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Hongyang Yu. *Dynamic risk assessment of complex process operations based on a novel synthesis of soft-sensing and loss function*. Pages 1-11.

Applications of soft-sensing techniques in modern complex process systems can significantly reduce the monitoring cost and minimize the chance of false alarm. However, the potential of soft-sensing techniques have yet to be adequately exploited in the realm of dynamic risk assessment. This paper attempts to close such a gap by proposing a novel synthesis of soft-sensing and loss function for dynamic risk assessment of complex process operations. The soft-sensing technique adopted in this work is based on a Bayesian formulation of the kernel regression which takes into account both the model uncertainty and data uncertainty. Such a probabilistic regression model is able to predict the probability of an undesired event in real-time. On the other hand, the potential economical losses associated with the undesired event is also quantified through loss function. Subsequently, the dynamic risk of an undesired event can be determined as the product of its occurrence probability and its associated potential economical losses. The effectiveness of the proposed dynamic risk assessment is demonstrated through an industrial case study.

- **Keywords:** Bayesian method; Dynamic risk assessment; Kernel function; Loss function; Nonlinear relationship modeling; Probabilistic regression

Karama Jardak, Ahmad Dirany, Patrick Drogui, My Ali El Khakani. *Statistical optimization of electrochemical oxidation of ethylene glycol using response surface methodology*. Pages 12-20.

Large amounts of ethylene glycol (EG) based antifreeze liquids are daily discharge into the receiving waters. The chemical oxygen demand (COD) detected in most of the lakes and rivers close to the discharge points exceeded 100,000 mg O2/L. With such an amount, biological and chemical processes are inefficient to completely remove EG. In order to efficiently remove EG, electrochemical oxidation (ECO) of EG was carried out. Niobium Boron Doped Diamond (Nb/BDD) was used as anode whereas carbon felt was used as cathode. Different operating parameters including current intensity, treatment time, electrolyte concentration and pollutant concentration were tested. The application of 0.077 A/cm2 of current density during 120 min in the presence of 7.0 g/L of Na2SO4 allowed 89.6 ± 0.2% of COD removal with 490 mg O2/L of residual COD. This result was far below the legislation standard set by the province of Quebec that allows the discharge of 800 mg O2/L of COD. The efficiency of ECO process was attributed to both direct and indirect oxidation that generate strong oxidizing species (OH°, S2O82−, H2O2, etc.)

capable of oxidizing organic matters on the surface of the anode and in the bulk of the solution.

- **Keywords:** Ethylene glycol; Electrochemical oxidation; Factorial; Central composite design

N.A. Oladoja, R.O.A. Adelagun, A.L. Ahmad, I.A. Ololade. *Green reactive material for phosphorus capture and remediation of aquaculture wastewater*. Pages 21-31.

A green biogenic resource, Gastropod shell (GS), was used as the reactive material in a column reactor to develop a double pronged approach for the management of aquaculture wastewater (AQW). The GS was used to capture and recover phosphorus (P) from AQW, for reuse as fertilizer cum soil conditioner, and for the remediation of AQW for safe discharge. The kinetics and equilibrium isotherm parameters of the P-recovery process were derived in a batch process and the time–concentration profiles of the P-recovery process and the ability of the process to remediate AQW were evaluated in a column reactor, over a period of 30 day. The batch kinetic analysis showed that the P recovery occurred via mechanism controlled by either chemisorption or ion exchange. Significant amount of the total P loaded (Pin = 50.71 g) into the column reactor was captured (Pads = 37.18 g) in the GS matrix. The values of the P-sorption-yield (P% = 73.32%) and the maximum-P-uptake (qmax = 185.9 mg/g), obtained from the column reactor, showed that the capacity of the GS for P was high and the capacity was not exhausted at the end of the 30 days. The values of the thermodynamic driving force (ΔG (kJ/mol) < 0) showed that the precipitation of phosphate, as calcium mineral, contributed to the P-recovery process. Despite the deposition of extraneous matters, as confirmed by the SEM, on the GS, the non-appearance of diagnostic peaks in the X-ray diffractogram of the spent GS showed that amorphous calcium phosphate mineral was formed on the GS.

- **Keywords:** Aquaculture wastewater; Column reactor; Eutrophication; Nutrient recovery; Phosphorus recovery; Resource recovery

Zhenlin Li, Haifeng Zhang, Dongjie Tan, Xin Chen, Hongxiang Lei. *A novel acoustic emission detection module for leakage recognition in a gas pipeline valve*. Pages 32-40.

Internal valve leakage in a natural gas pipeline seriously impairs the safe operation on pipelines, and the recognition of leakages has therefore been a major concern of the industry. In this study, a novel leakage detection scheme based on kernel principal component analysis (kernel PCA) and the support vector machine (SVM) classifier for the recognition of the leakage level is constructed. Using this approach, the acoustic signal of the leakage is obtained as the feature source using an acoustic emission (AE) sensor. The kernel PCA is used to reduce the dimensionality of the features and extract the optimal features for the classification process, and the SVM is applied to perform the recognition of the leakage levels. The performance of the classification process based on kernel PCA and the classifier are evaluated in terms of the accuracy, Cohen's kappa number and training time. The experimental results demonstrate that the intelligent recognition model based on kernel PCA and SVM classifier is very effective for recognizing the leakage level of a valve in a natural gas pipeline.

- **Keywords:** Valve leakage recognition; Acoustic emission; Kernel principal component analysis; Support vector machine; Nondestructive testing

K. Srithar, T. Rajaseenivasan. *Performance analysis on a solar bubble column humidification dehumidification desalination system*. Pages 41-50.

This paper describes the performance of a solar bubble column humidification dehumidification desalination system. A solar bubble column humidifier is fabricated similar to a single slope single basin solar still, where the saline water directly gets heated by the solar energy. The air enters into the humidifier through the nozzles, mixes with the water, gets humidified, and part of the air is condensed in the glass cover and the remaining air is condensed in the dehumidifier. Preliminary experiments are carried out to study the ability of the bubble column humidifier and then the humidifier connected with a dehumidifier to analyze the overall system performance. First set of experiments are carried out to analyze the effect of direct and preheated air supply (by a solar air heater) in the humidifier. Integration of solar air heater shows considerable enhancement of specific humidity in the humidifier outlet. In second set of experiments, the humidifier is integrated with the solar air heater and studied by varying the humidifier water depth and mass flow rate of air. The experiments are continued to investigate the humidifier performance with the turbulators in solar air heater. The best humidifier water depth, air flow rate and turbulator are selected from the previous experiments and the test is continued by integrating the humidifier with the dehumidifier. The humidifier integrated with the solar air heater contains concave turbulators provide the maximum specific humidity gain of 0.187 kgwater/kgair, whereas the humidifier integrated with the solar air heater without turbulator gives the maximum specific humidity gain of about 0.11 kgwater/kgair. The peak distillate of 20.61 kg/m2 day is collected.

- **Keywords:** Humidification dehumidification system; Bubble column humidifier; Solar air heater; Solar desalination; Turbulators; Solar still

Jiwan Singh, Lakshmi Prasanna Lingamdinne, Jae-Kyu Yang, Yoon-Young Chang, Byeong-Kyu Lee, Janardhan Reddy Koduru. *Effect of pH values on recovery of nano particles (NPs) from the fine fraction of automobile shredder residue (ASR): An application of NPs for phenol removal from the water*. Pages 51-59.

Nano particles (NPs) were synthesized from leachate of fine fraction (<0.25 mm) of automobile shredder residue (ASR) at pH levels of 3, 5, 7, 9 and 12. The removal of phenol using NPs in water was investigated to determine whether applying NPs for phenol removal from wastewater would be feasible. The recovered NPs were analyzed by scanning electron microscopy (SEM), Fourier transform infrared (FTIR) spectroscopy, X-ray diffraction (XRD) and X-ray photoelectron spectroscopy (XPS). In this research, phenol degradation was studied with hydrogen peroxide to assess the potential applicability of NPs for the treatment of wastewater. The results of the SEM and TEM analyses show that the separated NPs were <50 nm in size. The FTIR spectra indicate the presence of CO and OH bonds in the NPs. The XRD results show the presence of metals oxides of Fe, Zn, and Cu, among others, on the surfaces of the NPs. The results of the XPS analyses show that various elements (e.g., C, O, Zn, and Fe) existed in the recovered NPs. The degree of phenol degradation by NPs in the presence of hydrogen peroxide was significant. Phenol degradation was found to be 100% for NPs synthesized at pH levels of 3 and 7 at a reaction time of 210 min. A pseudo-first-order kinetic model showed a very good fit to the phenol degradation results. The probable mechanism for the removal of phenol by NPs was the degradation of phenol by hydroxyl radicals which were produced during the reaction between H2O2 and NPs in a liquid medium. The results of the present study indicate that NPs recovered from low-grade ASR can be applied for the removal of phenolic compounds from water.

- **Keywords:** Automobile shredder residue; Nano particles; Phenol; Scanning electron microscope; X-ray diffraction; X-ray photoelectron spectroscopy

Michael Bjerre, Jacob G.I. Eriksen, Anders Andreasen, Carsten Stegelmann, Matthias Mandø. *Analysis of Pressure Safety Valves for fire protection on offshore oil and gas installations*. Pages 60-68.

The effectiveness of fire Pressure Safety Valves (PSV) has been investigated when offshore process equipment is exposed to a fire. Simulations of several typical offshore pressure vessels have been performed using the commercial software VessFire. The pressure vessels are exposed to a small jet fire, large jet fire, and a pool fire on both the wetted and unwetted part of the vessels. Rupture times of the vessels are calculated by comparing the pressure in the vessel with the tensile strength of the material. Rupture times are then compared for the vessels, with and without a PSV, in order to see the effect of the installed PSV. It is found that when a fire affects the unwetted part of a vessel, the PSV offers only minor or no additional protection. When a fire affects the wetted part of a vessel, the PSV relieve the inventory as designed. It is argued that PSVs provide insufficient fire protection for typical offshore fire scenarios and that Blowdown Valves and Passive Fire Protection should be considered as alternatives.

- **Keywords:** PSV; Fire protection; Pressure vessel; Oil and gas; Offshore installations; Fire simulation

Samirys Sara Rodrigues Cirqueira, Eduardo Hiromitsu Tanabe, Mônica Lopes Aguiar. *Evaluation of operating conditions during the pulse jet cleaning filtration using different surface treated fibrous filters*. Pages 69-78.

This work was performed in order to evaluate the operating conditions during the pulse jet cleaning filtration using different surface treated fibrous filters. The experiments were realized using a small flat media. The comparative studies were performed with untreated and treated (singeing/calendering and calendering/thermofixation with an eggshell type anti-pilling finish (smooth surface) on one side) polyester filters to remove micrometric particles of dolomitic limestone. Filtration tests were conducted with a superficial velocity of 4 cm/s. The stipulated maximum pressure drop was 100 Pa, the pulse time was 200 ms and pressure pulse (Pp) of 2 kgf/cm2. The filters showed satisfactory performance during fifty cycles. The untreated filter presented better cleaning efficiency and lower residual pressure drop, resulting in better regeneration of the filter during fifty cycles. However, the collection efficiency of the untreated filter was lower, compared to the surface-treated filters. The findings indicate that it is important to use surface treatment of filters in order to avoid deep deposition of particles and achieve high collection efficiencies during prolonged filtration cycles.

- **Keywords:** Gas filtration; Pulse jet cleaning; Filter efficiency; Surface treatment; Cleaning effect; Filter cleaning

E. Demirbas, M. Kobya. *Operating cost and treatment of metalworking fluid wastewater by chemical coagulation and electrocoagulation processes*. Pages 79-90.

The present study dealt with treatment performances and operating cost of real metalworking fluid wastewater (MWFW) using chemical coagulation (CC) and electrocoagulation (EC) processes. The optimum coagulant dosage for COD and TOC removal efficiencies from the MWFW was determined with varying concentrations of alum, aluminium chloride, ferric sulphate, and ferric chloride. COD and TOC removal efficiencies in the coagulant dosage range of 50–1000 mg/L were obtained as 65–97%

and 49–81% for alum, 48–96% and 38–80% for aluminium chloride, 43–92% and 36–76% for ferric sulphate, and 55–93% and 41–77% for ferric chloride, respectively. The aluminium-based coagulants at a pH of 7.5 showed better performances than ferric-based coagulants in terms of COD and TOC removals. COD and TOC removal efficiencies from the MWFW in the EC process were 93% and 80% for Al electrode at a pH of 5, 80 A/m2 and 25 min, and 93% and 82% for Fe electrode at a pH of 7, 80 A/m2 and 25 min, respectively. Operating costs at the optimum conditions were calculated to be 1.190 US $/m3 for Al and 1.813 US $/m3 for Fe electrodes, respectively. Alum in chemical coagulation process provided a lower operating cost (0.12 US $/m3) as compared with the EC process using Al electrode (1.19 US $/m3). The results demonstrated that both investigated treatment processes were effective to treat wastewater from a metalworking plant.

- **Keywords:** Metalworking fluid wastewater; Coagulation; Electrocoagulation; Operating cost; Iron electrode; Aluminium electrode

Qing Zhao, Chengjun Liu, Dapeng Yang, Peiyang Shi, Maofa Jiang, Baokuan Li, Henrik Saxén, Ron Zevenhoven. *A cleaner method for preparation of chromium oxide from chromite*. Pages 91-100.

A new leaching process for preparing chromium oxide from chromite was studied in this paper, using Cr(VI) extracted from the remediation treatment of chromite ore processing residue (COPR) as an oxidant. Thus, the "detoxification" of deposited COPR could be achieved and no new Cr(VI)-bearing substances would be generated in preparation process of chromium oxide. Thermodynamic analysis was applied and several tests were conducted. It was found that a chromite with higher Fe(II) content showed lower stability in an oxidizing solution. A general decomposition mechanism of chromite is proposed and suggests that the oxidation of ions in spinel plays a significant role in decomposing chromite. Furthermore, the extraction process of chromium from leachate was investigated. Results demonstrated that iron, magnesium and aluminum could be effectively removed via oxalic acid treatment and subsequent pH adjustment, with chromium oxide as the final product.

- **Keywords:** Sulfuric acid leaching; Cleaner method; Chromite; Cr(VI); Decomposition mechanism; Spinel

Rajinikanth Rajagopal, David Bellavance, Md. Saifur Rahaman. *Psychrophilic anaerobic digestion of semi-dry mixed municipal food waste: For North American context*. Pages 101-108.

Treating municipal organic solid wastes economically is a challenge, predominantly in cold and high-altitude regions, where the temperature can be below 20 °C. The aim of this research was to improve the anaerobic digestion (AD) of food waste (FW) with or without animal manure in a low-cost psychrophilic anaerobic digestion in sequencing batch reactor (PADSBR) at 20 °C. Feed solid content was varied from 37% to 13%, mainly to validate the stability of digestion process suitable for different scenarios and OLR was increased from 0.8 to a maximum of 4.2 kg VS/m3 d. Results showed that methane production from FW mixture was feasible at low-temperature and specific methane yield of 0.401 ± 0.01 m3 CH4/kg VSfed was observed even at high OLR. When loading rates applied to bioreactors were increased by 225%, methane conversion rates decreased only by 10%, while maintaining the operational stability (e.g. no foaming, no acidification). Methane content was constantly in the range of 64–69%, which shows the quality of biogas is excellent and remained almost steady. The results suggest that PADSBR at 20 °C is comparatively efficient in saving the heat energy and at the same time obtains the CH4 values close to mesophilic/thermophilic conditions. This concept is particularly vital for cold countries facing energy constrains.

- **Keywords:** Anaerobic digestion; Ammonia; Food waste; Methane yield; Psychrophilic temperature; High solids

Mingwei Liu, Guoren Xu, Guibai Li. *Effect of the ratio of components on the characteristics of lightweight aggregate made from sewage sludge and river sediment*. Pages 109-116.

Previous studies shown that sewage sludge and river sediment can be used to produce lightweight aggregate (LWA). Control of the ratio of components in the LWA production process is important. In this study, we investigated the effect of mass ratio (K) of basic (Fe2O3, CaO, and MgO) and acidic (SiO2 and Al2O3) oxides on the characteristics of LWA. The studies show that LWA with lowest water absorption, the lowest solubility in hydrochloric acid and the highest grain density, the highest bulk density can be obtained when K in the range of 0.15–0.3, the properties of LWA in accordance with the standard of GB/T 17431.2-1998, China. When K was fixed at 0.2, the mass ratio of SiO2:Al2O3 in the range of 4:1–1:1 and the mass ratio of Fe2O3:CaO:MgO in the range of 5:2.2:1–1.7:1.9:1 resulted in LWA with the desired physical properties, the maximum compressive strength can reach 17.07 MPa. The heavy metals experiments show that the leaching content (Cd, Cr, Cu and Pb) is closely related to a variation in K ratio, heavy metals can existed as stable crystalline compounds in LWA, and exhibiting excellent heavy metals solidification ability even it subjected to destruction, which indicates that stronger chemical bonds are formed between these heavy metals and the components through heat-induced transformation to the crystalline state. Investigations indicate that K can be a useful parameter to optimize LWA qualities.

- **Keywords**: Lightweight aggregate; Sewage sludge; River sediment; Acidic-basic oxidant; Heavy metals; Physical properties

A.G. Skerman, S. Heubeck, D.J. Batstone, S. Tait. *Low-cost filter media for removal of hydrogen sulphide from piggery biogas*. Pages 117-126.

The presence of elevated concentrations of hydrogen sulphide (H2S) in piggery biogas is problematic due to its corrosiveness and toxicity. At small scale, the cost of using iron or carbon-based commercial filter media to remove H2S can act as a barrier to the uptake of on-farm biogas technology. To identify cost-effective, alternative options, this study tested and compared H2S removal by the commercial iron-oxide H2S scavenger (cg5) with the alternative solid media: granulated steel furnace slag (GSFS), red soil, compost, composted beef feedlot manure, granular activated carbon (GAC) and biochar. Experiments measured single-pass H2S removal from a pre-humidified standard gas (2000 ppm H2S in nitrogen) onto solid media contained in a cylindrical plastic column (DN 25 mm, depth 110–147 mm). The commercial medium (cg5) performed considerably better than the other media, achieving sulphur removal of 143 g S/kg medium at breakthrough (>10 ppm outlet H2S). A red soil was the most promising alternative medium (2–12 g S/kg medium at breakthrough). The crystalline structure of the iron-oxide minerals appeared to strongly influence the H2S removal capacity of the red soils, and pressure drop was generally high. Bulking with ground sugar cane mulch (SCM) was effective at reducing pressure drop. Interestingly, H2S removal with red soil improved when the soil was regenerated by exposure to air, followed by reuse in the column. Overall, red soil may be a suitable low-cost option, especially for polishing biogas after initial biological H2S removal.

- **Keywords:** Biogas; Hydrogen sulphide; Iron-oxide; Pig; Swine; Manure

A. Alibakhshi, H. Mirshahvalad, S. Alibakhshi. *Prediction of flash points of pure organic compounds: Evaluation of the DIPPR database*. Pages 127-133.

The flash point is one of the most important flammability properties of compounds for the design of inherently safe processes. Many models have been developed to predict the flash point using the DIPPR database. However, for only 740 of the 1628 organic compounds available in the DIPPR database, the data for both flash point and normal boiling point were experimentally determined. For the other compounds, at least one of these properties was predicted and therefore is not appropriate for model development. The present study introduces a model to predict the flash points of pure organic compounds using their molecular structures and normal boiling points. The new model exploits the equality of the relative errors observed for the normal boiling point and flash point values predicted using the Joback method. Consequently, the relative error of the predicted normal boiling points can be used as a scaling factor to modify the predicted flash points. The ability of the model to evaluate the accuracy of a database was investigated. The ratio of the relative error of the predicted flash point to the relative error of the predicted normal boiling point obtained using the Joback method was proposed as a measure to evaluate the accuracy of flash point data.

- **Keywords:** Flash point; Normal boiling point; Group contribution method; DIPPR; Joback method; QSPR molecular based models

Naoyuki Kishimoto, Masaki Hatta, Masaaki Kato, Hideo Otsu. *Effects of oxidation–reduction potential control and sequential use of biological treatment on the electrochemical Fenton-type proces*. Pages 134-142.

This paper reports on the effects of an oxidation–reduction potential (ORP) control on the electrochemical Fenton-type process (EFT process) and the efficacy of a combined approach, namely, the EFT process with an ORP control together with an activated sludge process, on the treatment of wastewater contaminated with 1,4-dioxane. The EFT process with an ORP control was able to improve the current efficiency from 16.9% to 73.6–81.9%. A superior performance for both the current efficiency and the treated water quality was recorded by the EFT process with an ORP control of 1000 mV. This superior result was ascribed to the approach preventing an excessive accumulation of hypochlorous acid. Two combined processes, namely, an activated sludge process followed by the EFT process with an ORP control (AS-EFT process) and the EFT process with an ORP control followed by an activated sludge process (EFT-AS process), were examined by using 1,4-dioxane contaminated municipal wastewater. As a result, the AS-EFT process was superior to the EFT-AS process in respects of both energy consumption and the performance of chemical oxygen demand (COD) removal, as well as the removal of 1,4-dioxane, due to the smaller COD loading onto the EFT reactor in the AS-EFT process.

- **Keywords:** Activated sludge process; Advanced oxidation process; Biodegradability enhancement; 1,4-Dioxane; Electro-Fenton-type process; Oxidation–reduction potential

Peiwei Xin, Faisal Khan, Salim Ahmed. *Dynamic hazard identification and scenario mapping using Bayesian network*. Pages 143-155.

Hazard identification is of vital importance in risk management. It is the first step of undertaking accident likelihood and associated consequence analysis. The traditional hazard identification techniques suffer from being static. New information or evolving conditions cannot be easily incorporated in already identified hazards. To overcome this, the Bayesian network is used to bring dynamics to the hazard identification step. The present work develops a new methodology to map hazard scenarios into the Bayesian network model, which enables real time hazard identification. The model presents a probability ranking for hazards using given input observations. It helps to identify the most credible hazard scenarios for further analysis. Sensitivity analyses are also conducted to investigate the influence of the input parameters on identified hazards.

- **Keywords:** Hazard identification; Hazard scenarios; Bayesian network; Risk assessment; Dynamic hazards; Fire and explosion hazard.

Morteza Zadkarami, Mehdi Shahbazian, Karim Salahshoor. *Pipeline leak diagnosis based on wavelet and statistical features using Dempster–Shafer classifier fusion technique*. Pages 156-163.

Leaks in hydrocarbon transporting pipelines cause major problems including environmental hazards and financial losses. Many leakage diagnosis methods try to detect the leaks with a small False Alarm Rate (FAR). However, they are not capable of identifying leakage location and size. In this paper, a novel leakage diagnosis method is introduced which not only detects the leakage occurrence, but also determines its location and size. The inlet pressure and outlet flow signals at different leakage conditions are generated using the OLGA software. Different feature extraction methods including statistical techniques and wavelet-based approaches are used to extract the features from the signals. The statistical and wavelet features are then individually used as inputs to a Multi-Layer Perceptron Neural Network (MLPNN) classifier to determine the leakage state. Finally, the outputs of two MLPNN classifiers are fused by the Dempster–Shafer (D–S) technique. The proposed leakage diagnosis method is applied to the first 20 km of the Golkhari to Binak pipeline located in the south of Iran. Simulation results show that the Correct Classification Rate (CCR) of the simultaneous detection and identification of the leakage location and size is about 95%.

- **Keywords:** Leak diagnosis; Multi-Layer Perceptron Neural Network (MLPNN) classifier; Wavelet transform; Statistical features; Dempster–Shafer (D–S) classifier fusion; Correct Classification Rate (CCR); OLGA software

B. Ruiz, R.P. Girón, I. Suárez-Ruiz, E. Fuente. *From fly ash of forest biomass combustion (FBC) to micro-mesoporous silica adsorbent materials*. Pages 164-174.

According to the EU recommendations on solid residue management, fly ashes derived from biomass combustion and other solid wastes from energy production must be recycled since their disposal in dumps and landfills, etc., leads to environmental and space availability problems. This study is focused on minimization and beneficiation of an industrial waste, fly ash, derived from the combustion of forest biomass in a fluidized bed combustor for subsequent use as a precursor of porous silica materials for environmental applications. The predominant component of fly ashes is silica, which comes from both the original composition of the forest biomass and from the bed of the fluidized combustor. The fly ashes were activated with KOH, at a temperature of 750 °C using soaking time of 60 min. The porosity in these materials is mainly due to the activation of silica and, to a lesser extent, unburned carbons. These materials, that have a surface area, SBET, of up to 654 m2/g, are mainly mesoporous (0.186–0.258 cm3/g) with a significant proportion of micropores (0.116–0.142 cm3/g). Mesoporosity developed mainly in the inorganic part of the fly ash. Fly ash from forest biomass combustion can be used as a precursor of adsorbent materials or as catalyst support.

- **Keywords:** Biomass-fly-ash; Fluidized-bed-combustion; Waste-minimization-valorization; KOH-activation; Porous-silica; Adsorbent-catalyst-materials

Amirhosein Rad, Davood Rashtchian, Naser Badri. *A risk-based methodology for optimum placement of flammable gas detectors within open process plants*. Pages 175-183.

Although the main objective of utilizing gas detection systems is risk reduction by detecting high-risk scenarios, the majority of published placement procedures do not

address the risk concept quantitatively. To include this concept, a risk-based methodology is proposed that consists of four key steps: input data, dispersion analysis, risk analysis, and optimization. In the first step, a set of release scenarios are defined and required data, including frequency of release, wind rose, and grid set, are provided. In the dispersion analysis step, the set of scenarios is simulated using a dispersion simulation tool and the ability of grid points to detect any scenario is stored in a binary matrix called detection matrix (DI). In the risk analysis, the risk of each scenario is calculated incorporating these factors: frequency, damage to personnel, asset loss, and probability of delayed ignition. Once the DI and risk of scenarios are provided, at the last step, optimum placement is performed using a risk-based objective function, which is defined as the sum of the risk of undetected scenarios. The optimization formulation called maximum risk reduction is solved by a greedy approach known as dynamic programming in which the location of detectors is determined by an iterative procedure: each time finding the grid point that can cover maximum undetected risk. The applicability of the methodology is shown in a case study and the results are compared with a coverage-based formulation.

- **Keywords:** Risk; Detector; Sensor placement; Flammable gas; Optimization; QRA

Swapnila Roy, Papita Das, Shubhalakshmi Sengupta. *Treatability study using novel activated carbon prepared from rice husk: Column study, optimization using response surface methodology and mathematical modeling*. Pages 184-193.

In this present study, activated carbon was synthesized from rice husk and was used for the removal of fluoride present in water. The adsorption of fluoride from aqueous solution by activated carbon (ACRH) was investigated in a laboratory-scale fixed-bed column. A two-level three factor (23) full factorial central composite design with the help of Design Expert Version 7.1.6 (Stat Ease, USA) was used for optimization of the fluoride removal process and evaluation of interaction effects of different operating parameters: initial fluoride concentration (20–50 mg L−1), flow rate (5–10 mL min−1) and bed height (3–7 cm) were studied. The higher correlation coefficient (R2) value of 0.9893 and low p value (<0.0001) indicating the fitness of the response surface quadratic model developed by the Design expert optimization process. Numerical optimization was used to identify the optimum conditions for achieving the targeted breakthrough time of 17.26 h. The optimum conditions were found to be initial fluoride concentration of 50 mg L−1, flow rate of 10 mL min−1and bed height of 3 cm. A confirmatory experiment was conducted to evaluate the accuracy of the optimized procedure. The Thomas model showed excellent fit to the dynamic fluoride adsorption data obtained from the experimental results. Therefore, it can be concluded that the current investigation provided valuable insights for designing and establishing a continuous waste water treatment process.

- **Keywords:** Adsorption; Activated carbon from rice husk; Fluoride; Fixed-bed column; Response surface methodology; Desirability function

Evandro Zanin, Jaqueline Scapinello, Maickson de Oliveira, Cassiano Lazarotto Rambo, Francini Franscescon, Lucimaira Freitas, Josiane Maria Muneron de Mello, Marcio Antonio Fiori, J. Vladimir Oliveira, Jacir Dal Magro. *Adsorption of heavy metals from wastewater graphic industry using clinoptilolite zeolite as adsorbent*. Pages 194-200.

Most paints used for printing in the graphic industry contain traces of heavy metals that are dissolved and carried in the effluent, and the risk posed by these contaminants in the environment is associated with toxicity and bioaccumulation in living beings. The aim of this study was to evaluate the use of natural clinoptilolite zeolite (CL) as adsorbent for

removal of heavy metals in wastewater from the graphic industry. Adsorption experiments were performed with the CL zeolite for copper(II), chromium(III) and iron(III) so as to determine equilibrium constants and kinetic models. Kinetic assays performed for each metal resulted in removal up to 95.4% iron, 96.0% copper and 85.1% chromium, at 25.0 °C and pH 4.0. The zeolite selectivity followed the order Fe > Cr > Cu and the adsorption mechanism followed pseudo-first order kinetic model for copper and chromium and pseudo-second order for iron. The Langmuir model provided the best fit of adsorption isotherms for chromium and copper while Freundlich model was the best for iron. Toxicity and genotoxicity assays in Allium cepa showed the efficiency of the use of CL zeolite as an adsorbent for treating printing industry effluent, showing no toxic and genotoxic potential, contrary to untreated effluent which showed a decrease in germination and increase in total cells with alterations (toxic and genotoxic effect).

- **Keywords:** Zeolite; Heavy metals; Wastewater; Graphic industry; Toxic effect; Genotoxic effect

Elena Stefana, Filippo Marciano, Paola Cocca, Marco Alberti. *A Near Field–Far Field model for assessing Oxygen Deficiency Hazard*. Pages 201-216.

Oxygen Deficiency Hazard (ODH) due to inert gas releases can be assessed by the use of predictive models. Several models are available in the literature: the majority of them can be classified as "well-mixed" models because they assume the existence of completely and instantaneously well mixed air. In order to provide a more precise estimation of the indoor oxygen level in the breathable air close to a release point, we propose a Near Field–Far Field (NF–FF) model in which the Near Field volume is an output and can vary over time. The trend of the Near Field size can be a useful data for the risk assessor in order to determine the safety distance from point source releases, and improve the emergency response plan. Starting from balances of mass of air and moles of oxygen both in the Near Field and in the Far Field, the objective of our model is to predict the volume of the Near Field that contains a limit value for the oxygen concentration at every time instant. The approach includes several analytical formulas that model the different flows occurring in each field and between the two fields. In particular, we assume the existence of inert gas releases, forced and natural ventilation airflows, interzonal airflows, and air that has to move from the Far Field to the Near Field, or vice versa, for assuring a limit value for the oxygen concentration in the Near Field. Finally, examples of the application of this model in some case studies available in the literature are presented and discussed.

- **Keywords:** ODH; Two-zone; Asphyxiation risk; Mathematical model; Inert gas; Occupational health

Kai Zhang, Zhirong Wang, Lei Ni, Yangyang Cui, Yaya Zhen, Yiqing Cui. *Effect of one obstacle on methane–air explosion in linked vessels*. Pages 217-223.

The effect of one obstacle on the explosion intensity of a methane–air mixture in connected vessels was studied. The experimental results suggested that the blockage ratio and the position of obstacles played a great role in this intensity. The obstacles could increase the reaction speed. When the blockage ratio reaches a certain value, the disturbance effect on the flame is at its highest, and the turbulence intensity and explosion intensity are at their strongest. If the obstacle's blockage ratio is greater than or less than this value, the explosion intensity is weaker. If the obstacles are closer to the initiating container, the combustion pressure will rise earlier both in the initiating container and in the connecting pipe. However, the effect of the obstacle position on the

peak combustion pressure is limited. The conclusions provided an important reference for the safety design of explosion venting and explosion resistance.

- **Keywords:** Linked vessels; Obstacle position; Explosion intensity; Blockage ratio

Sureshinie Warnasooriya, Manisha Yasanthi Gunasekera. *Assessing inherent environmental, health and safety hazards in chemical process route selection*. Pages 224-236.

During early stages of plant design and development chemical process route selection needs to be carried out considering factors such as inherent safety, health and environment associated with the plant along with economic aspects. These factors need to be studied by looking at the worst possible impact that can result in from a catastrophic emission and also from daily operational conditions in the plant. This paper presents a methodology that can be used to select process routes during early design stages based on inherent safety, health and environmental friendliness considering impacts due to daily plant operational activities. An integrated index called Inherent Chemical Process Route Index (ICPRI) is proposed. The ICPRI considers the potential toxicological impacts on the environment and on the occupational health and the potential chemical and process safety impacts within the plant. A lower ICPRI value indicates a more inherently environmentally friendly, inherently occupationally healthy and inherently safer process route. The ICPRI is tested on four routes to produce acetone. The propene oxidation route showed the lowest ICPRI value indicating having the lowest hazard among potential chemical process routes based on the inherent safety, health and environment assessment.

- **Keywords:** Environmental hazard; Occupational health; Inherent safety; Chemical process route selection

Jihao Shi, Yuan Zhu, Guoming Chen, Ruoxin Zhang, Zichen Guo. *Assessment on blast loading resistance capacity of corrugations on offshore cabins based on the P–I model*. Pages 237-249.

Pressure–impulse (P–I) diagrams are commonly used for assessment on blast resistance capacity of corrugations on offshore cabins for given blast-loading scenarios or in the early design. Current methods such as experimental models, analytical models and Nonlinear Finite Element Analysis (NLFEA) models could be used to generate the P–I diagram. However , each single model has certain shortcomings in despite of its advantages. Based on the convenience of analytical model and the accuracy of numerical model, this study presents a numerical procedure to derive analytical formulae to easily generate P–I diagram for corrugations with NLFEA method. Numerical model of corrugations which considers strain rate effect, buckling and membrane effects and adopts an equivalent plastic strain based failure criterion is built. Parametric studies are performed to investigate the parametric effects on the P–I diagram. Based on the numerical results, analytical formulae to predict the P–I diagram are derived. An experimental case study shows that the proposed analytical formulae can be easily used to generate P–I diagram for corrugations. The results are also compared with those obtained from the SDOF approach. It is shown that the proposed procedure gives better prediction of P–I diagram than the SDOF approach.

- **Keywords:** NLFEA; Blast loading resistance capacity; Parametric analysis; Pressure–impulse model; Empirical formulae; SDOF

Xiaohui Shen, Juan Zhang, Min Hua, Xuhai Pan. *Experimental research on decontamination effect of water curtain containing compound organic acids on the leakage of ammonia*. Pages 250-261.

Tests between a pure water curtain and a water curtain containing three organic acids (CH3COOH, C6H807 and C4H6O5) and surfactants were conducted to compare the release of ammonia in confined space. These additives are composed of different concentrations of single CH3COOH, C6H8O7, C4H6O5 solution and their pair combinations of compound additives. The results showed that the organic acids can promote the chemical decontamination effect of the water curtain on ammonia. The compound additives have better synergistic decontamination effect on ammonia. The decontamination mechanisms are physical absorption, air entrainment, physical block and chemical absorption. The addition of surfactant additive can improve the surface properties of the solution, reduce the surface tension, increase the contact area with the water curtain and ammonia, efficiently promote the physical and chemical effect of contains inorganic salt additive. The causticity of organic additives was tested and the results showed that three organic acids have faint corrosive effect on the surrounding facilities.

- **Keywords:** Water curtain; Decontamination of ammonia; Compound additive; Synergistic effect; Optimal ratio

L.L. Lulbadda Waduge, S. Zigan, L.E. Stone, A. Belaidi, P. García-Triñanes. *Predicting concentrations of fine particles in enclosed vessels using a camera based system and CFD simulations*. Pages 262-273.

One of the main challenges in industries handling biomass is the consequence of the particle breakage of pelletised biomass in smaller fractions which can lead to fine particles smaller 500 μm that can form dust clouds in the handling and storing equipment. These dust clouds present potential health and safety hazards as well as dust explosion hazards to plant operators because the airborne dust can occur in high concentrations close to the dust explosion limits of the biomass material, during the filling process of storage silos. Preventing dust explosions and the damage of plant infrastructures requires a profound understanding of the particle/air dynamics in the dust cloud circulating in the storage silo. The limited access to the storage facilities as well as the silo size requires a detailed study of the particle/air dynamics at different scales. Lab scale experiments were conducted as a first step to establishing a new optical method for measuring particle concentrations. A small scale experimental rig was fed centrally with different sized wood pellets and a single camera and a laser was utilised to capture the dust concentration in different areas of the silo. According to the experimental results, a higher mass concentration of dust was observed near the silo wall as well as near the main particle jet. However, the mass concentrations were below the explosive limits at the area in between main particle jet and silo wall. These experimental results were then feeding into a 2D CFD simulation representing the particle dynamics in the laser sheet (2D plane). Qualitative findings show a good agreement of the particle/air dynamics between experiments and simulations.

- **Keywords:** Laser; Optical method; Dust explosions; CFD; Experimental; Storage silos; Particle dynamics

Ionel Humelnicu, Adriana Băiceanu, Maurusa-Elena Ignat, Viorica Dulman. *The removal of Basic Blue 41 textile dye from aqueous solution by adsorption onto natural zeolitic tuff: Kinetics and thermodynamics*. Pages 274-287.

The adsorption of Basic Blue 41 textile dye from aqueous solutions on a zeolite tuff (Nereju-Romania) was studied in batch mode. SEM, EDX, FT-IR, N2 gas adsorption–desorption techniques of characterization of tuff samples were applied. The effects of the initial pH solution, dye concentration, contact time between the adsorbent and the dye, the temperature and the particle size of the tuff correlated with their composition were

investigated. The kinetic studies show that the adsorption follows the pseudo-second order kinetics. The experimental data were analyzed according to the Langmuir, Freundlich, Temkin and Dubinin–Radushkevich isotherms. The adsorption equilibrium was best described by the Langmuir isotherm. There was a higher adsorption capacity of particles with a 0.085 mm average diameter containing larger amounts of zeolites (predominant analcite) and a specific surface area than of those with a larger average diameter of 0.9 mm. An increase in the temperature from 8 °C to 50 °C favorably influences the adsorption equilibrium. The maximum adsorption capacity for the investigated basic textile dye (~40% pure dye) was 192.31 mg g−1 at 50 °C (at pH 5) for the average diameter particles tuff of 0.085 mm. The positive enthalpy change for the adsorption process confirms the endothermic nature of adsorption and a free energy change confirms the spontaneity of the process.

- **Keywords:** Basic dye; Volcanic tuff; Zeolite; Kinetics; Isotherms; Adsorption

David de la Lama, Rafael Borja, Bárbara Rincón. *Performance evaluation and substrate removal kinetics in the semi-continuous anaerobic digestion of thermally pretreated two-phase olive pomace or "Alperujo"*. Pages 288-296.

A study of the semi-continuous anaerobic digestion process of thermally pretreated two-phase olive pomace (TPOP) at 120 °C during 180 min was carried out in laboratory-scale completely stirred tank reactors at mesophilic temperature. Organic loading rates (OLRs) in the range of 2.0–7.0 g VS/(L d) were tested after the pretreatment and the breakage of complex organic matter. Total and soluble chemical oxygen demand (CODt and CODs) removal efficiencies decreased slightly between 77.9–71.7% and 92.3–85.0% when the OLR increased from 2 to 5 g VS/(L d). However, when the OLR increased to 7.0, a sudden decrease in process performance was observed. The maximum methane production rate (1.72 L CH4/(L d)) was achieved at an OLR of 4.5 g VS/(L d). This value was 39.8% higher than that obtained in the semi-continuous anaerobic digestion of untreated TPOP at the same OLR. The modified Stover–Kicannon model and the Grau second-order kinetic model were found to be adequate to fit the experimental results of CODt and CODs, respectively.

- **Keywords:** Two-phase olive pomace; Thermal pretreatment; Semi-continuous anaerobic digestion; Substrate removal; Sustainable energy; Kinetic study

Tiejun Chun, Hongming Long, Zhanxi Di, Xiangyang Zhang, Xuejian Wu, Lixin Qian. *Novel technology of reducing SO2 emission in the iron ore sintering*. Pages 297-302.

Iron ore sintering is the main SO2 emission process in iron and steel industry. The flue gas of iron ore sintering has been cleaned by desulfurization equipment, which causes high capital and operation cost. A novel technology of reducing SO2 emission of flue gas during iron ore sintering process by adding urea into granules bed was investigated in this paper. The results show that the emission concentration of SO2 in flue gas decreased significantly by adding urea loaded in the bed. The desulfurization rate higher than 85% was obtained when 0.05% urea was added in the bed at the height of 70–150 mm from the bed bottom, and there is no adverse influence on sintering indexes and final sinter quality.

- **Keywords:** Iron ore sintering; Urea; Flue gas; SO2 emission; Desulfurization; Low cost

O.N. Syazwani, Siow Hwa Teo, Aminul Islam, Yun Hin Taufiq-Yap. *Transesterification activity and characterization of natural CaO derived*

***from waste venus clam (Tapes belcheri S.) material for enhancement of biodiesel production*. Pages 303-315.**

In this study, waste venus clam (WVC) was used as a raw materials of catalyst to produce biodiesel from palm oil at atmospheric pressure. The thermogravimetric, surface functional group, morphology, structure, basicity, surface area and leaching properties of catalyst was studied by using TGA, FTIR, SEM, XRD, TPD-CO2, BET, and AAS respectively. The result demonstrated that CS-900 catalyst gave high amount of total basicity at about 44 times than commercial CaO catalyst which is favorable for higher catalytic activity. Further, it was evident from BET that the shells calcined in temperature range 800–900 °C was exhibited enhance surface area than uncalcined shells. Under the best reaction condition (temperature 65 °C, methanol/oil molar ratio 15:1, reaction time 6 h, and catalyst 5 wt.% of oil), a high biodiesel yield of 97% was obtained. The leaching test on synthesized biodiesel revealed that the concentration of Ca in the biodiesel was 1.214 ppm which is inacceptable levels of metals as ASTM D6751 (United State) and in Europe, EN 14214 (Europe) standards. The subsequent reuse of the catalyst indicates the viability of utilizing waste shell as green catalysts for synthesis of biodiesel.

- **Keywords:** Heterogeneous catalyst; Waste Tapes belcheri; Recycled calcium carbonate; Transesterification; Correlation of basic sites; Biodiesel

Tamer Akar, Fatih Sayin, Serpil Turkyilmaz, Sibel Tunali Akar. *The feasibility of Thamnidium elegans cells for color removal from real wastewater*. Pages 316-325.

Biosorptive treatment of contaminated solutions with different biomaterials has been extensively studied in recent years. However, application of the suggested biosorbents in industrial scale has been very limited so far. Real wastewater conditions play an important role in the commercial success of the biosorption process. This study describes the potential use of Thamnidium elegans (T. elegans) cells for the biosorptive treatment of real industrial wastewater. Biosorption mechanism was characterized by zeta potential, Brunauer, Emmett and Teller (BET), Infrared (IR) spectrometry, Atomic force microscopy (AFM) and elemental analysis. A quadratic model was built for the batch process and optimum values of variables were recorded as pH 2.0, biosorbent amount: 0.06 g and contact time: 39.3 min with the removal yield of 99.42%. Isotherm studies indicated that the process follows the Langmuir model. Relatively fast decolorization (40 min) process was well described by the pseudo-second-order kinetics. Conversely, the biosorbent exhibited high biosorption efficiency (97.55%) in continuous mode. In addition to high batch biosorption capacity (288.08 mg g−1) of the biosorbent, another impressive aspect of this study, even after ten regeneration cycles, is high biosorption yield (95%). Consequently, T. elegans cells showed great potential for the treatment of colored real wastewaters.

- **Keywords:** Biosorption; Dye; Process design; Reactive Yellow 2 (RY2); Real wastewater; Thamnidium elegans

Nagarajan P.K., S.A. El-Agouz, Harris Samuel D.G., Edwin M., Madhu B., Magesh babu D., Ravishankar Sathyamurthy, Bharathwaaj R. *Analysis of an inclined solar still with baffles for improving the yield of fresh water*. Pages 326-337.

In the present study, the performance of an inclined solar still with and without baffles are studied. From the study, it is identified that the yield of fresh water and the evaporation of water inside the solar still are completely dependent on the retention time of water with solar radiance. Furthermore, a theoretical and experimental analysis is carried out in order to evaluate the performance of the solar still using RHN (Ravi–

Harris–Nagarajan) Model. The yields are 5.4 kg/m2day ± 3.6% for solar still with baffles and 3.4 kg/m2day ± 3% for solar still without baffles during April month with a total daily intensity of 8.125 kWh/m2. The yield of the solar still is increased by 1.68 times the solar still without baffles. Results prove that the improvement of yield from inclined solar stills depends on the contact time of flowing water with solar radiance and temperature of the absorber.

- **Keywords:** Inclined solar still; Baffles; Flow rate; Improvement; Yield

Zujing Zhang, Yanping Yuan, Kequan Wang. *Effects of number and layout of air purification devices in mine refuge chambre*. Pages 338-347.

Air quality is a basic requirement for the survival of miners in distress while waiting for rescue in a MRC (mine refuge chamber). The use of air purifying devices is an effective supplement for removing harmful gas in a MRC. Scholars have paid much attention to the structure of air purifying devices and purifying agents for MRCs, but research on the number and layout of purifying devices in MRC has attracted little attention. To determine a reasonable number and layout of purifying devices in a MRC, theoretical analysis was conducted on the relationship between harmful gas concentration and the number, as well as the operating parameters, of devices in the chamber. A configuration calculation formula for purifying devices in MRCs was thus obtained. By conducting five experiments in a MRC with capacity of 50 people, the influence of the number and layout of purifying devices in the chamber, on the CO2 concentration distribution, was studied. The results show that, when the number of personnel is constant, the final concentration of harmful gas in the MRC is only related to the air volume from the air purifying devices and the efficiency of the air purifying devices. When using air purifying devices to remove CO2 in the MRC, the maximum CO2 concentration difference between different measuring points was less than 0.15%. With increasing number of purifying devices, the harmful gas concentration decreases, and the distribution of harmful gas is more uniform. When using two purifying devices, one at either end of the MRC, the harmful gas concentration was more uniform than when both devices were located in parallel at one end.

- **Keywords:** Mine accident; Mine refuge chamber; Survival safe; Air purifying devices; CO2 concentration; Layout; CO2 absorbent

Ivana Jelić, Marija Šljivić-Ivanović, Slavko Dimović, Dragi Antonijević, Mihajlo Jović, Radmila Šerović, Ivana Smičiklas. *Utilization of waste ceramics and roof tiles for radionuclide sorption*. Pages 348-360.

The possible utilization of waste ceramic (CT) and roof tiles (RT), as sorbents for liquid radioactive waste (LRW) treatment, was investigated. Following the European directives on waste and politics of saving natural raw materials, it is reasonable and desirable to explore potential applicability of such construction wastes. These materials are low-cost and locally available in high quantities, yet, their sorption characteristics were not evaluated to this point. In the present study, detailed physicochemical characterization of waste CT and RT included determination of mineral composition, surface functional groups, radioactivity, as well as the stability in aqueous media. The batch sorption study of Sr2+, Co2+ and Ni2+ ions from single- and multi-component solutions was performed, as their radioactive isotopes are common constituents in LRW. Sorption equilibrium was best described by Freundlich isotherm model, regardless of the sorbent and the sorbate type. Sorption capacities of CT, defined in single element solutions, increased in the order 0.035 mmol Sr/g < 0.12 mmol Ni/g < 0.17 mmol Co/g, while the affinity of RT was generally lower (0.030 mmol Sr/g < 0.065 mmol Co/g < 0.10 mmol Ni/g). The study of competitive cation sorption was performed following a simplex centroid experimental design matrix. The equations for the prediction of metal sorption

capacities from multi-component solution were derived. Utilization of CT and RT might be an efficient way for waste water purification, with simultaneous reduction in construction waste amount on municipal landfills.

- **Keywords:** Radionuclides; Waste tiles; Sorption; Recycling; Water treatment; Mixture design

Mostafa Lashkarbolooki, Shahab Ayatollahi, Masoud Riazi*. Mechanistical study of effect of ions in smart water injection into carbonate oil reservoir*. Pages 361-372.

The concerns for water availability, affordability and environmental consideration have motivated more research on the development of smart water injection for enhanced oil recovery process. Although wettability alteration has been considered as the dominant mechanism, there is an ample space in this area needs to be explored more. Therefore, a systematic series of experiments is designed and performed to examine the effect of salinity and ion type on the wettability of the carbonate rock surface to find the active mechanisms. For this purpose, the concentrations of different salts including NaCl, KCl, CaCl2 and MgCl2 are examined during 10 days of soaking for salts concentrations range of 0–45,000 ppm. Based on the measurements of contact angle (CA), it is concluded that the monovalent cation bonded to the chloride anion showed better performance on the wettability alteration of oil wet carbonate rock surface compared to the divalent cations bonded to the chloride anion. In addition, comparing the results of CA measurements of NaCl and KCl solutions as a function of concentration showed completely different wettability behaviors. The presence of KCl shifted the wettability of the carbonate rock surfaces from strongly oil wet to strongly water wet state for all of studied concentrations while as the concentration of NaCl was decreased, the more wettability alteration was observed.

- **Keywords:** EOR; Smart water; Ion; Wettability; Contact angle; Mechanism

M. Kobya, E. Demirbas, F. Ozyonar, G. Sirtbas, E. Gengec. *Treatments of alkaline non-cyanide, alkaline cyanide and acidic zinc electroplating wastewaters by electrocoagulation*. Pages 373-385.

Treatments of alkaline non-cyanide, alkaline cyanide and acidic zinc electroplating rinse wastewaters were investigated in an electrocoagulation (EC) reactor using Fe plate electrodes. This is the first study involved with removals of zinc and cyanide together from three different wastewaters in the literature. The effects of the operating parameters namely, initial pH (pHi), current density and operating time on the removal efficiencies were evaluated. The removal efficiencies and operating costs were determined as 99.8% for Zn and 0.74 €/m3 at a pH of 7, 80 A/m2 and 60 min for alkaline non-cyanide, 99.9% for Zn, 99.9% for CN and 1.72 €/m3 at a pH of 9.5, 60 A/m2 and 60 min for alkaline cyanide, and 99.9% for Zn and 2.26 €/m3 at a pH of 8, 80 A/m2 and 60 min for acidic zinc electroplating wastewaters, respectively. Moreover, toxicity test was conducted to obtain information about the toxic effect of the raw and treated wastewaters. The toxicity results indicated that all the raw wastewaters contained hardly toxic effect (EC50 for acidic, alkaline cyanide and alkaline non-cyanide were 0.62, 5.25 and 3.38). On the other hand, the treated wastewater was non-toxic. This study revealed that the EC process with Fe electrode was very effective for removal of zinc and cyanide ions from different zinc electroplating rinse wastewaters.

- **Keywords:** Zinc plating wastewater; Alkaline non-cyanide; Alkaline cyanide; Acidic zinc; Electrocoagulation; Operating cost; Iron electrode

Marko Racar, Davor Dolar, Ana Špehar, Krešimir Košutić. *Application of UF/NF/RO membranes for treatment and reuse of rendering plant wastewater*. Pages 386-392.

The treatment of animal by-products in rendering plants consumes large amounts of water generating wastewater with high content of organic matter. Literature review has shown that there is no study that evaluated the application of membrane technology for the treatment of rendering plant wastewater (RPW) and its reuse. A combination of sequential batch reactor (SBR), sand filtration, ultrafiltration (UF), nanofiltration (NF), and reverse osmosis (RO) was used to treat the RPW. Three UF (MW, GM, and CQ), two NF (NF90 and NF270), and one RO membrane (XLE) were tested along with the water analysis (conductivity, pH, turbidity, chemical oxidation demand, and contents of carbon, nitrogen, and phosphates) at each step of the process. During UF, the high content of effluent organic matter (EfOM) caused severe fouling. Sand filtration was an effective pretreatment for UF, lowering the fouling. The most suitable combination of membranes according to their separation efficiency and permeability was selected. The quality of permeates confirms its reusability in the process for washing and steam generation.

- **Keywords:** Rendering plant; Wastewater reuse; Ultrafiltration; Nanofiltration; Reverse osmosis

Giordano Emrys Scarponi, Gabriele Landucci, Alessandro Tugnoli, Valerio Cozzani, Albrecht Michael Birk. *Performance assessment of thermal protection coatings of hazardous material tankers in the presence of defects*. Pages 393-409.

Fires following road or railway accidents may escalate and cause catastrophic loss of containment and extremely severe final scenarios when hazardous material tankers are engulfed in flames. A heat-resistant coating is usually adopted to protect such tankers. However, defects may form on the coating due to wear, erosion, or accidental failures, thereby affecting the effectiveness of the thermal protection. In the present study, a methodology was developed to assess the performance of thermal protection coatings in the presence of defects. A thermal model based on finite element modeling (FEM) was developed to reproduce the behavior of tankers coated with defective insulation when exposed to fires. Experimental data were used to validate the model, which allowed to determine the temperature profile of tank shell with respect to time under different fire conditions. Specific key performance indicators (KPIs), calculated on the basis of the results of FEM simulations, were defined. The KPIs allow the identification of threshold conditions in which fireproofing performance is degraded and jeopardizes the structural integrity of the protected vessel when involved in fire. An approach based on the KPIs was developed to support the implementation of on-condition inspection-based maintenance strategies of thermal coatings.

- **Keywords:** Hazardous material transportation; Major accident hazard; Finite element analysis; Key performance indicators; Thermal protection; Maintenance