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Bruce Peachey. Environmental stewardship : what does it mean? *Pages 227-236.*

Abstract: Human activities have impacted the environment since the first toolmakers learned to make fire. As the human population has grown and changed, so has our impact on the environment. Currently the world's population is estimated at 6–7 billion, and that number of people, along with the billions of domesticated animals, and their activities, are large enough to have major global and regional impacts. Climate change, declining fish populations in the oceans, and ever decreasing ranges for "wild" ecosystems are the most obvious impacts. Other impacts may be surprising to many people, especially those impacts that are regional and not raised to the level of international concern. This paper will take a very high level look at a number of global, regional and local human interactions with the environment, and how mitigating those impacts requires a very broad and multi-disciplinary response. Examples will focus on water, carbon and energy, all of which are needed for life, as we know it, to exist. Stewardship will be shown to involve determination and monitoring of many key indicators and environmental processes, followed by the tough decisions on how to steward those processes to maintain a healthy environment for all the planet's inhabitants. Stewardship is not easy, and there are few cases where solutions can be neatly divided into good or bad, positive or negative.

- **Keywords:** Environment; Stewardship; Water; Carbon; Energy; Climate change

Mohamed H. Mohamed, Lee D. Wilson, John V. Headley, Kerry M. Peru. *Novel materials for environmental remediation of tailing pond waters containing naphthenic acids*. Pages 237-243.

Abstract: A nanofiltration strategy for tailing pond waters (TPWs) that utilizes cyclodextrin (CD)-based polymeric materials as supramolecular sorbents is proposed. Naphthenic acids (NAs) from the Athabasca TPWs are investigated as the target sorbate molecules.

The sorption properties of several supramolecular porous materials were characterized using equilibrium sorption isotherms in aqueous solution wherein electrospray ionization

mass spectrometry was used to monitor the concentration of NAs in aqueous solution. The characterization of the supramolecular sorbents was performed using ^{13}C NMR and IR spectroscopy, while nitrogen porosimetry was used to estimate their surface area and pore structure properties. Independent estimates of surface area were obtained using a chromophore dye adsorption method in aqueous solution. The sorption results for NAs in solution were compared between a commercially available standard; granular activated carbon (GAC) and three types of synthetic materials. The sorption capacities for GAC ranged from 100 to 160 mg NAs/g of material whereas the polymeric materials ranged from 20 to 30 mg NAs/g of material over the experimental conditions investigated. In general, differences in the sorption properties between GAC and the CD-based sorbents were observed and related to differences in the surface areas of the materials and the chemical nature of the sorbents. The CD-based supramolecular materials displayed sorption capacities ranging from 36.2 to 657 m^2/g as compared to that for GAC (795 m^2/g).

- **Keywords:** Naphthenic acids; Sorption; Porous materials; Tailing pond waters; Isotherm

Ali Deriszadeh, Thomas G. Harding, Maen M. Husein. *Role of naphthenic acid contaminants in the removal of p-xylene from synthetic produced water by MEUF*. Pages 244-251.

Abstract: The high demand for water in oil sands operations in addition to the shortage of fresh water resources mandate continuous search for reliable and cost effective water treatment technologies. Micellar-enhanced ultrafiltration (MEUF) is potentially applicable to produced water treatment. MEUF is, however, susceptible to membrane plugging and back contamination, especially at high surfactant dosages. Recent investigations showed that addition of small amounts of a non-ionic surfactant to an ionic surfactant solution reduces the critical micellar concentration (CMC) of the mixed surfactant solution, and consequently reduces the surfactant dosage required to achieve certain removal of contaminants using MEUF. In the present study a naphthenic acid, octanoic acid, typically existing in produced water is shown to play a similar role as the non-ionic surfactant when added to the cationic surfactant cetylpyridinium chloride (CPC). Cross-flow MEUF using three different molecular weight cutoffs (MWCOs) of polyacrylonitrile (PAN) hollow fiber membranes was used to treat synthetic produced water containing *p*-xylene. The mixed CPC/octanoic acid solution removed comparable percentages of *p*-xylene contaminant at much lower concentrations of CPC. Decreasing CPC concentration in the feed resulted in less fouling and higher permeate flux and reduced back contamination. This, in turn, enhanced the performance of MEUF.

- **Keywords:** Oil sands;Produced water; Octanoic acid; *P*-xylene; Micellar-enhanced ultrafiltration; Cetylpyridinium chloride

Hossein Nikakhtari, Pardeep Kumar, Mehdi Nemati, Gordon A. Hill. *Mass transfer and bioremediation of aromatics from NAPL in a baffled roller bioreactor*. Pages 252-258.

Abstract: A non-aqueous phase liquid (NAPL) containing dissolved naphthalene or phenol was used to simulate water insoluble contaminants which are produced during the processing of oil sands. Mass transfer and biodegradation of organic contaminants in the aqueous phase were studied in a baffled roller bioreactor. Mass transfer of both naphthalene and phenol from NAPL into the aqueous phase was completed in less than 60 min, by which time naphthalene reached its saturation concentration in the aqueous phase and phenol was completely transferred into the aqueous phase. *Pseudomonas putida* (ATCC 17484) was subsequently used in biodegradation experiments in the baffled bioreactor containing the model NAPL contaminant. The optimum loading of NAPL for biodegradation of naphthalene at 500 mg/L was found to be 40%. High biodegradation

rates (136.4 mg/L h for naphthalene and 13.2 mg/L h for phenol based on the working volume of the bioreactor) were achieved. In the case of simultaneous biodegradation of naphthalene and phenol, the highest total biodegradation rate of 102.6 mg/L h was achieved.

- **Keywords:** Bioremediation; Roller bioreactor; Naphthalene; NAPL

H.D. Doan, A. Lohi, V.B.H. Dang, T. Dang-Vu. *Removal of Zn^{+2} and Ni^{+2} by adsorption in a fixed bed of wheat straw*. Pages 259- 267.

Abstract: Zn^{+2} and Ni^{+2} in a solution were removed by biosorption in a fixed bed of wheat straw *Triticum aestivum*. The removal rate and the mass transfer coefficient for Zn^{+2} and Ni^{+2} were found to be proportional to the liquid superficial velocity to the power of 0.31 for the range of the particle Reynolds number from 18 to 445 (equivalent liquid rates of 0.00070–0.0175 $m^3\ m^{-2}\ s^{-1}$). This agrees well with reported literature for mass transfer in a packed bed of solid particles under a laminar flow regime. Effect of the solution pH, temperature and the particle size (0.5, 1.0, 1.5 and 2.0 in.) on biosorption of Zn^{+2} and Ni^{+2} was also investigated. Biosorption of both Zn^{+2} and Ni^{+2} increased significantly with the solution pH from 4.0 to 7.0. On the other hand, Zn^{+2} and Ni^{+2} removal appeared to be insensitive to liquid temperature from 25 to 30 °C. Nevertheless, a 25% increase in the percentage removal of metal ions was observed with further increase of liquid temperature from 30 to 35 °C. However, the biosorbent particle size did not seem to have a systematic effect on the biosorption of Zn^{+2} and Ni^{+2}. In addition, biosorption of Zn^{+2} was not affected considerably by co-adsorption of the bimetal solution while biosorption of Ni^{+2} decreased about 14%.

- **Keywords:** Adsorption; Biosorbent; Zn^{+2} and Ni^{+2}; Fixed bed

Yuming Xu, Tadek Dabros, Jianmin Kan. *Filterability of oil sands tailings*. Pages 268-276.

Abstract: In Canadian oil sands mining operations, bitumen is extracted from oil sands using the hot water extraction process, which produces tremendous amounts of tailings. Currently, these tailings are disposed of in large ponds, in which coarse particles settle out relatively quickly and fine particles remain suspended in water and settle very slowly. After years of settling, the fine particles form a stable suspension in water known as mature fine tailings (MFTs). Long-term storage of the MFT is costly and poses a major environmental liability. Oil sands companies are now actively investigating different approaches to replace or reduce the use of oil sands tailings ponds. Filtration of the tailings to produce "dry tailings" for stacking is now being investigated as an alternative by a number of companies. Fast water drainage is a critical step for the filtration process. In this paper, we use simple laboratory-scale filtration tests to evaluate the filterability of the oil sands tailings and to generate a parameter that can be used in filtration scale-up. It was found that the filterability of the original coarse oil sands tailings was relatively low. However, after the fines are flocculated with the coarse particles to form uniform flocs the filterability was improved by several orders of magnitude. The results demonstrate that filtration of the flocculated coarse tailings to produce the "dry" stackable tailings may be viable.

- **Keywords:** Oil sands tailings; Filterability; Specific resistance to filtration; Tailings disposal; Flocculation

Alex De Visscher, Gui Qin Li. *Toluene removal biofilter modeling : optimization and case study*. Pages 277-282.

Abstract: Based on the model proposed by De Visscher and Van Cleemput for methane oxidation in landfill cover soils, a simulation model for biofiltration of toluene-

contaminated air has been developed for biofilters with substrate inhibition. A convenient way to optimize biofilter performance was developed assuming Haldane kinetics. It was calculated that for a typical oilsands operation emitting 200 ton of toluene annually, 90% of the toluene can be removed by a 740 m^3 biofilter, if the waste gas sent to the biofilter has a toluene concentration of 2.25 g m^{-3}. The optimal initial concentration increases with increasing target efficiency.

- **Keywords:** Biofiltration; Model; Haldane kinetics; Logistic growth; Pirt kinetics

Kyla Clarke, Gordon A. Hill, Todd Pugsley. *Improved VOC bioremediation using a fluidized bed peat bioreactor*. Pages 283-290.

Abstract: A gas–solid fluidized bed bioreactor was successfully used to treat air contaminated with a volatile organic compound (VOC). A bioreactor containing both a fluidized and packed bed of moist peat granules removed ethanol, a representative VOC, from an air stream. The fluidized bed operation mode of the bioreactor outperformed the packed bed mode. The maximum elimination capacity (EC) of ethanol in the fluidized mode was 1520 g m^{-3} h^{-1}, with removal efficiencies ranging between 45 and 100%, at loadings up to 3400 g m^{-3} h^{-1}. Maximum EC was 530 g m^{-3} h^{-1} in the packed bed mode. Removal efficiency in the fluidized bioreactor was best at the lowest velocity, where the bubbling bed fluidization regime predominated. As gas velocity increased, the size and amount of large bubbles (slugs) increased and removal efficiency decreased while elimination capacity increased.

- **Keywords:** Gas-fluidized bioreactor; VOC contaminated air; Bioremediation; Peat granule

Kreangkrai Maneeintr, Amr Henni, Raphael O. Idem, Paitoon Tontiwachwuthikul, Andrew G.H. Wee. *Physical and transport properties of aqueous amino alcohol solutions for CO_2 capture from flue gas streams*. Pages 291-295.

Abstract: Densities, viscosities and refractive indices of 4-diethylamino-2-butanol + water mixtures were measured over the entire concentration range of 0–1 mole fraction and temperature range from 298.15 to 343.15 K. Excess molar volumes, viscosity deviations, and molar refraction changes were calculated from the measurement results and correlated as a function of the mole fractions. Various models were used for correlation with the measured data. Out of these, the Redlich–Kister equation was the most suitable model that correlated best with experimental data. The percent absolute deviations obtained with this model were 0.03% for density, 0.88% for viscosity and 0.009% for refractive index.

- **Keywords:** Amino alcohol; Carbon dioxide capture; Physical and transport properties; Flue gas; Excess molar volume

Hui Wang, Dongmei Fang, Karl T. Chuang. *A sulfur removal and disposal process through H_2S adsorption and regeneration : ammonia leaching regeneration*. Pages 296-302.

Abstract: An iron oxide solid sponge H_2S adsorbent works by reacting H_2S and turning ferric oxide into ferric sulfide. The ferric sulfide will be converted back into ferric oxide and elemental sulfur when contacting oxygen or air. This study investigates the leaching of elemental sulfur from the solid sponge using anhydrous liquid ammonia as solvent. The leaching treatment expectedly results in effective regeneration of the adsorbent, which is able to lead to a sulfur removal and recovery process suitable for handling the small and mid-sized sulfur production cases, i.e., those less than 10 ton/day sulfur. The

leaching does not significantly impair the physical properties, including the adsorbent pellet strength. The adsorption–regeneration (or leaching) cycle could be repeated at least three times. The cumulative sulfur loading can achieve as high as 50% (w/w), three times greater than that in the one-time use. The wash-off in leaching and the spent adsorbent can be made into slurry that is to be injected into underground formations such as depleted oil wells. It is anticipated that this underground injection is safer and more efficient than acid gas injection.

- **Keywords:** Sulfur removal and recovery; Hydrogen sulfide; Iron oxide; Leaching

S.R. Dhanushkodi, N. Mahinpey, M. Wilson. *Kinetic and 2D reactor modeling for simulation of the catalytic reduction of NO_x in the monolith honeycomb reactor*. Pages 303-309.

Abstract: Emission of NO_x is of primary environmental concern in the oil sands industry. Selective catalytic reduction (SCR) is one of the best NO_x reduction technologies. The present study discusses the testing of a mechanistic kinetic model for the SCR of NO_x to describe the kinetics of V_2O_5/TiO_2 catalysis at atmospheric pressure and a temperature of 623 K in a monolith honeycomb reactor. The modeling results impart insight into the significance of the diffusion with reaction steps and guidance for optimal monolith design for SCR. The validated expression would predict the conversion performance of the catalysts for different values of temperature inlet and ammonia concentration. A good agreement between experimental and model results has been obtained. A heterogeneous numerical model consisting of coupled mass and momentum balance equations was solved using the finite elements method without neglecting the axial dispersion term. The operating range for the catalyst relies on the NO conversion and emission. The optimum operating range for the best performance of the reactor is discussed.

- **Keywords:** Selective catalytic reduction (SCR); NO_x reduction; Monolith honeycomb reactor; LAR method; Finite element method