition including the solution pH (4.0–10), catalyst dose (0.01 to 0.5 g), reaction time (0–180 min) and initial concentration ranged of 10–200 mg/L. Under the visible light, the degradation efficiencies of benzene and toluene were up to 81.2 and 97.8%, respectively. Reusability of Cu-Ti/ACF was tested and the degradation efficiencies for benzene and toluene were not affected after three cycles. The introduction of CuO and TiO2 onto ACF effectively extended the spectral response of TiO2 to the visible light. On basis of these evidences, the mechanism degradation of benzene and toluene by Cu-Ti/ ACF was proposed. The paper suggests that the Cu-Ti/ACF has potential for degradation of benzene and toluene in aqueous solution.

- **Keywords:** Toluene; Benzene; TiO2; Degradation; Photocatalytic

S.M. Al-Salem, A. Al-Nasser, A.T. Al-Dhafeeri. *Multi-variable regression analysis for the solid waste generation in the State of Kuwait*. Pages 172-180.

Accurate prediction of solid waste (SW) generation is considered an important aspect of waste management. It plays a major role in strategy development especially in developing countries. In this work, six independent variables related to the state of Kuwait were used as inputs for the development of multi-variable regression models. The aim was to predict SW generation rates from a number of sectors within the country, namely the domestic, commercial, building and construction (B&C), and agricultural ones. The variables included comprised the total population of the country, gross domestic product (GDP) index, construction area, cost of utilised constructed agricultural area and total agricultural production requirements. Statistical analysis was used to confirm the reliability of the regression models developed. The results indicated that predications were highly accurate with standard errors (SE) ranging between 3.52% and 10.46% for the indicators of the multiple regression predictive models. Multiple-variable regression models developed showed mean standard errors ranging between 0.125 and 1.09% for the dependent variables considered. The developed regression models can be used to predict individual SW components which could be used by decision makers when devising measures and policies for long-term SW management strategies.

- **Keywords:** Solid waste; Modelling; Regression; Generation; Kuwait

Qiang Chen, Guodong Shen, JunCheng Jiang, Xu Diao, Zhirong Wang, Lei Ni, Zhan Dou. *Effect of rubber washers on leak location for assembled pressurized liquid pipeline based on negative pressure wave method*. Pages 181-190.

Leakage in pressurized pipelines is a serious problem in petrochemical plants because it might cause a fire or an explosion. The negative pressure wave (NPW) method is a practical method of locating leaks in a pipeline, and it has been used widely in the energy

distribution industry. However, it is difficult to obtain the pressure wave velocity accurately and to localize leakage by using NPW method because of the complexity of real pipeline components, especially in assembled pipeline. Thus, in this study, the influence of assembly rubber washer on pressure wave velocity is analyzed; in addition, considering the effect of the rubber washer, a numerical method for calculating the velocity of pressure wave propagation in liquid pipelines is proposed. Then, the propagation velocity of NPWs is measured experimentally to verify the feasibility of the improved method on a self-made pipeline leak detection test platform. The results show that the presence of rubber washers in an assembled pipeline decreases the propagation velocity of NPWs and that the correction model established in this study can adequately modify the propagation velocity of NPWs. The improved method containing the modified formula can improve the accuracy of leak localization for assembled pressurized liquid pipelines.

- **Keywords:** Assembled pipeline; Leak location; Negative pressure wave; Propagation velocity; Rubber washer

Hossein Jalaei Salmani, Mohammad Nader Lotfollahi, Seyed Hossein Mazloumi. *A model for predicting flash point of alkane-alkane and water-alcohol mixtures by the Cubic-Plus-Association Equation of State*. Pages 191-197.

A vapor-pressure-based model has been constructed to predict the closed-cup flash points of binary miscible mixtures. The model utilizes a cubic-plus-association (CPA) equation of state (EoS) to thermodynamically describe the behavior of both liquid and vapor phases. The alkane-alkane and water-alcohol mixtures were selected to examine the predictive potential of the model. Compared to known models, which use the activity coefficient models, the proposed flash point calculation procedure has fewer binary interaction parameters (BIPs) and does not need the Antoine equation to calculate the vapor pressure of pure components. Moreover, another advantage is that by utilizing the published experimental flash point data, no binary vapor-liquid equilibrium (VLE) data are required to obtain the BIPs.

- **Keywords:** Flash point; Prediction; Non-ideal mixture; CPA EoS

Satya Sundar Mohanty, Hara Mohan Jena. *Process optimization of butachlor bioremediation by Enterobacter cloacae using Plackett Burman design and response surface methodology*. Pages 198-206.

The present study was undertaken to assess the biodegradation efficiency of native butachlor catabolizing bacterial strains isolated from the soil contaminated with the effluents from pesticide formulation units of Odisha, India. Butachlor, a chloroacetanilide class of herbicide, is widely used for the control of unwanted annual grasses and broadleaf weeds. The microbial strains designated as FP1, FP2 and FP4 showed better butachlor tolerance capability than the rest of the isolates. Out of these, the strain FP2 demonstrated the highest degradation efficiency and hence been subjected to morphological, biochemical and genetic characterisation. The bacterial isolate was identified as Enterobacter cloacae as per the 16 s rRNA gene sequencing. Two-step statistical approach was employed to optimised various parameters that affect the butachlor degradation efficiency of the bacteria. Parameters such as growth temperature, pH and media components were screened applying Plackett–Burman design and were optimised further by employing the response surface methodology. Fitting the experimental results via a second order quadratic polynomial equation having a correlation coefficient of 0.99 has been achieved. Under optimised conditions, the microbial strain was able to display a biodegradation efficiency of 1.67 mg/L/hr of

butachlor. The obtained results proved the ability of the isolated strain to be used for the remediation of butachlor-contaminated effluents efficiently.

- **Keywords:** Bioremediation; Butachlor; Enterobacter; Pesticide; Response surface methodology

Muhammed Kamil Oden, Hanife Sari-Erkan. *Treatment of metal plating wastewater using iron electrode by electrocoagulation process: Optimization and process performance*. Pages 207-217.

In this study, electrocoagulation (EC) process was used to remove COD, color and several toxic heavy metals from metal plating wastewater and central composite design (CCD) combined with response surface methodology (RSM) were applied for optimizing the operating parameters of the process, which utilized iron (Fe) electrodes. The interaction effects of the current density, reaction time and initial pH were analyzed and were correlated to assess the removal efficiencies for COD, color, total chromium, nickel and zinc. The ANOVA results revealed that the predicted models for the experimental design were within 95% confidence level, coefficient of determination (R2) and adjusted R2 were found to be higher than 96.44% and 90.04% respectively for all responses. Removal efficiencies were determined to be 76.2%, 99.9%, 98.9%, 96.3% and 99.8% for COD, color, total chromium, nickel and zinc, respectively under optimum operating conditions. In terms of electrical energy consumption and electrode consumption, the operational cost of the EC process for the removal of COD at optimum conditions was calculated to be 6.55 €/m3. The results show that the EC process seems to be an efficient treatment method for the removal of COD and toxic heavy metals from the metal plating wastewater.

- **Keywords:** Metal plating wastewater; Toxic metal removal; Electrocoagulation; Iron electrode; Optimization; Response surface method

Xuewu Jia, Feng Sun, Yi Fei, Manping Jin, Fan Zhang, Wei Xu, Ning Shi, Zhiguo Lv. *Explosion characteristics of mixtures containing hydrogen peroxide and working solution in the anthraquinone route to hydrogen peroxide*. Pages 218-222.

The explosive properties of mixtures of aqueous hydrogen peroxide (H2O2) and working solution (WS), and the main components of the working solution (1, 3, 5-trimethyl benzene(TMB), trioctylphosphate (TOP)) were investigated by the drop weight test. The explosion range was interpreted by thermal calculation, and the calculated results agreed well with the experimental test. The explosion mechanism of the TMB/H2O2 mixture is the partial oxidation of TMB by H2O2, which is qualitatively obtained by analyzing the gaseous and liquid products of the TMB/ H2O2 mixture after explosion. Finally, a proposed explosion mechanism was suggested.

- **Keywords:** Hydrogen peroxide; Anthraquinone process; Explosive property

Bin Zhou, Jianming Wu, Junfeng Wang, Yuguo Wu. *Surface-based radon detection to identify spontaneous combustion areas in small abandoned coal mine gobs: Case study of a small coal mine in China*. Pages 223-232.

In China, small coal mines refer to non-state-run coal mines with an annual production of less than 300,000 tons. The mining recovery rate of these small Chinese coal mines is low, and large amounts of coal remain in the gob. The mining seams of small coal mines are shallow, which induces extensive fissures between the gob and ground and provides easy pathways for air leakage. Consequently, long-term air leakage and oxygen supplies can result in spontaneous coal combustion in the gob, forming fire areas for many years.

Determination of spontaneous combustion areas in the gob of small coal mines is difficult because fire sources are hidden underground and the geological data and roadway layout are poorly documented. Surface-based radon detection provides a fast, accurate, and low-cost method to identify spontaneous combustion areas in the gob of small coal mines. This study focuses on a small abandoned coal mine in Shanxi Province, China, using surface-based radon detection. Three abnormal temperature areas (A, B, C) and a potential abnormal temperature area (D) were identified. Drilling was subsequently performed to measure the temperature distribution in these areas. The results show that spontaneous combustion areas in small abandoned coal mine gobs can be successfully identified.

- **Keywords:** Small coal mines; Abandoned gobs; Spontaneous combustion; Radon measurement; Field measurement

Boon-Chin Lim, Jun-Wei Lim, Yeek-Chia Ho. *Garden cress mucilage as a potential emerging biopolymer for improving turbidity removal in water treatment*. Pages 233-241.

Agricultural anthropogenic processes have resulted in high turbidity to nearby river water. This study aims to study the possibility and mechanism of biopolymer extracted from garden cress (Lepidium Sativum sp.) seed as natural coagulant aid in a point source agriculture wastewater discharge. Various physico-chemical characterisation studies were conducted i.e. functional group, zeta potential and surface floc morphology. FTIR spectra results indicated the biopolymer was assigned to band peaks at for hydroxyl, carboxyl groups. Whilst, zeta potential was around −16 mV, describing its anionic nature. The morphologies study depicted that the addition of biopolymer produced a more compact and larger structure of the settled sludge. Influence of pH, dosage of Fe3+ and biopolymer were studied in synthetic kaolin and agricultural wastewater using factorial design. pH, dosage of Fe3+ and biopolymer significantly affect the turbidity removal in coagulation process with p-value < 0.05. While, optimized setting is at pH 5, concentration of Fe3+ is at 50 mg/L and concentration of biopolymer is at 15 mg/L for turbidity removal of 99.32%. Interestingly, it could achieve more than 92% turbidity reduction within one-minute settling time at pH 6, concentration of Fe3+ is at 8–10 mg/L and concentration of biopolymer is at 2.8–5.0 mg/L.

- **Keywords:** Agriculture; Biopolymer; Coagulation; Flocculation; Garden cress

Rubén Díez-Montero, Alessandro Solimeno, Enrica Uggetti, María Jesús García-Galán, Joan García. *Feasibility assessment of energy-neutral microalgae-based wastewater treatment plants under Spanish climatic conditions*. Pages 242-252.

The energy balance of a hypothetical microalgae-based wastewater treatment plant (WWTP) has been performed for thirteen geographic locations covering the whole range of latitudes, longitudes and climate conditions of the different Spanish regions. The proposed WWTP includes high rate algae ponds (HRAPs) for secondary treatment and nitrogen removal, anaerobic codigestion of primary sludge and the biomass grown in the HRAPs, and a combined heat and power unit for electricity and heat production. The operation of the HRAPs was optimized using the BIO_ALGAE model, which also predicted the biomass production of the HRAPs under the different climate conditions. Under the assumptions of this study, the electrical energy balance resulted neutral or even positive in all the locations during the whole year, in spite of the climatic conditions variations. However, the heat balance resulted closer to the neutral footprint. The most favorable locations (Almeria and Seville, south of Spain) were analyzed in detail, confirming the feasibility of a positive electrical energy balance, while the heat balance resulted slightly negative in the cold season. Along with the solar radiation, the air temperature and its

variation during the year are determinant to predict the feasibility of the heat balance in the proposed WWTP scheme.

- **Keywords:** Numerical simulations; Energy balance; Nature-based process; Low-cost wastewater treatment; Energy footprint; Anaerobic digestion

Geraint O. Thomas. *Buncefield: A possible alternative multi-stage route to localised overpressure generation*. Pages 253-260.

The paper presents an independent assessment of evidence in the public domain pertaining to the Buncefield fuel depot explosion event in December 2005. Based on this analysis, together with other relevant scientific observations, an alternative mechanism is proposed that could potentially account for the localised overpressure development indicated by forensic evidence, e.g. in Northgate car park, and whose origin cannot be explained by mechanisms contained within the existing lexicon of explosion development scenarios. The basis of the alternative mechanism is the interaction of a shock or blast wave from an initial event with a second separate explosion combustion front. The basic science of such shock–combustion interactions are introduced, as are the sequence of events, consistent with known facts, that could have led to a multi-stage explosion development event at Buncefield.

- **Keywords:** Buncefield; Multi-stage; Explosion; Overpressure; Shock; Combustion enhancement

Ahmad Hosseinzadeh, Ali Asghar Najafpoor, Ahmad Jonidi Jafari, Reza Khani Jazani, Mansour Baziar, Hasan Bargozin, Fardin Ghasemy Piranloo. *Application of response surface methodology and artificial neural network modeling to assess non-thermal plasma efficiency in simultaneous removal of BTEX from waste gases: Effect of operating parameters and prediction performance*. Pages 261-270.

This study aimed to assess the prediction efficiencies of response surface methodology (RSM) and artificial neural network (ANN)-based models in terms of benzene, toluene, ethylbenzene, and xylenes (BTEX) removal from a polluted airstream using non-thermal plasma (NTP). The effect that key elements of the NTP process, including temperature, BTEX concentration, voltage and flow rate, had on the BTEX elimination efficiency was investigated using a central composite RSM design along with three ANN models including Feed-Forward Back Propagation Neural Network (FFBPNN), Cascade-Forward Back Propagation Neural Network (CFBPNN) and Elman-Forward Back Propagation Neural Network (EFBPNN) with the topology of 4-h-1. The RSM and ANN models were statistically compared using some indicators including Sum of Squared Errors (SSE), adjusted R2, determination coefficient (R2), Root Mean Squared Error (RMSE), Absolute Average Deviation (AAD). According to the RSM output, voltage was the most efficient variable with a coefficient proportion of 8.28. Besides, FFBPNN was the best model among the considered ANN models. Also, the R2 achieved for ANN (FFBPNN) and RSM models were 0.9736 and 0.9656 correspondingly. Therefore, it was concluded that the ANN (FFBPNN) represents a powerful tool for modeling the BTEX removal.

- **Keywords:** Air pollution; BTEX; Non-thermal plasma; RSM; ANN

Hamidreza Pourzamani, Yaghoub Hajizadeh, Nezamaddin Mengelizadeh. *Application of three-dimensional electrofenton process using MWCNTs-Fe3O4 nanocomposite for removal of diclofenac*. Pages 271-284.

Abstract: The electrochemical removal of diclofenac (DCF) in aqueous solution was investigated by three-dimensional electrofenton (3DEF) process using Ti/TiO2-RuO2

anode electrode in the presence of composites of multi-walled carbon nanotubes (MWCNTs) and magnetite (Fe3O4) nanoparticle. The response surface methodology (RSM) coupled with central composite design (CCD) was used to evaluate the effects of different variables on the removal of DCF. Based on the experimental results, an empirical relationship between response and independent variables was obtained and expressed by a quadratic polynomial equation. Maximum DCF removal was 98.52% in optimum conditions at initial pH of 5.56, DCF concentration of 6.71 mg/L, the current density of 19.74 mA/cm2, MWCNTs-Fe3O4 concentration of 58.33 mg/L, and electrolysis time of 82.24 min. The chemical oxygen demand (COD) removal efficiency and H2O2 production in the 3DEF system were much higher than other electrocatalytic processes. This is related to the presence of MWCNTs-Fe3O4 as a particle electrode that can activate the molecular oxygen for higher production of hydrogen peroxide (H2O2) and hydroxyl radical (•OH). The MWCNTs-Fe3O4 nanocomposite indicated a high degree of stability and reusability. Additionally, 1-(2,6-dichlorophenyl) indolin-2-one, 2,6- dicholoaniline, 2,4- dichlorophenol, and 1,2- benzene dicarboxylic acid were identified as main oxidation products after 60 min reaction. Based on the reaction intermediate identified, a possible pathway for the electrochemical oxidation of DCF by the 3DEF process was proposed. Eventually, the 3DEF system with MWCNTs-Fe3O4 particle electrodes can be considered as a viable alternative for DCF removal from aqueous solution.

- **Keywords:** Three-dimensional electro-Fenton; Ti/TiO2-RuO2; MWCNTs-Fe3O4 nanocomposite; Diclofenac; Response surface methodology

Biao Kong, Zenghua Li, Enyuan Wang, Wei Lu, Liang Chen, Guansheng Qi. *An experimental study for characterization the process of coal oxidation and spontaneous combustion by electromagnetic radiation technique*. Pages 285-294.

Coal spontaneous combustion results from a complex reaction between coal and oxygen. Previous studies on coal oxidation spontaneous combustion process provided guidance for fire prevention and control. In this work, we present a novel electromagnetic radiation (EMR) method to detect spontaneous combustion of coal. We established a multi-index experimental system for estimating various factors during coal oxidation (heating) and combustion and analyzed the characteristic temperature, index gases, and EMR signals. With the increase of temperature, the central temperature of coal varies significantly with the temperature around the coal oxidation heating device. Besides, we simultaneously tested the EMR signals generated during coal oxidation and combustion. EMR signals showed a positive correlation with temperature changes (i.e., EMR signal intensity increases with the increase in temperature and vice versa). The change trend of EMR signals with the CO is notable, and there is a good correspondence between the EMR signals and the change rule of CO gas. With the increase of temperature, the dielectric properties of coal change quickly, resulting in the occurrence of thermal deformation and rupture in the coal body, which produces significant EMR signals. The research results are of great significance for applying the EMR technique to directly detect hidden fire hazards in coal mines.

- **Keywords:** Coal spontaneous combustion; EMR; Temperature field; Thermal cracking; Free electron

Aitao Zhou, Kai Wang, Tianfei Feng, Jiawen Wang, Wei Zhao. *Effects of fast-desorbed gas on the propagation characteristics of outburst shock waves and gas flows in underground roadways*. Pages 295-303.

Coal and gas outbursts are the most serious disaster in the underground mining. During an intense outburst, ejection of millions tons of coal and cubic meters of gas with high kinetic energy can cause death or injuries and even destroy underground facilities, the

intensity of outburst shock waves and gas flows is highly related to the gas expansion energy, and the gas expansion energy requires the participation of a large amount of desorption gas. There is a significant difference in the gas desorption law between the pulverized coal and the unaffected coal. To investigate the effects of fast-desorbed gas on the propagation characteristics of outburst shock waves and gas flows, the particle size distribution characteristics of pulverized coal were obtained by site investigation. Then, gas desorption experiments were conducted for coal particles of various sizes at different gas pressures and temperatures. The results indicate that a segmentation function is reasonable for representing the gas desorption law during coal and gas outbursts. Based on the gas desorption law, numerical simulation for the propagation characteristics of outburst gas flows were conducted. The results show that fast-released gas compresses the air within the roadway, thereby generating outburst shock waves that propagate at high speed. The intensity of the outburst shock waves decrease with time. Simultaneously, the gas convective transport velocity is lower than that of the outburst shock waves, large areas of high-concentration gas in roadways are induced by the outburst gas flows.

- **Keywords:** Coal and gas outburst; Gas desorption; Outburst shock waves; Gas flows

Jianying Xiong, Zheng Zheng, Xiaoying Yang, Jian He, Xingzhang Luo, Bin Gao. *Mature landfill leachate treatment by the MBBR inoculated with biocarriers from a municipal wastewater treatment plant*. Pages 304-310.

With a growing number of landfills reaching the mature stage, finding feasible alternatives for effective treatment of mature landfill leachate has become an imminent challenge for landfill management worldwide. Due to its special characteristics of low levels of biodegradable organic matters but extremely high levels of ammonia, removing nitrogen from mature landfill leachate is especially challenging. Focusing on the nitrification process, this study examined the nitrification efficiency of the moving bed biofilm reactor (MBBR) inoculated with biocarriers from a municipal wastewater treatment plant (MWTP). The MBBR was operated to treat mature landfill leachate over a period of 126 days to evaluate its nitrification efficiency in five phases with variable operation conditions in terms of running mode, hydraulic retention time, carbon source, duration of aeration and agitation, pH, and influent ammonia concentration. Our study results have indicated that the MBBR could tolerate the large fluctuations in ammonium concentrations at high levels and maintained a nitrification efficiency of above 60% under various operation conditions. The abundance of ammonia-oxidizing bacteria such as β-Proteobacteria and nitrite-oxidizing bacteria such as α-Proteobacteria in the biofilm sludge facilitated the nitrification process in the MBBR. As more MWTPs are expected to install MBBRs in the near future, inoculating the MBBR with biocarriers from MWTPs for mature landfill leachate treatment may provide a viable solution to the imminent risk of secondary landfill leachate pollution in China, and possibly other countries around the world.

- **Keywords:** Mature landfill leachate; Moving bed biofilm reactor; Nitrification; Biocarrier inoculation; Municipal wastewater treatment plant

Vasiliki Matthaiou, Zacharias Frontistis, Athanasia Petala, Maria Solakidou, Yiannis Deligiannakis, George N. Angelopoulos, Dionissios Mantzavinos. *Utilization of raw red mud as a source of iron activating the persulfate oxidation of paraben*. Pages 311-319.

The degradation of emerging micro-contaminant propylparaben (PP) by persulfate oxidation was studied in this work. The activation of sodium persulfate (SPS) was done

utilizing raw red mud (RM), a by-product of bauxite processing. RM with a specific surface area of ~10 m2/g is rich in metal oxides, including Fe, Al, Ti, Si, Na and Cu, as this has been evidenced by X-ray diffraction (XRD) patterns, and scanning electron microscopy (SEM) equipped with energy dispersive spectrometer (EDS). Experiments were conducted at RM concentrations between 0.5 and 4 g/L, SPS concentrations of 1 and 2 g/L and PP concentrations between 0.4 and 6.4 mg/L at pH = 3 in ultrapure water. PP degradation, approached by a pseudo-first order rate expression, increased with increasing SPS and RM concentrations (for the latter up to 2 g/L) and decreasing PP concentration. Acidic conditions favor iron dissolution, whose extent depends on the operating conditions; leached iron contributes significantly to PP degradation. The reaction is retarded in environmental matrices, i.e. bottled water and secondary treated wastewater highlighting possible interactions amongst RM, PP, inherent water constituents and reactive species; the latter include sulfate and hydroxyl radicals as this has been evidenced by electron paramagnetic resonance (EPR) measurements. SPS activation by RM was also coupled with other activators, i.e. simulated solar irradiation, 20 kHz ultrasound or heating to 40 °C and 50 °C in an attempt to evaluate the level of synergy. Depending on the integrated processes and the operating conditions in each case, the effect was negative (i.e. −177% for solar light), near zero or positive (i.e. 48% for ultrasound at 8 W/L).

- **Keywords:** Activators; Advanced oxidation; Metal leaching; Parabens; Process integration; Waste valorization

Xiaoling Yuan, Nihong An, Zongxin Zhu, He Sun, Jixing Zheng, Mingjun Jia, Chunmei Lu, Wenxiang Zhang, Na Liu. *Hierarchically porous nitrogen-doped carbon materials as efficient adsorbents for removal of heavy metal ions*. Pages 320-329.

Abstract: A series of hierarchically porous nitrogen-doped carbon materials (HNC) were prepared by using chitosan as main carbon/nitrogen source through a feasible sol-gel route. A variety characterization results confirm that the resultant HNC materials possess three-dimension (3D) interconnected porous structure, high BET surface area (591–1027 m2/g) and abundant surface nitrogen-containing groups (ie., pyridine N, pyrrole N, quaternary N species, etc.). All the HNC materials exhibit strong adsorption capacity for heavy metal ions (Pb2+ and Cd2+) in wastewater at room temperature, while relatively high adsorption efficiency could be achieved over the optimized material named HNC-3. Furthermore, the HNC materials can even work well in a solution with relatively wide pH range (from 2 to 6) for removing heavy metal ions, and can be easily recycled for several times without obvious loss in adsorption capability. The adsorption behaviors of Pb2+ and Cd2+ ions on the HNC materials comply with the Langmuir model and pseudo-second-order model, revealing a chemisorption nature of the adsorption process. These hierarchically porous nitrogen-doped carbon materials may have great potential for the remediation of heavy metal-polluted aqueous environment.

- **Keywords:** N-doped carbon; Hierarchical porous; Chitosan; Adsorption; Heavy metal ions

Muzammil Anjum, Rajeev Kumar, Hasan A. Al-Talhi, Saleh A. Mohamed, M.A. Barakat. *Valorization of biogas production through disintegration of waste activated sludge using visible light ZnO-ZnS/Ag2O-Ag2S photocatalyst*. Pages 330-339.

The key requirements for accelerating the anaerobic digestion process and clean energy production involve the disintegration of the recalcitrant structure of waste activated sludge and transforming it into soluble organic components for microbial degradation. Herein, the visible light-active ZnO-ZnS/Ag2O-Ag2S nanocatalyst was used for the

photocatalytic solubilization of sludge to improve methane production through anaerobic digestion. The photocatalysis released the soluble substances in sludge slurry, in which soluble chemical oxygen demand was increased from 410 to 3892 mg L−1 after 6 h. The volatile solids content was only decreased by 13.1%, which indicated that a short period of pretreatment could avoid the mineralization of organic matter. Methane production was improved by 54% in photocatalytic pretreated sludge, where the cumulative methane production was up to 0.6985 mL g−1 of VS compared with 0.4533 mL g−1 of VS in untreated sludge. Similarly, a higher organic matter removal efficiency of 54% was achieved due to the increased bioavailability of organic compounds under the influence of the pre-solubilization of sludge during photocatalysis. Moreover, photocatalysis reduced the start-up time for methanogenesis from 23 to 13 days. Overall, this study determined the significance of visible light-active ZnO-ZnS/Ag2O-Ag2S photocatalysis for sludge treatment and cleaner energy production, while providing a useful reference for its industrial applications.

- **Keywords:** Sludge; Photocatalysis; Solubilization; Pretreatment; Anaerobic digestion; Biogas

Keke Li, Huosheng Li, Tangfu Xiao, Gaosheng Zhang, Jianyou Long, Dinggui Luo, Hongguo Zhang, Jingfang Xiong, Qimin Wang. *Removal of thallium from wastewater by a combination of persulfate oxidation and iron coagulation*. Pages 340-349.

Thallium (Tl) removal from wastewater using a ferrous iron-persulfate (Fe2+-S2O82−) Fenton-like system was investigated. Factors influencing Tl removal, namely S2O82− dosage, Fe2+/S2O82 molar ratio, reaction pH, coagulation pH, co-existing metal ions, co-existing organic matter, and initial Tl concentration, were examined. The results show that Tl removal efficiency increased with increasing S2O82− dosage. Effective Tl removal (>96%) was achieved when the Fe2+/S2O82− molar ratio was higher than 1:1. The reaction pH had little effect on Tl removal, while the coagulation pH significantly affected it. Coagulation pH exceeded 10 was favorable to Tl removal (>96%). Tl removal efficiency was reduced by about 30% when the concentration of co-existing organic matter was higher than 100 mmol/L. More than 90% of Tl was removed when the initial Tl concentration increased from 20 μM to 150 μM. Based on the SEM-EDS, XPS and FT-IR spectroscopic analyses, it is concluded that the absorption of colloidal ferric hydroxide and the oxidative precipitation of the Fe2+-S2O82− system are the main mechanisms for the removal of Tl. Given the excellent Tl removal and stable performance, the Fe2+-S2O82− system could be an effective and promising alternative for Tl removal from wastewater.

- **Keywords:** Thallium; Persulfate; Oxidation; Coagulation; Heavy metals; Sulfate radicals

Bohong Wang, Yongtu Liang, Taicheng Zheng, Meng Yuan, Haoran Zhang. *Multi-objective site selection optimization of the gas-gathering station using NSGA-II*. Pages 350-359.

The gas-gathering station (GGS) is a key component in the gas field, and its site selection is an important issue for designers. Since the diffusion of gas from the station may pollute the surrounding environment, it is a trend to consider the environmental and economic factors in the site selection of GGSs. In this study, a model is developed with the objective functions of minimal construction costs and environmental impact. We apply NSGA-II to search for the Pareto frontier and couple A* algorithm to find the optimal routes, and we use the Monte Carlo method to sample the uncertain wind data and evaluate the environmental impact. The effectiveness of the proposed method is demonstrated in a design problem in a gas field. The optimal construction site for the

GGS is solved by the proposed method. The results show that this work can serve as a decision-support tool for the design of GGS.

- **Keywords:** Gas gathering station; Gas field; NSGA-II; A*; Monte carlo

Jingde Li, Hong Hao. *Far-field pressure prediction of a vented gas explosion from storage tanks by using new CFD simulation guidance*. Pages 360-378.

An extension of previous work to predict the far-field overpressures of vented gas explosions from small-medium scale storage tanks is presented. Four actual vented explosion experiments with different methane-air mixture concentrations were conducted. The recorded internal and external pressures from the tests were compared with the predictions from the Multi-Energy Method (MEM) model and Baker–Strehlow–Tang (BST) model. The limitations of these two empirical models in predicting the vented gas explosion pressures are discussed. Compared to the empirical model predictions, a combined CFD modelling approach (FLACS simulation plus ANSYS Fluent simulation) yields respectable accuracy in far-field overpressure prediction. The flame speed and initial mechanical energy, which are incorrectly assumed in the MEM and BST models, are taken into account in this study. Furthermore, this study simplifies previous work by using FLACS simulations for internal pressure estimation and a newly derived correlation for far-field pressure estimation. In addition to the peak pressure estimation, the equations to calculate the pressure-time history duration and shape are proposed. Computational efficiency and prediction accuracy are both achieved in the proposed approach for far-field overpressure predictions.

- **Keywords:** Multi-energy method; Baker–Strehlow–Tang model; Far-field pressure; Vented gas explosion; CFD; FLACS; ANSYS fluent

Pegah Rezaei, Mehran Rezaei, Fereshteh Meshkani. *Low temperature CO oxidation over mesoporous iron and copper mixed oxides nanopowders synthesized by a simple one-pot solid-state method*. Pages 379-388.

Mesoporous iron and copper mixed oxides nanopowders with high specific surface area were synthesized by a very simple, fast, surfactant-free, environment-friendly and inexpensive solid state method. The catalytic behavior of the nanopowders was investigated in low-temperature CO oxidation at atmospheric pressure. The physicochemical characteristics of the catalysts were characterized by X-ray diffraction (XRD), Brunauer–Emmett–Teller (BET), temperature programmed reduction (TPR), thermal gravimetric and Differential thermal analyses (TGA and DTA), Fourier transform infrared spectroscopy (FT-IR) and scanning electron microscopy (SEM) techniques. The powders showed mesoporous texture with relatively small pore diameter distributions with crystal sizes in nanometer order (12–30.7 nm). The incorporation of CuO into the Fe2O3 and the creation of a synergetic effect influenced the physicochemical and catalytic properties of the Fe2O3 in low temperature CO oxidation. The CuO·Fe2O3 catalyst possessed the highest BET area and activity with a CO total conversion at 100 °C. This catalyst also illustrated high catalytic stability during the reaction, without any decline in CO conversion.

- **Keywords:** CO oxidation; Catalyst; Mixed oxide; Copper oxide; Iron oxide; Mesoporous