Monday, 11/7/2022; 8:00

M1 Tr-As-Se Co-N-Ti-Al-Mn-Ts

IWC Rep: Jay Harwood, Newterra, Inc., Ontario, Canada

Session Chair: John Van Gehuchten, P.E., McKim & Creed, Sewickley, PA

Discussion Leader: Joshua Pendergrass, P.E., Stantec,

Trace contaminants describes those small but problematic compounds that the water industry strives to find effective and economical solutions to remove or manage. This session has a focus on a few different versions of selenium removal, including a non-biological option. Not to be forgotten other trace metals, such as mercury and arsenic, are being co-managed as part of this process. With the projects involving power, mining, and superfund sites, everyone can find something to learn from this talented group of authors.

IWC 22-01: Demonstration Selenium Removal Plant for EPA Superfund Groundwater Remediation

Thomas Rutkowski, WSP Golder, Lakewood, CO ; Karen Budgell, WSP Golder, CO

Over the past several decades, selenium has emerged as a significant water quality issue that impacts multiple industries including mining, agriculture, petroleum, and power generation. Anaerobic biological treatment has been implemented at numerous sites and is generally an effective treatment method. With some waters, biological treatment alone is sufficient to achieve stringent regulatory limits; however, in other cases, additional unit processes are required. This paper presents results from a demonstration scale (Demo Unit) Suez ABMet treatment process with a design flow rate of 400 gallons per minute (gpm).
WSP-Golder provided engineering support for pilot testing and design and implementation of the Demo Unit under a site's EPA Superfund program. Pilot testing included two biological technologies and membrane treatment. The Demo Unit receives seleniferous groundwater containing elevated levels of carbon dioxide (i.e., sodic water). Demo Unit results to date indicate excellent selenium removal with results below one part-per-billion and effective management of carbon dioxide. One of the goals of the Demo Unit is to understand if biological treatment alone can effectively meet stringent treatment limits.

Discusser: Paul Togna, Envirogen Technologies, Inc., East Windsor, NJ

IWC 22-02: Selenium, Mercury and Arsenic Removal with Ion Exchange Resins and Iron Oxide Media

Zhendong Liu, Lanxess Corporation, Birmingham, NJ ; John McPeak, Lanxess Corporation, Birmingham, NJ; Wilson Nova, Lanxess Corporation, Birmingham, NJ; Kresimir Ljubetic, BQE Water, Vancouver, BC, Canada; H.C. Lang, BQE Water, Vancouver, BC, Canada

Selenium, Mercury and Arsenic are often contaminants of concern contained in waste water, from mining, oil and gas, waste incineration, coal-fired power plants or groundwater in certain geological formations. Historically, conventional techniques such as biological treatment, precipitation/co-precipitation and membrane filtration are used to remove these species, but they all suffer from a major disadvantage of generating large amounts of secondary wastes in the forms of biological residues, sludge and/or RO concentrate. The biological treatment and precipitation methods can be used as primary treatments of high level influent contaminants, but are not capable of reducing these contaminants to ultralow concentrations necessary for environmental compliance. RO membrane could achieve very low level of the contaminant species in effluent, but it requires expensive capital equipment, larger footprint and generate large volumes of secondary waste for further treatment. Although these traditional methods have many disadvantages and limitations, industry has been implementing them because there were no commercially available alternatives under the regulatory requirements.

With evolving stringent requirements in environmental regulations towards selenium, mercury, arsenic discharge, more efficient treatment technologies and engineering design are sought for. Generally, these species are present in very low concentrations (e.g. ppb level) together with larger quantity of other non-regulated species. Ion exchange resins and an iron oxide media provide a unique solution to remove these target trace species with high selectivity, smaller footprint, less wastes, better effluent water quality, reduction in risks and costs, and enabling intermittent operation with fast start-up and shut-down in both mobile and stationary applications. The removal of the target species by ion exchange resin combined with appropriate post-treatment technologies (e.g. electro-reduction for selenate) has been proved technically and economically effective.

This paper discusses the applicability of the ion exchange technology to mining waste, incineration waste, power plant ash pond and municipal applications. Also will touch on Arsenic immobilization, and other operation and implementation techniques for these systems to work optimally and efficiently.

Discusser: Max Swoboda, Evoqua Water Technologies, Irondale, AL

IWC 22-03: Full-Scale Non-Biological Selenium Treatment Systems for the Power and Mining Sectors

Kresimir Ljubetic, BQE Water, Vancouver, BC Canada; H.C. Liang, BQE Water, Vancouver, BC, Canada; David Kratochvil, BQE Water, Vancouver, BC, Canada; Zhendong Liu, LANXESS, Birmingham, NJ; Wilson Nova, LANXESS, Birmingham, NJ

Selenium occurs as a contaminant of concern in wastewaters from coal-fired power stations, mining operations, oil refineries, or in groundwater exposed to selenium-containing geological formations. Selenium in the form of selenate, which dominates selenium speciation in coal ash ponds and mine wastewaters, is particularly challenging to remove by conventional chemical treatment; treatment processes such as chemical precipitation/co-precipitation are ineffective for removing selenate. Historically, biological selenium reduction treatment has been utilized at full-scale facilities to treat coal ash pond and mining wastewaters to meet applicable regulatory standards because of the lack of other viable treatment options.
Selen-IX™ is a non-biological active selenium treatment technology that combines ion exchange (IX) with electro-reduction to remove selenium, and it is the first full-scale, non-biological selenium treatment process to be designed and built to remove selenate for various industrial wastewaters. Several full-scale facilities have recently been implemented to treat mine-impacted water as well as the first system to remove selenate from coal ash pond water. This paper will present and discuss data from the successful application of Selen-IX™ from the coal ash pond water facility and a mine water treatment facility. Data starting from laboratory testing and pilot testing through the commissioning and operations of the full-scale facilities will be presented. Among some highlights and advantages of using the IX-based treatment process compared to biological selenium reduction to remove selenate are that 1) lower end-of pipe concentrations can be achieved; 2) the non-biological active selenium treatment process avoids generating highly bioavailable organoselenium species; 3) it can handle large fluctuations in flow, mass loadings, and temperatures; and 4) it can provide intermittent or seasonal treatment.

Discusser: William Stevick II, P.E., Santee Cooper, Moncks Corner, SC

Monday, 11/7/2022; 8:00

M2 Corrosion and Scale Control in Boiler Systems

IWC Rep: Wayne Bernahl, W. Bernahl Enterprises,

Session Chair: John Ostberg, NALCO WATER, An Ecolab Company, Naperville, IL

Discussion Leader: Abena Koom-Dadzie, ExxonMobil Technology & Engineering Company (EMTEC), Spring, TX

Steam boiler systems are essential components of manufacturing processes. Proper control and mitigation of corrosion and scale deposits in boiler systems is critical for ensuring steam generation reliability. This session includes three outstanding technical papers presenting considerations for mitigating boiler system corrosion and scale. The first paper discusses best practices for monitoring and inspection of deaerators to ensure proper DA performance to prevent pre-boiler oxygen corrosion. The second paper reviews the performance of several scale and deposit control chemistries for Oil Sands Once Though Steam Generators (OTSG). The third paper in this session presents case studies on the cause and corrective actions for chloride stress corrosion cracking in stainless steel alloy boiler system components.

IWC 22-04: A Closer Look at Deaerator Performance Monitoring and Inspection

Colleen Scholl, P.E., HDR, Whitewater, WI

Like any piece of plant equipment, routine inspections of deaerators and their storage tanks should be performed to ensure that the equipment is operating properly and safely. It is important to monitor operation daily and perform routine in-service performance testing to provide early detection and enable correction of minor operational issues. Given this need, the ASME Research and Technology Committee on Water and Steam in Thermal Systems has recently published the first in a series of guidelines focused on providing information on how to plan for, conduct, and interpret the results of equipment inspections on specific pieces of equipment in the steam/water cycle.

This paper will discuss the key aspects of this guideline focusing on thermo-mechanical deaeration systems that utilize steam as the means to heat the incoming feedwater and liberate non-condensable gases. The paper, and the document, will provide guidance on understanding why and when to inspect, recognizing the warning signs and early indicators of problems, planning for the inspection, working with an inspection contractor in conducting the inspection, and interpreting the results received.

Discusser: Robert Bartholomew, P.E., Sheppard T. Powell Associates LLC, Baltimore, MD

IWC 22-05: OTSG : Steam Boiler Feed Water - Potential Solutions with the Use of Additives

Marlon Norona, Southern Alberta Institute of Technology, Calgary, AB Canada; Aprami Jaggi, Southern Alberta Institute of Technology, Calgary, AB, Canada; Vita Martez, Southern Alberta Institute of Technology, Calgary, AB, Canada; Dave Rowley, ConocoPhillips, Calgary, AB, Canada

Once Through Steam Generators (OTSGs) are the most common means of generating steam for extraction of bitumen from the oil sands in situ sector. Improving the energy efficiency and effectiveness of OTSGs has a significant impact on reducing the environmental impact in situ facilities but, these efforts are challenging due to the poor quality of produced water. These waters contain considerable amounts of suspended solids and dissolved organic and inorganic constituents including calcium, magnesium, iron, sodium, silica, which are then treated to meet OTSG boiler feed water (BFW) quality. Despite treatment the BFW constituents cause mineral (scale) and organic (fouling) during steam-generation, resulting in higher tube wall temperatures, and often contributing to premature OTSG failure.
A state-of-the-art OTSG pilot test-rigs were built in collaboration with Canada's Oil Sands Innovation Alliance to investigate the chemical and process changes needed to reduce inorganic and organic tube scaling/fouling occurrences in OTSGs, while simultaneously improving efficiency of steam generation. The objective of this study was to systematically investigate the performance efficacy of five additive chemistries on tube scaling/fouling under high pressure and temperature operating conditions. The performance of these additives was evaluated using industrial BFW from cyclic-steam-stimulation at approximately 314°C temperature and 11MPa pressure. The additives include: 'Additive-A': boiler polymer; 'Additive-B': silica inhibitor; 'Additive-C': organic dispersant; 'Additive-D': filming amine; and

‘Additive-E’: filming amine with boiler polymer. Within the first phase of experiments, the baseline skin temperature profiles for BFW chemistries were established. Each additive was then evaluated for their individual and comparative efficiencies using a combination of process conditions, chemistries, surface temperature profiles and ion balance analyses.
The boiler polymer and silica inhibitor additive chemistries, showed a decrease in skin temperature relative to the baseline, indicating its effectiveness in reducing the extent of skid scaling/fouling, with reduced precipitation of magnesium silicate salts. The organic dispersant, showed a comparable performance and was able to retain a higher percentage of organics in the BFW. While the filming amine chemistry was ineffective in reducing scaling/fouling, the combination of the filming amine with boiler polymer showed the best performance amongst the additives, with a significant decrease in skin temperature relative to the baseline. Overall, the results will contribute to industry best practices, by enhancing the understanding of scaling and fouling occurrences in boiler equipment, and the effective use of additive chemistry for boiler treatment that may accelerate water recycle rates and energy efficiency and decrease GHG emissions.

Discusser: James Bellows, James Bellows and Associates, Maitland, FL

IWC 22-06: Chloride Stress Corrosion Cracking of Stainless Steel Alloys in Boiler Systems

Mel Esmacher. P.E., Veolia Water Technologies & Solutions, Tomball, TX ; Donald Meskers, Jr., Ph.D., Veolia Water Technologies & Solutions, Trevose, PA; Mahesh Budhathoki, Ph.D., Veolia Water Technologies & Solutions, Trevose, PA

This paper discusses case histories involving chloride Stress-Corrosion Cracking (Cl-SCC) of stainless steel alloy components in boiler systems. In most cases, stainless steel alloys are selected for specific boiler areas (such as deaerator internals) or other applications where carbon steel or low-alloy steel would exhibit severe rusting or pitting corrosion failure in the boiler environment, leading to increased maintenance costs and unplanned downtime. Unfortunately, there are some applications where the concentration of chlorides in the boiler feedwater, in conjunction with elevated temperatures in the presence of relatively high dissolved oxygen levels, have resulted in cracking failures. The results of laboratory investigations will be provided that assist in identifying the root causes for this Cl-SCC problem. Corrective actions will be proposed to resolve this type of failure mechanisms involving stainless steel components in boiler systems and provide best practices that can be considered to help minimize stress corrosion cracking failures related to chlorides.

Discusser: Brad Buecker, Buecker & Associates, Lawrence, KS, USA

Monday, 11/7/2022; 8:00

M3 101 Fun Things to do with FGD Water

IWC Rep: Bill Kennedy, P.E., Stantec, Charlotte, NC

Session Chair: Kirk Ellison, Electric Power Research Institute, Charlotte, NC

Discussion Leader: Joseph M. Woodley, UCC Environmental, Waukegan, IL

In this session, we will explore approaches to treating and managing FGD wastewater generated in the energy industry. From innovative approaches to operations as well as alternative approaches to managing FGD wastewater, a hearty discussion will be had.

IWC 22-07: Operating a cycling FGD WWT System

Derek Henderson, P.E., Duke Energy, Raleigh, NC ; Megan Nevill, Duke Energy; Ray Lidke, Duke Energy

Coal generating units used to provide a steady stream of energy on the grid. Overtime, low natural gas prices, increase renewables, and carbon reduction initiatives have forced coal generating units to be flexible and run at min design or have cyclical operations. The environmental systems on these units though were designed to be optimal at base load conditions. A utility perspective and experience on the impact of these cyclical operations on the downstream impacts to FGD WWT. Overview of common problems and issues that emerge when running at these cyclical operations for extended periods of time and common observations that have been noticed as well. Issues such as FGD WWT water quality changes, below design FGD blowdown volumes, maintaining a bioreactor through extended outages, and even observations of stream quality at a dual fuel unit (natural gas and coal) will be overviewed with solutions and experience to help address them.

Discusser: Carson Brown, Southern Company, Birmingham, AL

IWC 22-08: Achieving FGD ZLD by Softening and Treatment in a Cooling Tower Evaporator System

Thomas Higgins, Worley, St. Augustine, FL ; Tom Gaboian, Orlando Utility Commission, Orlando, FL; Nate Parker, Orlando Utility Commission, Orlando, FL; Mary McCloud, Worley, Stuart, FL; Lanny Weimer, Ormond Beach, FL

Orlando Utilities Commission (OUC) operates two coal-fired power units in the Stanton Energy Center. The plant is a zero-liquid discharge (ZLD) facility. OUC plans to convert Unit 2 to gas and decommission Unit 1

Cooling tower blowdown is routed to the Cooling Tower Brine Plant, where 4 falling film evaporators and 4 forced circulation crystallizing evaporators generate a salt cake that is landfilled, and a distillate which is returned to the cooling towers.

FGD scrubbers evaporate water and generate a gypsum slurry which is dewatered and disposed of in an on-site landfill. FGD purge water, coal pile runoff, and other wastewaters drain to ponds and are recycled for FGD makeup. Approximately 100 million gallons of wastewater can accumulate in the ponds.

Currently rain is evaporated in the FGD systems and landfilled with salts in gypsum waste. During high rainfall periods (particularly the summer) water level in ponds is maintained by evaporating water in the FGD scrubbers and disposal of gypsum. If the generating units are not operated at sufficient capacity, FGD evaporation and gypsum disposal are limited. After gas conversion and decommissioning, an alternative is needed to remove salts and water that has accumulated in the pond system.

Worley and OUC developed a water model (IWC 21-34) which was used to evaluate alternatives for managing the inventory of water. The model indicated that if 200 gpm of water (and attendant salt) were diverted to the Cooling Tower Brine Plant, then salt could be controlled and the ponds could be sequentially decommissioned; reducing the number of ponds reduces the rainwater collection area, and hence the volume needing evaporation.

The chemistries of cooling towers and reclaim pond are significantly different. Cooling tower water is dominated by calcium, sodium and sulfate. The reclaim water is dominated by magnesium, sulfate and chloride. Magnesium chloride is difficult to crystalize in the plant's equipment, and analysis showed that combined treatment of cooling tower blowdown and reclaim water would risk formation of glauberite (sodium calcium sulfate) in the evaporator. Our proprietary evaporator model showed that the best option would be softening of the reclaim water to convert it from a magnesium chloride dominated water to a sodium chloride dominated water, which can be crystallized in the brine plant. Laboratory treatability testing was performed for the alternative softening processes. In addition to the modelling and lab testing results, we will present details of the softening design.

Discusser: Keith Ambrose, Electric Power Research Institute (EPRI), Palo Alto, CA

IWC 22-09: Online Measurement of Dissolved Trace Species Concentrations in Wet FGD Absorber Slurry

Cassandra Hutson, AECOM, Austin, TX ; Gary Blythe, Granite Shoals, TX; John Currie, AECOM, Austin, TX; Jose Sanchez, EPRI, Palo Alto, CA

In coal-fired generating units, conditions in wet flue gas desulfurization (FGD) systems and their wastewater treatment (WWT) systems are affected by fuel quality and operations in the boiler, upstream control devices and the FGD system itself. Parameters such as pH, ORP, and concentrations of dissolved species such as selenium (Se), mercury (Hg) and arsenic (As) may be affected. Selenium, Hg and As are mostly introduced to the FGD system as impurities in the coal fired. Impending Effluent Limitations Guidelines (ELGs) will limit FGD wastewater discharges to very low concentrations of these species.
Selenium, Hg, and As may be found in both liquid and solid phases of FGD absorber slurry, and their phase partitioning is greatly impacted by FGD operating conditions. Higher dissolved concentrations will require greater removal in the WWT system prior to discharge. Their oxidation states are also affected by these parameters; for dissolved Se, oxidation state impacts its difficulty of removal in the WWT system. Higher dissolved Hg concentration in absorber slurry affects not only WWT operation but can affect Mercury and Air Toxics Standards compliance due to chemical reduction, causing insoluble elemental Hg "re-emission" and increased stack Hg emissions.
Measuring dissolved concentrations of these and/or other species in FGD absorber slurry in real time could allow plant operators to make informed decisions to maintain FGD and WWT process control, lower operating costs and avoid exceeding stack and/or WW effluent limits. Monitoring directly within the FGD absorber slurry is challenging, though, because of suspended solids levels (15 to 25 wt%) and ongoing liquid-phase chemical reactions.
EPRI conducted field trials on absorber slurry at a full-scale wet FGD system, developed a novel continuous filtering technique to provide clear liquid for analyses, and demonstrated monitors that provided semi-continuous concentration data for dissolved Se and Hg, respectively. A major objective was to quantify effects of upstream variables on dissolved species' concentrations and phase-partitioning. Understanding operating conditions that impact regulated species' concentrations can help maintain process control, lower costs, and keep units compliant.
The near-real-time data generated by the online analyzers were compared to FGD and other plant data to identify correlations and possible causes of observed concentration spikes. The paper will illustrate monitoring data that identified large spikes in dissolved Se and Hg concentrations caused by changes in FGD operating conditions. In addition, the uptime, maintenance requirements, and relative accuracy of the monitors evaluated will be discussed.

Discusser: Tyler Sullens, Alabama Power Compnay, Calera, AL

Monday, 11/7/2022; 1:15pm

M5 Advanced Membrane Treatment

IWC Rep: Dennis McBride, Burns & McDonnell, Kansas City, MO

Session Chair: Tom Imbornone, Avista Membrane Treatment Solutions,

Discussion Leader: H G Sanjay, Bechtel Infrastructure and Power Corp., Reston, VA

As we continue to move into more challenging water treatment applications, membrane technology has advanced and there have been improvements to the pre-treatment and operational techniques. This section focuses on challenging membrane applications and how new technologies and membrane materials allow systems to sustain reliable operation. The four papers in this session will present a new membrane chemistry and its performance on wastewater, the use of online turbidity measurement for RO feed water in place of SDI, the operation of EDR and EDI systems for pre and post RO treatment, and the use of ceramic microfilters on "flowback" water from the fracking industry in addition to their use on secondary and tertiary wastewater effluent.

IWC 22-13: Driving High Recoveries in Water Reuse Applications with Novel, Zwitterionic Membranes

Christopher Roy, ZwitterCo, Woburn, MA ; Judy Ledlee, Ph.D., P.E., ZwitterCo, Woburn, MA

Achieving exceedingly high water recoveries in membrane processes has become increasingly important in establishing environmentally sustainable plant operations and meeting corporate sustainability goals across industries. This paper focuses on a new patented zwitterionic membrane chemistry immune to irreversible fouling that has demonstrated its ability to reach ultra-high recoveries in the most difficult-to-treat wastewater and process fluids.

This paper reviews data from field testing in dairy, landfill leachate, and produced water where recoveries of as high as 99% (a 100x concentration factor) are sustainably achieved. Additionally, it discusses the science behind this novel polymeric membrane chemistry that leads to unprecedented performance in streams with high concentrations of fat, oils, protein, and other high-fouling organic constituents. The paper also highlights data sets showing these membranes as an ideal pretreatment step to reverse osmosis, enabling higher combined clean water recoveries than standard pretreatment plus reverse osmosis process trains available on the market today.

Discusser: Parker Ervin, Kurita America, Minneapolis, MN

IWC 22-14: Continuous Nephelometric Measurement of Suspended Solids in Reverse Osmosis as a Surrogate for the Silt Density Index (SDI)

Denton Slovacek, Hach, Timnath, CO ; Vadim Malkov, Ph.D, Hacj, Loveland, CO

Monitoring and managing of the water quality throughout power generation cycle and specifically prior to reverse osmosis is extremely important for the life and efficiency of the RO membranes. Inadequate pretreatment of the feed water prior to RO is a major cause to these issues. Fouling, whether biological and/or mineral, is a primary issue directly affecting uptime and membrane replacement. The potential of particle fouling typically measured by the silt density index (SDI) must be known and minimized.

Monitoring and control of particulates is critical in RO membrane management. While the SDI is an accepted method for the fouling potential of water, the measurement does not lend itself to real time monitoring. Nephelometry (turbidity) can monitor in real time but the nephelometric response is variable based on the nature of the particulates being measured. Different types of suspended solids, or more specifically varied mineral and organic colloids, each affect the relationship of turbidity to SDI. Nevertheless, turbidity monitoring and interpretation of its results can provide enough correlation to use this method as real-time surrogate for SDI.

This paper features research that shows where turbidity can behave as a surrogate to the SDI and addresses a case study related to fouling where turbidity indicated particulate events while the SDI remained below levels of concern. This study conclusively demonstrated how online monitoring of the RO feedwater for turbidity can help protect the membranes and improve direct and indirect cost control.

Discusser: Chip Westaby, Turner Designs Hydrocarbon Instruments, Kirkwood, MO

IWC 22-15: Electrochemical Technologies

Jeff Tate, Agape Water Solutions, Inc., Harleysville, PA

Electrodialysis Reversal (EDR) and Electrodeionization (EDI) are both electrochemical technologies frequently used in power plant, semiconductor and oother industrial process water treatment systems. Both technologies evolved from Electrodialysis (ED) research in the 1950's. EDR was developed to reduce cleaning frequency of ED, and EDI reduced the electrical resistance and membrane polarization whiling producing much higher purity water. Electrodialysis Reversal (EDR) is a durable technology that can handle large volumes of Total Dissolved Solids (TDS) and high hardness and high silica feed water. New EDR technologies are used to pretreat Reverse Osmosis (RO) feed water, to recover RO concentrate wastewater and to treat cooling tower water. Electrodeionization (EDI) is the standard method of generating high purity water by polishing reverse osmosis permeate and is used in demin water applications. This paper will review the principles of operation of both types of electrochemical technologies and compare the various available devices. Field data, observations, troubleshooting will be provided as well as considerations and lessons learned for new projects.

Discusser: Saurabh Tonapi, P.E., HDR, Austin, TX

IWC 22-16: Ceramic Microfiltration Allows Reuse of Challenging Wastewaters at Two U.S. Locations

Dave Holland, Aqua-Aerobic Systems, Loves Park, IL

The current water shortage is forcing industries to look for ways to reuse wastewater and rely less on fresh water sources. One such industry, a Houston-based oil company, is involved in hydraulic fracturing – "fracking" – which typically injects into each well 30 – 85 thousand barrels of water consisting of about 9.5% proppant (usually sand) and 0.5% other additives. Nearly half of this water returns to the surface, now containing traces of the additives as well as oil, metals, and salts from the rock formations. This "flowback" water - high in salinity, metal concentrations, and hydrocarbons - can be costly to dispose. Therefore, fracking companies are always looking for ways to reuse this water. In 2017, the oil company partnered with Aqua-Aerobic Systems to design, manufacture, and commission a 6,000 barrels per day (bbl/day) mobile ceramic membrane system for use at their wells in western Texas. The system operates at 6 – 8 psi TMP and removes over 98% of the hydrocarbons, iron, and suspended solids.

The second industry is a southern California oil refinery that takes a portion of the effluent discharged by an adjacent 15 MGD reuse plant, which currently treats a 3:2 ratio of industrial and domestic wastewaters having a combined total dissolved solids of up to 5,000 mg/L. The 20-year-old plant has a conventional activated sludge process discharging to its Advanced Water Purification Facility, which contains sand filtration, microfiltration (MF), reverse osmosis, and an advanced oxidation process. The current MF system contains polymeric hollow fiber membranes, which have performed well but have had a high incidence of fiber breakage; therefore, the plant piloted a ceramic membrane system from mid-June 2018 through mid-April 2019 to determine the viability of replacing the existing system with one containing more-durable membranes. The pilot treated both tertiary and secondary effluent from the plant, with and without coagulant pretreatment. Once optimized, the pilot was able to maintain stable operation treating secondary effluent containing 4.2 mg/L Al^{+3} at a flux of 100 gallons per square foot of membrane area per day (gfd), over 3 times the flux of the current polymeric membranes! In addition, the pilot operated at around 97% recovery. As a result, the plant is interested in installing a full-scale ceramic system.

This presentation describes the ceramic system used, details the performance at each site, and discusses some of the issues encountered and how they were resolved.

Discusser: John Williams, MANN+HUMMEL Water & Fluid Solutions, Inc,, Goleta, CA, USA

Monday, 11/7/2022; 1:15pm

M6 Trace Contaminants Pushing at Boundaries

IWC Rep: Colleen Scholl, P.E., HDR, Inc., Whitewater, WI

Session Chair: Colleen Scholl, P.E., HDR, Inc., Whitewater, WI

Discussion Leader: Matt Roth, DuPont, Philadelphia, PA

This session features four papers that challenge and expand the existing knowledge base of emerged and emerging trace contaminants. The session scope ranges from familiar contaminants such as arsenic and selenium, to the emerging contaminant microplastics, to co contaminants such as aluminum and fluoride that accumulate along with the metallic trace contaminants in the sludge produced by precipitation systems.

Session papers include the following:

The necessary demethylation of organic arsenic species prior to removal by conventional arsenic methods.

Accuracy, bias, and precision comparisons between EPA certified laboratories of selenium species in FGD waste treated by two biological treatment processes.

Fundamental facts about micro and nano plastics, characterization by size and shape, and extent of removal in water and wastewater plants.

Concentration of metals such as Al, Cd, Cu, Mn, and Zn plus the non-metal fluoride in high density sludge produced by treatment of acid mine water.

IWC 22-17: Arsenic Removal from Coal Ash Pond Water

Jack Ma, Ph.D., P.E., UCC Environmental, Waukegan, IL ; David Donkin, UCC Environmental, Waukegan, IL; Joseph Woodley, Eng., UCC Environmental, Waukegan, IL

This paper discusses coal ash pond water treatment with a focus on approaches for arsenic removal. The development of cost-effective technologies to reliably remove arsenic, selenium and mercury from water has been prioritized by coal fired power industry as environmental standards are currently very low in North America with a potential to be even lower. The arsenic treatment goal is targeted around 10 µg/L in general or driven by site specific requirements. Achieving these low levels poses a challenge given that:

- Arsenic removal is affected by the flows that can vary tremendously over time;
- Arsenic levels and forms are greatly variable even within the same coal ash pond;
- Arsenic removal is confounded by the water characteristics including pH, temperature, and other interfering constituents;
- Arsenic treatment generally results in concentrated residuals which are subject to release arsenic;
- Arsenic standards are very close to analytical limits.

In addition to provide insights on various physical and chemical technologies for arsenic removal, this paper highlights the lessons learned from one full-scale case study of coal ash pond water arsenic removal. Based on the favorable outcome of a bench-scale treatability study on the representative coal ash pond water samples, the full-scale treatment process was configured as a robust system consisting of flow and constituent equalization, multi-chemical injection for the pH control and particulate coagulation, staged filtration for the solids separation, and activated media adsorption of dissolved arsenic. For six months since commission of the wastewater treatment system, arsenic has been consistently reduced from hundreds-thousands µg/L to less than 10 µg/L.

Discusser: Shannon R. Brown, Bayer, Creve Coeur, MO

IWC 22-18: Analytical Variability of Selenium in FGD Wastewater

Mayra Giraldo, Stantec Consulting, Atlanta, GA ; William Kennedy, Stantec Consulting, NC, ; Adam Sutherland, Stantec Consulting, Nashvile, TN,

A coal fired electric power generating facility operated two biological pilot systems with the objective to validate the technology was capable of selenium (Se) reduction from atypical FGD wastewaters to meet the 2020 Steam Electric Power Generating Effluent Limitation Guidelines (ELGs). Throughout the pilot, samples were collected and analyzed at multiple commercial laboratories experienced with the FGD water matrix. Each lab analyzed Se using EPA recommended standard operating procedures (SOPs) adapting analytical method 200.8 for the FGD matrix.
This paper compares total and dissolved Se results, evaluating biases and variability between collection methods, labs, and actual analytical methods used. Discussion reviews the effects of each lab's unique combination of digestion, sample container, preservative procedure, dilution factors, and reporting limits allowable within the EPA 200.8 FGD SOPs method. Specific identified biases related to volatile, elemental, and reduced forms of selenium are discussed and challenge the established practices and historical data sets for selenium reduction in the FGD wastewater matrix.
The relevance of this review is related to the decades long deliberation by regulatory authorities attempting to accurately determine best available economically achievable technology standards for FGD wastewaters and the need for the electric power industry to strategically plan for the future of coal fired generation.

Discusser: Shelley Wojciechowski, CAMS, New Florence, PA

IWC 22-19: What can we Learn from Treatment of Emerging Contaminants to Build a Framework for Mitigating Microplastics?

Sara BinAhmed-Menzies, Ph.D., Barr Engineering, Minneapolis, MN ; Mike Ellis. P.E., Barr Engineering, Ann Arbor, MI, ; Tom Boom, P.E., Barr Engineering, Ann Arbor, MI,

Plastics have become an indispensable part of our daily life. Global production of plastics is estimated to be 320 million tons (MT) per year and is projected to reach 12,000 MT by 2050. Only 18% of plastics are recycled, 24% are incinerated, and 58% end up in a landfill or are released to environment. As they reside in the environment under different conditions such as heat, precipitation, and sunlight, plastics undergo degradation through different pathways: mechanical, photochemical, and microbial. Degradation of plastics affects their physical and chemical properties causing them to become more brittle and susceptible to fragmentation and formation of microplastics (MPs) and eventually nanoplastics (NPs). The size of MPs vary in shape (fibers, fragments, films, etc.) and size (0.1 - 5 mm). Several studies have confirmed the presence of MPs in various environmental media such as surface water, air, biosolids, and soil.
The effect of MPs on human health are still not fully understood, but MPs have been quantified in surface water organisms such as fish which indicates their presence in the food chain. Therefore , it will be important to understand how MPs are removed during water and wastewater treatment.
Currently, there is no federal legislation that identifies maximum contaminant levels for MPs in the various environmental media, so there has been little effort devoted to removing them from the environment. But as more research emerges, it is expected that regulations will be proposed to mitigate the levels of MPs in the environment, so it will be important to have a set of tools in place to address the problem. A framework for how to evaluate treatment options for MPs can be developed by leveraging experience evaluating treatment options for other contaminants of emerging concern (CEC), such as Per- and Polyfluoroalkyl substances (PFAS), and will be an important tool for navigating potential new requirements and treatment technologies for MPs.
In this paper we will present the fundamental facts about MPs, their sources in water, and the challenges of quantifying them, in addition to the extent of their removal in water and wastewater treatment plants. We will draw from the knowledge built by experience treating CECs to create a framework that addresses removal of MPs at different levels of water and wastewater treatment. The challenges unique to treating MPs compared to other contaminants such as the variation in size and shape will also be presented.

Discusser: Bill Carlin, DuPont Water Solutions, Wilmington, DE

IWC 22-20: Removal of Trace Metals in HDS Process

John Schubert, HDR, Sarasota, FL

There are usually a variety of metals in acidic mining influenced waters that are removed along with sulfate and more common metals like iron in lime precipitation processes. This paper will explore the removal of aluminum, cadmium, copper, manganese, zinc and fluoride in two High Density Sludge (HDS) pilot studies that considered the use of one stage versus two stage HDS processes. The paper will evaluate operating pH conditions and recycle solids levels versus removal efficiencies. Soluble metals concentrations will be compared with theoretical values as a point of reference. The comparison of performance will provide insight into the disposition of the listed ions. The impact of recycle ratio, solids formed staging of operations, pH and operational criteria will be considered. Since the characteristics of the two wastewaters being treated are different (i.e. one is much more concentrated than the other), the results should be reflective of a range of concentrations that covers many applications.

Discusser: Thomas Rutkowski, WSP Golder, Lakewood, CO

Monday, 11/7/2022; 1:15pm

M7 Wastewater Treatment Projects from Business and Technical Perspectives

IWC Rep: Jonathan Shimko, Michael Baker International, Pittsburgh, PA

Session Chair: John Yen, Marmon Water, Warren, NJ

Discussion Leader: Kai Zhang, Veolia,

Wastewater treatment is extremely challenging, not only from an technical perspective but also from a economic point of view. This session focuses on several papers looking into successful industrial wastewater projects, improvements and a pilot study for large scale development. The topics include a progressive design-build delivery model, an innovative biofilm treatment system, an alternatives analysis study for landfill leachate treatment and a successful water treatment pilot study to evaluate wastewater treatment options for sludge dewatering effluent.

IWC 22-21: Success Using the Progressive Design-Build Model for Food and Beverage Industrial Wastewater Treatment Projects

Tommy Lawlor, Bowen Engineering, Glen Burnie, MD ; John Van Gehuchten, P.E., McKim and Creed, Sewickley, PA, ; John Mickler, P.E., PMP, World Water Works, Inc, Oklahoma City, OK,

Food and Beverage producers need wastewater treatment solutions that work and are implemented quickly. The progressive design-build project delivery model is a time saving and cost-effective solution for food and beverage processors to efficiently comply with industrial wastewater discharge limits. The water characteristics require significant treatment flexibility and, due to the speed at which the design and construction occurs, engaging the operational and capital decision makers is critical to project success. Specifically, the project team must remain vigilant to ensure that the Owner is technically and commercially engaged during each design hold point to quickly make key decisions allowing the design to continue.

This paper will present a case study on the advantages of design-build in food and beverage industrial wastewater projects and the potential pitfalls.

The paper will present specific implementation results using a completed project. Technical content will include:

•Water chemistry influent and effluent design basis
•The treatment process selected and alternatives considered
•The speed of project kickoff and initiation with the design team and client
•Shrinking of overall project duration from Basis of Design to Start-Up
•Flexibility of contract model selection (i.e firm fixed price, target price, guaranteed maximum price)
•Cost savings and efficiencies afforded by true collaborative meetings with all stakeholders (this is key)

The potential pitfalls to look out for include:

•Critical technical or commercial misses during preliminary (30%/60%/90%) design review meetings.
•Pattern of repeat misses on these types of projects include:
oEyewash / shower facilities in the chemical storage and pumping areas
oContainment infrastructure at chemical storage areas
oLocation of key instruments and serviceable components

Finally, the paper will conclude with specific recommendations and best practices to assist teams using the progressive design-build model focus their reviews, limit common mistakes, and improve the likelihood for project success

Discusser: Scott Christian, P.Eng., Nijhuis Saur Industries, Chicago, IL

IWC 22-22: Ammonia Nitrogen Conversion in Struvite Using a Novel Sustainable Electrocoagulation Process

Eric Bergeron, WSP Golder, Sherbrooke, QC Canada; Valérie Léveillé, WSP Golder, Sherbrooke, QC, Canada

Treatment of ammonia nitrogen in groundwater, surface water, domestic and industrial wastewaters for various clients in the oil and gas, mining, food, slaughtering house and waste management (including landfill)) industries is challenging with conventional treatment technologies due to several limitation factors.
Golder has used a novel process to remove ammonia nitrogen based on the struvite (an agricultural fertilizer) formation using electrocoagulation (EC) to release in situ magnesium in order to combine with orthophosphate in water. The process developed is an alternative to conventional ammonia nitrogen removal technologies. The technology has the potential of reclaiming ammonia from water to make fertilizer. The EC technology using magnesium electrodes is a sustainable technology. EO uses one of the cleanest and safest reagents: “the electron.” The theory, two case studies and estimated operating and capital cost of this novel process will be presented. The struvite formation process will be discussed as well as observed theory deviations in practice.
The first case study is a retrofit of this novel process to an existing mine water treatment for a water having an average of 35 mg/L of ammonia nitrogen to be reduced to less than 10 mg/L and a maximum flowrate of 400 m3/d. The second case study is a landfill impacted groundwater treatment (pump and treat system) incorporating the novel process as the upstream treatment unit for a maximum flowrate of 166 m3/d in order to reduce the ammonia nitrogen from an average of 5 mg/L to less than 0.49 mg/L. The process also removed other contaminants: metals, hydrogen sulfide, suspended matter (colloidal form), mineral oil and grease, phosphor and surfactants.

Discusser: Sriram Ananathanarayan, BHP, Tucson, AX, USA

IWC 22-23: Boat Harbour Remediation, Pilot Study

Hojat Seyedy, GHD Limited, Waterloo, ON Canada; Christine Skirth, GHD, Vancouver, BC, Canada; Christopher Everest, GHD, Waterloo, ON , Canada; Sophia Dore, GHD, Niagara Falls, NY; Shannon Kemp, GHD, Calgary, AB, Canada

Nova Scotia Lands Inc. sought assistance to design and conduct bench and pilot scale wastewater treatment studies to evaluate wastewater treatment alternatives for sludge dewatering effluent within Boat Harbour (BH). The Province of Nova Scotia constructed the BH effluent treatment facility in 1967 to treat effluent from industrial sources, mainly from a bleached kraft pulp mill. As of January 2020, the facility is no longer being used to treat industrial effluent, and remediation is on the horizon. At the core of the remediation will be removal of impacted sludge/sediment and management of all associated effluents. A successful wastewater treatment trial was critical to inform potential plans for an efficient, safe, and cost-effective remediation project.

Heavy metals, petroleum hydrocarbons, dioxins and furans (D&Fs) and mercury were identified as the main chemicals of concern (COCs). A combination of pH adjustment, coagulation/ flocculation, multimedia filtration, and adsorption was proposed for remediation of identified COCs.

It was expected that using coagulant with the help of polymer would result in a fast sludge dewatering and clear supernatant. The results of the bench scale study were utilized in designing the water treatment plant which tested during pilot scale study. A containerized wastewater treatment facility (WWTF) were tested during pilot scale study. The main objectives of pilot scale study were to investigate and evaluate the proposed treatment method and collect necessary data for detail design of a full-scale treatment system.

An aluminum chloride hydroxide-based coagulant and an anionic acrylamide-based polymer which was found during the bench-scale study that creates the fastest sludge dewatering and clearest supernatant was used. The chemically dosed slurry was pumped into the Geotextile Tubes (GT) for dewatering. The pilot scale study demonstrated that the BH sediment could be dewatered and the dewatering effluent could be treated to provincial standards. For example, D&Fs total equivalent toxicity (TEQ) was dropped from 1,290 pg/l for the dredged slurry to 5.57 pg/l in the GT effluent. This value dropped even further to 1.79 pg/l in the WWTF final effluent. Exceeded metals also showed almost the same level of reduction. However, there were elements such as mercury, cadmium, chromium, copper, lead, zinc and petroleum hydrocarbons in the dewatering effluent that had concentrations higher that assessment criteria. The concentration of these elements was reduced to below assessment criteria in the WWTF final effluent. The results of this pilot study is used on detailed design of the full-scale treatment system.

Discusser: Sarah Petrovich, Valicor Environmental Services, Houston, TX

IWC 22-24: Case study: Improving Year-Round Removal of High-Strength Ammonia from Industrial Wastewater with Simple, Low-Energy Biological System

Tony Kobilnyk, Bishop Water Technologies, Renfrew, ON Canada; Wudneh Shewa, Bishop Water Technologies, Renfrew, ON , Canada; Kevin Bossy, Bishop Water Technologies, Renfrew, ON, Canada

Ammonia is a common constituent of industrial wastewater that is often collected in large, onsite ponds and treated using biological processes. However, the nitrifying bacteria that provide ammonia removal are temperature-sensitive, and under cold conditions become less active and less effective at achieving regulatory requirements. This is compounded by increasingly stringent ammonia discharge regulations that could render some systems non-compliant and necessitate upgrades. An example is Canada’s Metal and Diamond Mining Effluent Regulations (MDMER) that was strengthened in June 2021 and limits the monthly mean effluent concentration of un-ionized ammonia to 0.5 mg/L. This presentation will examine an innovative biofilm attached growth wastewater treatment system that was pilot tested at a Canadian gold mine from August to December 2021. The study evaluated the ability of Bishop BioCord Reactors to improve the facility’s cold-weather ammonia removal, meet more stringent discharge limits and increase the discharge rate.

The technology offers a simple, low-energy, and easy-to-operate process to upgrade wastewater lagoons and enhance removal of nutrients and organics. This fixed-film system provides microorganisms with optimal conditions for growth, proliferation and nutrient metabolism on a unique, high-surface area, polymer substrate. The system’s stable biofilm also helps insulate microorganisms within the inner layers and reduces washout, enabling continuous treatment in winter and high-flow conditions.

Full-scale systems can be installed directly into a lagoon cells, significantly reducing capital costs since additional equipment such as tanks, blowers and pumps are not required to support a sidestream process. Each Reactor is also equipped with a micro-bubble aeration system powered by low-energy compressors, which helps reduce operating costs when compared to blowers.

This presentation will discuss the methodology and results of the pilot system. The containerized system operated in two phases, receiving influent from two cells of the lagoon system to increase ammonia loading to the pilot and demonstrate cold-weather nitrification at variable influents.

The overview will include a summary of the pilot system design and the ammonia removal performance. It was demonstrated that steady-state nitrification was not negatively impacted by the cold-weather conditions observed during the second half of the pilot project, and that average nitrification rates increased from 38 g/day to 55 g/day of ammonia removed during the transition from warm (average 18oC) to cold (average 7oC) water conditions and lower to higher ammonia loading conditions. The summary will also discuss how the results were scaled and used to refine full-scale system design.

Discusser: Ron Ballard, Brown and Caldwell, Houston, TX

Monday, 11/7/2022; 1:15pm

M8 Sustainability

IWC Rep: Michele Funk, P.E., Bechtel Corp., Reston, VA

Session Chair: Juvencio Casanova, Evoqua Water Technologies LLC, The Woodlands, TX
Discussion Leader: Lindy Johnson, Stantec, Everett, WA

As many organizations focus not just on producing goods and services but on how they bring them to the market, sustainable performance, is at the center of how the industry is responding. Water and energy are essential components of every industrial process and companies have taken the responsibility to protect the environment by committing to reduce their own water and carbon footprint, and by having a handprint with solutions to help society improve their environmental impact. This session explores several cases of how sustainability is shaping environmental, social and governance programs from water treatment optimization to green energy, and from safe water to global initiatives.

IWC 22-25: Fundamentals of Sustainability: The Rise of ESG

Ivan Morales, Breakwater Vantage, Vancouver, BC Canada; Martin Grygar, Breakwater Vantage, Canada

Communities and stakeholders have made it clear that environmental, social, and governance (ESG) performance are critical to securing a sustainable future. This paper aims to provide a summary of the key ESG metrics, develop the frameworks, and the challenges the industry is facing. The term sustainability was developed in 1972 by the United Nations (UN). It was introduced by the report called Limits to Growth Report. Sustainability reflects on the management of a corporation's environmental and social impacts as well as its management of the environmental and social capital necessary. The paper discusses the four pillars of sustainability which are the following: Economics, Environment, Social, and Governance, and how the UN's 17 goals can shape the 2030 vision on the future business economic landscape.
To endeavor on a sustainable future and foster longevity, growth, and value of future corporate activities, the paper presents the research on publicly traded and private companies, emphasizing goal 6 "Clean Water and Sanitation" and goal 14 "Climate Action". The discussion covers the following areas: 1) information available, 2) the connection between key performance indicators (KPI) reported and UN goals, 3) existing standards, and 4) current taxation benefits in the USA and Europe.

Discusser: Nicole Bartoletta, McKim & Creed, Inc., Sewickley, PA

IWC 22-26: High Performance & Sustainability Now Go Hand in Hand

Elke Peirtsegaele, DuPont Water Solutions, Carpinteria, CA

While water is one of the world's most vital resources, decreasing supply and increasing demand have stressed global water supplies incredibly. Increasing population, climate change, and other stressors are limiting the availability of clean water and cheap energy, making it all more crucial for businesses and manufacturers to develop water sustainability programs to use this precious resource more efficiently.
For many years now, spiral-wound reverse osmosis (RO) and nanofiltration (NF) membrane elements have proven very successful in alleviating these freshwater shortages by treating various waters and wastewaters for reuse or discharge. However, membrane manufacturers continue to innovate and develop membrane elements with improved rejection and flow specifications as well as increased durability in effort to further assist users in meeting their water and energy needs. While improved RO permeate quality leads to reduced chemical regenerations in downstream mixed bed polishers, it is the increased productivity of the RO elements that results in significant energy consumption savings and reduced carbon emissions. Because less energy is required to produce the same amount of clean water, users can reduce their carbon footprint substantially.
This paper provides a detailed explanation of why water sustainability programs are necessary and how they address the freshwater supply and demand issues. It also discusses the various RO membrane improvements that are necessary in assisting the various initiatives of these water sustainability programs. Lastly, this paper looks at a case study to demonstrate how improved RO membrane elements successfully reduce the carbon footprint at one installation. Overall, this paper should leave the reader with a general understanding of how critical continuous innovation is to treat water in a sustainable manner with the goal of protecting our precious freshwater sources.

Discusser: Kristen Jenkins, Brown and Caldwell, Atlanta, GA

IWC 22-27: The Emerging Green Hydrogen Industry - Challenges and Opportunities for the Water Industry

Andrew Hodgkinson, Worley, Clifton Hill, Victoria Australia; Thomas Higgins, Worley, St. Augustine, FL

Pure water is critical for hydrogen production. For electrolysis, the usual means for producing "green" hydrogen, roughly 5 m3 (1,300 gallons) of pure water per day is required for every 1 MW of electrolyzer capacity. Many green hydrogen projects now in planning are for up to 10,000 MW. This potentially requires demineralizing systems with 50,000 m3 per day (13 MGD) of ultrapure water capacity.

Few cities in the world have this much spare water supply capacity. Many industrial centers are already at or near their water supply capacity. To provide so much extra water for hydrogen production, as well as the booming demand for semiconductor grade water by solar panel factories, will require creation of major new water supplies in hitherto unexpected locations, not currently considered as water stressed. Potentially the only raw water supplies available will be wastewater, or seawater. Meaning that many utility scale hydrogen plants must also include a major new water supply and processing facility.

The principal wastewater stream from hydrogen production will be the demineralizing reject stream, which is relatively modest for the less than 1 MGD demineralized water demand of the current generation of 100 – 300 MW electrolyzers.

One type of electrolyzer also produces spent alkaline electrolyte. At approximately 30% potassium hydroxide this stream requires specialized treatment and will likely need to be processed for direct reuse if this stream is still produced in the coming multi-gigawatt generation of electrolyzers.
The fast-emerging hydrogen economy, will not only revolutionize the global energy industry, it will transform the water industry bringing significant challenges, and vast new opportunities.
Challenges and Opportunities include:

• Total global demand for ultrapure water in this new industry is projected to be 150 m3 per second (3,400 MGD) by 2050. Where can we get this much water, and how will it be treated?
• To provide this new demand requires 5 to 6 m3/second (80,000 to 95,000 gpm) of NEW pure water production capacity per year until 2050 (the same as building approximately 5 new boiler feedwater plants for major thermal power plants PER WEEK from now until 2050).
• What is the best way to produce ultrapure water when the scales are an order of magnitude larger than the largest boiler feedwater plants or semiconductor water plants?
• How will so much water be supplied? Will any industries be expected to relinquish their water supplies to meet this new demand?

Discusser: Jay Harwood, Newterra, Ancaster, ON, Canada

IWC 22-28: Challenges in Sustainable and Economic Solutions for Access to Clean Water in Central America

Vanessa Willey, Culligan Water, Libertyville, IL

Even though Guatemala is the most populous country in Central America, rural access to safe potable water is a widespread challenge that exists in the present day. Due to pollution, population growth, lack of government funding, and an unregulated water and sanitation sector in Guatemala, most of the water in Guatemala is dangerous to drink. That is why the Engineers Without Borders (EWB) – Chicagoland Professional Chapter entered a partnership agreement to help a rural agricultural community (Tzaput) in the state of Quetzaltenango in Guatemala have access to safe water. A ravine and spring-fed stream separate Tzaput and its nearest neighbor. They share the same spring water source that requires minimal treatment to reach potable standards, but each community has its own pump house, tanks, and distribution system to access this resource. However, Tzaput's old water supply system of a diesel-driven pump to deliver this spring water has been non-functioning and the water supply line leaks. Therefore, Tzaput currently relies on a periodic supply of water via a pipeline from the neighboring community. Although this arrangement has been in practice for several years, the community is placed in a precarious position that limits its potential for growth and prosperity. The paper will discuss several alternatives that were not selected for reasons that ranged from unsustainability, cost, and difficulty of implementation and maintenance. The final equipment solution provided the best balance between cost, reliability, serviceability, and ease of implementation. Direct access to the spring water will eliminate their reliance on the limited supply of water provided by the neighboring village and allow them to focus on the growth and sustainability of their community and lifestyle for years to come. Significant changes to the expediency of the program occurred as a result of the COVID-19 global pandemic, forcing a change in direction to a remote implementation and all the difficulties that come with that. Equipment solution is currently being remotely implemented, and the paper will discuss future upgrades under consideration for implementation by end of 2022.

Discusser: Juan Meneses, Nalco Water, an Ecolab Company, Lake Charles, LA

Tuesday, 11/8/2022; 8:00am

T1 Trace Metals – Lithium, Rare Earths and Selenium

IWC Rep: Jay Harwood, Newterra, Ontario, Canada

Session Chair: Mark Owens, UCC Environmental, Waukegan, IL

Discussion Leader: Evan Claytor, SUEZ, Glen Allen, VA

Lithium-ion batteries are powering today's technology from phones to laptops to electric cars. Rare Earth Elements are also essential to today's electronics. However, the mining and refining processes required are very resource intensive. Improving the processes necessary to mine, refine and produce these metals is a global priority. This session presents three papers (two on lithium and one on rare earth elements) focused on improving these processes. The fourth paper presents a potential removal mechanism for removing selenium along with sulfates using barium.

IWC 22-29: Recovery of Lithium from Brine Using Lithium Ion Sieves

Craig Brown, Chemionex Inc., Pickering, ON Canada; Andy Robinson, Standard Lithium Inc., Vancouver, BC, Canada; Ron Molnar, MetNetH2O, Peterborough, ON, Canada

The Smackover Formation in southern Arkansas, USA, is an extensive porous and permeable limestone aquifer that hosts huge volumes of mineral-rich brines, as well as hydrocarbons. The Smackover brines are currently the largest source of bromine in the world, but the brine also contains significantly elevated levels of lithium – typically ranging from 150 to 500 mg/L. With an annual brine production of 42.6 million m3, this represents a huge potential resource. The high background salt level (TDS~300,000 mg/L) however, makes recovery of the lithium very challenging. Conventional ion exchange resins do not have sufficient lithium selectivity to be effective in recovering the lithium.

A novel ion exchange process for recovery of lithium from these brines has been developed. The process utilizes a fine (2-40μm), powdered lithium ion sieve (LIS). The LIS has an extremely high selectivity for lithium over sodium, calcium, magnesium and other cations so that it can extract the lithium from the brine. The LIS is contacted with the brine in a continuous stirred tank reactor (CSTR) at LIS solids concentrations of greater than 100 g/L. After loading, the LIS is separated from the brine and washed with water in a series of countercurrent decanters. The lithium is then eluted from the LIS with dilute hydrochloric acid in another stirred tank reactor to produce a lithium chloride product. The lithium is concentrated by a factor of approximately ten times while achieving a separation factor of about 100 vs calcium, sodium and magnesium. The lithium chloride eluate is further purified by ion exchange prior to conversion to lithium carbonate

The process has been operated in a pilot plant at a brine flow rate of 240 litres per hour and is currently being demonstrated in a small, commercial-scale plant in southern Arkansas at a flow rate 11 m3/h. The first full-scale commercial plant with a design brine flow 360 m3/h of is now being designed.

Discusser: Daryl Gisch, Ph.D., DuPont Water Solutions, Midland, MI

IWC 22-30: A Rare Opportunity: Treatability Evaluation for Oxalate-Rich Rare Earth Processing Wastewater

Alison Ling, Ph.D., P.E., Barr Engineering, Minneapolis, MN ; Sara BinAhmed-Menzies, Ph.D., Barr Engineering, Minneapolis, MN, ; Becca Vermace, Barr Engineering, Minneapolis, MN, ; Brittany Rew, University of North Dakota, Grand Forks, ND, ; Josh Kirk, Barr Engineering, Minneapolis, MN

A novel process was developed to extract rare earth resources from coal, producing both an upgraded coal product and mixed rare earth concentrates. The rare earth elements (REE) consist of 15 elements in the lanthanide series (plus yttrium and scandium) that are key in enabling many high-tech devices. The lignite coal targeted for use contains sufficient concentrations of total rare earth elements (TREE) to make it worth evaluating as a domestic source of REE to replace or use alongside mineral-based ore deposits. The novel process being developed responds to critical security and supply chain issues.
Process wastewater from the proposed REE extraction process has elevated concentrations of sodium sulfate and sodium oxalate, with smaller contributions from rare earth and other metals. The wastewater is saltier than seawater, with total dissolved solids concentrations above 50,000 mg/L. Oxalate is used in the process to precipitate rare earth elements into a concentrated form, and excess oxalate is routed to the wastewater resulting in high organic loading on the order of 2,500 mg/L TOC.
We evaluated two levels of treatment, including small-scale discharge to a publicly owned treatment works (POTW) and large-scale discharge to surface water. Chemical precipitation of calcium oxalate and metal hydroxides with co-precipitation of organic matter was sufficient to meet POTW pre-treatment requirements, but imparted a large salt load. Bench- and pilot-scale testing demonstrated the ability to meet targets and resulted in dose selection and equipment sizing information to support scale-up when discharging to a POTW. For surface water discharge, we evaluated membrane separation with pre-treatment, but found that the water quality was unsuitable for membrane treatment due to high salinity and organic loading. In response, we evaluated brine concentrators and multiple slurry management approaches. This paper summarizes results from the two treatability evaluations and outlook for full-scale implementation.
As plans to develop more domestic sources of rare earth elements advance, processing plants should evaluate wastewater management needs early in the project. In this case, wastewater treatment comprised between 25% and 50% of total project costs for the rare earth recovery process.

Discusser: Dave Ciszewski, SUEZ Technologies & Solutions, Bellevue, WA

IWC 22-31: E3 Lithium’s Innovative Journey to Lithium Recovery

Caroline Mussbacher, E3 Lithium, Calgary, AB Canada; Joshua Rubenstein, E3 Metals Corporation, Calgary, AB, Canada

E3 Metals Corporation (E3) is a lithium resource and technology company aiming to produce high purity, battery-grade lithium products from brines to power the growing electrical revolution. Based in Alberta, E3's Clearwater Project represents a significant lithium resource and an opportunity to leverage a mature and sophisticated oil and gas industry for accelerated project development. The saline formation fluids from E3's Clearwater Project area contain lithium in solution with high levels of dissolved solids. E3 has focused on developing and optimizing a highly lithium selective sorbent for Direct Lithium Extraction (DLE). These sorbents selectively extract lithium from saline formation water and produce a relatively clean lithium product stream with low levels of unwanted ions. This presentation will share E3's project and technology development journey to date, including bench scale and prototype testing lessons learned. An overview of E3's path forward, and key challenges to overcome on the journey to lithium recovery will also be discussed.

Discusser: Jack Ma, UCC Environmental, Waukegan, IL

IWC 22-32: Barium Chemistry to Treat Sulfate – But What About Selenium?

Kevin Dufresne, P.Eng., Geosyntec Consultants, Guelph, ON Canada; Alicia Herrin, Southern Company, Birmingham, AL, ; Mehmet Iscimen, P.E., CPESC, Geosyntec Consultants, Kennesaw, GA, ; Hariprasad Parthasarathy, Ph.D., P.E., Geosyntec Consultants, Chicago, IL, ; Andrew Holmes, P.Eng., Ph.D., Geosyntec Consultants, Guelph, ON, Canada

Sulfate is a ubiquitous constituent in industrial wastewaters. It is generally non-toxic but can be a large contributor to total dissolved solids and pose challenges with treatment processes, such as reverse osmosis. With intensification of water resources and the advent of widespread water reuse, the ability to selectively remove sulfate from wastewaters is becoming progressively more relevant.

Our paper will discuss a study using barium chemistry to remove sulfate from an industrial wastewater stream. The study demonstrates that for wastewaters rich in calcium and bicarbonate ions, barium hydroxide can be used to simultaneously precipitate barium sulfate and calcium carbonate, resulting not only in a decrease in sulfate but a net decrease in TDS. For the wastewater studied, the reaction became bicarbonate limited after removing 1140 mg/L (or 62%) sulfate and 1590 mg/L (or 48%) TDS. Additional tests were performed where carbon dioxide was dissolved in solution to overcome the bicarbonate deficiency, removing 1570 mg/L (or 85%) sulfate and 2450 mg/L (or 75%) TDS, at which point the system then became limited by a calcium deficiency. As a secondary objective, the impact of these reactions on other constituents in the wastewater was monitored, including selenium. It was hypothesized that selenium would be coprecipitated with barium sulfate and/or precipitated directly with barium ions. Study demonstrated that selenium was removed at a rate of approximately 40% of the sulfate removal rate. Additionally, even once the sulfate was fully depleted the further addition of barium hydroxide continued to remove selenium from solution. The study demonstrated removals of selenium of up to 94%.

Some follow up tests from this work currently contemplated and potentially to be included in this paper includes: (i) assessing the impact of barium hydroxide on selenium speciation, (ii) assessing if the treatment conditions could be optimized specifically for the removal of selenium, and (iii) assessing if the barium sulfate could be extracted from the precipitated solids to a purity sufficient to be recovered as a marketable product.

Discusser: Jord Yniguez, Purolite, King of Prussia, PA

Tuesday, 11/8/2022; 8:00am

T2 Novel Approaches to Brine Management

IWC Rep: Ivan Morales, Breakwater Vantage, Calgary, AB, Canada

Session Chair: Adam Sutherland, Stantec, Nashville, TN

Discussion Leader: Alan Daza, Safbon Water, Tampa, FL

As the world drives towards increased sustainability and reuse, there is an expanding market for the use of membranes to recover valuable minerals and organics from brine. This session will explore product recovery as an emerging application of membrane technology which is minimizing waste disposal in a variety of industries.

IWC 22-33: Dynamic Evaporation Pond Performance Modeling for Prediction of Carnallite Recovery as a Function of Pond Area Expansion

Arash Karimi, Ph.D., P.Eng., Worley, Calgary, AB Canada; Sergei Panasiuk, Ph.D., P.Eng., Worley, Markham, ON, Canada; Andrew Hodgkinson, , Worley, Melbourne, Victoria, Austria

Advisian (Worley Group) used innovative numerical modelling to predict an increase in production of carnallite from evaporation ponds with pond expansions and help with pond configuration optimization to maximize production. Carnallite is an important mineral used in the production of potash as a fertilizer.
A complex system of multiple evaporation ponds was modeled using a dynamic model capable of performing a mass balance over each pond in each time step (daily, weekly, and monthly options) by taking into account the various water and solids sources and sinks, including intake, discharge, evaporation, seepage, rainfall, surface runoff water, salt harvesting slurry draw, and return brine and tails recycled from the salt refining process. The model can estimate the evaporation rates from environmental parameters or use standard pan evaporation rate measurement data from the site. Variable operating parameters such as monthly target pond levels and solids dredging/harvesting rates and schedules are specified in the model.
For this project, further enhancements were made to the model, including the addition of detailed thermodynamic and water chemistry modeling using OLI Engine: Developer Edition. To this end, the model maintains detailed brine and solids composition vectors for each of the incoming streams and the initial and ongoing pond inventories during and after each time step of the calculation. In each time step, the model performs a mass balance to estimate the new composition after accounting for the changes pertinent to that time step, which is then passed on to the OLI Engine to estimate the phase distribution of components and the expected solids precipitation amounts. The brine amount in excess of the target pond level in that time step is designated as the discharge from the pond to the downstream pond or ponds. A stochastic surveying feature was also added to enable identifying the operating parameter values that would improve the performance of the system.
Validation of the model was achieved using historical operating data from the 2020 operating year, for which the model predicted the annual carnallite production within 10% of the reported amount. Multiple ponds expansion scenarios were then modelled to help identify the scenarios with the highest rate of return on investment. An optimization algorithm was developed to find the optimum intake rate and flow split ratios between existing and new ponds. The model was also able to predict delay in production increase due to the initial dilution effect of the expanded areas.

Discusser: Saurabh Tonapi, P.E., HDR, Austin, TX

IWC 22-34: New Approaches for Membrane-Based Ocean Mining of Sodium Chloride for Chloralkali Feedstock

Craig Bartels, Ph.D., Hydranautics, San Diego, CA ; Rich Franks, Hydranautics, Oceanside, CA, ; Eli Oklejas, FEDCO, Monroe, MI, ; Rory Weaver, FEDCO, Monroe, MI,

Historically, reverse osmosis (RO) and nanofiltration (NF) membranes have been used to make drinking water or high-quality process water for industry. Although this continues to be the primary use of membranes today, there is a rapidly growing market to expand the use of membranes for the super concentration of brines to minimize waste disposal (such as Zero Liquid Discharge, ZLD), or for the recovery of valuable minerals and organic molecules in the brine. This paper will report on testing and evaluation of novel membrane processes to maximize the recovery of minerals from seawater. A novel pilot has been designed, built, and operated at a site in Saudi Arabia to demonstrate such a process in conjunction with ongoing research by Saudi's Desalination Technologies Research Institute (DTRI). The goal of the pilot is to treat Arabian Gulf seawater to make three key products: a magnesium rich brine for augmenting drinking water, a low salinity drinking water, and a highly concentrated sodium chloride brine for use in the chloralkali industry. The novel process utilizes a variety of membranes, including softening nanofiltration, SWRO, ultra-high-pressure RO, and brine concentration membranes. The pilot also demonstrates the benefit of using multiple turbochargers that can be linked together to recover energy more efficiently and precisely control the boost pressure to each stage of the high-pressure RO system. The pilot data proves that the system can make all three desired products at high quality and at relatively low energy and capital costs. Initial results indicate that the brine from the UHPRO can reach TDS values as high as 93,000 mg/l, while the combined RO permeate was 700 mg/l TDS. This process will be the basis for a 53 mgd (200,000 m3/d) commercial treatment system that will supply concentrated sodium chloride brine to the Saudi chloralkali industry.

Discusser: Shaleena Smith, Safbon Water Technology, Tampa, FL

IWC 22-35: Design Best Practices - Considering the End at the Beginning

Bryan Hansen, P.E., Burns & McDonnell, Kansas City, MO

We often get wrapped up in the novelty of a new treatment design concept during the engineering design phases of the project. In the rush to bring the project from concept to reality we sometimes fail to focus on what may be the most important aspects to the end user - ease of operation and accessibility for maintenance activities. This paper will summarize some general engineering 'best practices' to consider that may make your next project a more functional and well received design. We'll cover numerous topics like 1) equipment redundancy and balancing system cost versus reliability, 2) equipment and building layout highlighting the importance of a well thought out floor drain or trench system and building sumps, 3) leaving space for piping supports when laying out the equipment, 4) designing the equipment skids to provide supports when needed or to have removable shipping supports to make access after installation easier, 5) instrumentation type selection for all process parameters in a variety of common equipment configurations, 6) piping layout considerations, and 7) valve selection and placement including additional valves needed for venting, draining, and lock-out, tag-out needs. The paper will present these 'best practice' concepts through use of sketches, models, and photos and show how we need to consider the end purpose of the device at the beginning of the design activity in order to provide a great product.

Discusser: Henlo (for Ken) Du Preez, Stantec, Reno, NV

IWC 22-36: What About Other Brines?

Omkar Lokare, Gradiant Corporation, Woburn, MA ; Ana Guedes, Gradiant Corporation, Woburn, MA, ; Kurt Blohm, Gradiant Corporation, Woburn, MA, ; Rohan Swaminathan, University of British Columbia, Vancouver, BC, Canada; Richard Stover, Gradiant Corporation, Woburn, MA

In the context of desalination and wastewater treatment, brine is composed mostly of sodium chloride in water. However, different industrial sectors produce brines where sodium chloride is not the dominant species. Specific examples include brines rich in lithium chloride for lithium extraction, sodium sulfate rich brines from the food and beverage industry, and ammonium sulfate rich brine generated in the fertilizer or mining industries. While thermal processes are the most widely applied option for brine concentration, the high capital costs and energy consumption entailed are prohibitive for most applications. Conventional reverse osmosis (RO) is limited by the pressure capacity of standard RO membranes and equipment to seawater brine concentrations of about 80,000 mg/l total dissolved solids (TDS), far below saturation concentrations of over 260,000 mg/l TDS. Disc tube RO and ultra-high-pressure RO (UHPRO) can be operated at pressures of up to 1,800 psi (124 bar), increasing seawater brine concentrations to as high as 130,000 mg/l TDS. However, such high-pressure operation presents potentially prohibitive challenges for equipment sourcing and cannot compete with thermal process brine concentrations.
Osmotically-assisted RO (OARO) processes use pressure to drive purified water across a semi-permeable membrane against the osmotic pressure difference between the feed and permeate streams, similar to conventional RO. What makes the OARO process unique is the relatively high salinity on the permeate side of the brine concentration (BC) membranes. This reduces the osmotic pressure barrier, which lowers the feed pressure required to drive permeate flow. As a result, ultra-saline feeds can be treated at low enough hydraulic pressures to enable the use of standard RO equipment.
This paper considers the application of this emerging technology for challenging non-sodium-chloride brines from different industries. Bench-scale testing results, theoretical calculations, and full-scale projections are presented to demonstrate the benefits of OARO in such applications. These benefits include a lower cost of brine concentration and a lower cost of brine disposal when compared to other treatment technologies, which is shown through data-based economic analyses in the paper.

Discusser: Bryan Hansen, P.E., Burns & McDonnell, Kanas City, MO

Tuesday, 11/8/2022; 8:00am

T3 PFAS - Pretreatment, Residual Management, and Destruction

IWC Rep: Michael J. Soller, P.E., CPC, DBIA, Bowen Engineering, Indianapolis, IN

Session Chair: Russell C. Huffmyer, V-Systems, Pittsburgh, PA

Discussion Leader: Tom Higgins, P.E., Ph.D., Worley, St. Augustine, FL

Within this session on PFAS, we will learn about the use of a pilot scale hybrid engineered wetland treatment system for removal of PFAS from landfill leachate, the destruction of PFAS-contaminated fire training pond water utilizing continuous hydrothermal processing, some technologies for effective treatment of ultra-short chain PFAS, and we will wrap up with some perspective on pretreatment.

IWC 22-37: Use of a Pilot-Scale Hybrid Engineered Wetland Treatment System for Removal of Per- / Poly-Fluoroalkyl Substances (PFAS) and Other Constituents of Concern from a Landfill Leachate

O'Niell Tedrow, Northeast Technical Services, Inc. and Vermilion Community College, Virginia, MN ; Andrew McQueen, US Army Corps of Engineers, Vicksburg, MS; Peter Lee, Lakehead University, Thunder Bay, ON , Canada

Aqueous landfill leachates can be sources of contaminants of concern (CoC) including per- and polyfluoroalkyl substances (PFAS) to surface- and ground- water resources. Active mechanical and chemical methods of PFAS removal prior to leachate discharge can be cost prohibitive for perpetual field-scale applications. Therefore, semi-passive leachate treatment is preferred for removal of CoC. During 2020 and 2021, pilot-scale hybrid engineered wetlands (EWs) were evaluated for removal of 14 PFAS, ammonia-nitrogen (NH3-N), manganese (Mn), and boron (B) from a landfill leachate. The 2020 EW series consisted of four vegetated reactors, two bulrush and two cattail, and an aerated sand-gravel-GAC mixed-medium reactor; final treatment was an ultra-violet / hydrogen peroxide / GAC exposure chamber. The 2021 EW series consisted of four bulrush reactors, an aerated sand-gravel reactor, and a GAC or biochar exposure chamber. During 2020, hybrid EW PFAS removal averaged 72%; NH3-N decreased from ≥ 140 mg/L to near non-detect within vegetated reactors; Mn decreased from approximately185 to 70 and 20 µg/L in aerated and final reactor outflows, respectively; and B concentrations increased by approximately 17%. During 2021, significant decreases of multiple PFAS (~82% GAC/biochar), NH3-N (~113 to 3.5 EWTS; 0.3 mg/L GAC/biochar), Mn (~1.7 to 0.1 EWTS; 0.02 mg/L GAC/biochar), and B (~21.5 to 8.8 mg/L GAC/biochar) were observed, specifically within the GAC/biochar reactor. Although removal of PFAS, NH3-N, and Mn was observed within the EWs, the final active treatment component was required to achieve overall CoC removal objectives. This current study emphasizes the benefit of semi-passive EWs as a component of an overall leachate treatment system, but also the need for active treatment targeting removal of more resilient contaminants of concern.

Discusser: Pierre Kwan, P.E., P.Eng., HDR, Seattle, WA

IWC 22-38: Destruction of PFAS-Contaminated Fire Training Pond Water via Continuous Hydrothermal Processing

Brian R. Pinkard, Ph.D., Aquagga, Inc., Tacoma, WA ; Igor Novosselov, Ph.D., University of Washington, Seattle, WA,

The use of per- and polyfluoroalkyl substances (PFAS) in manufacturing processes, consumer goods, and firefighting foams has resulted in widespread need to remediate sites with PFAS-contaminated soil and groundwater. PFAS exhibit high toxicity, even at very low concentrations (<100 ppt), and the stability of the carbon-fluorine bond means that PFAS are perpetually stable in the environment. Current remediation methods for PFAS-impacted sites primarily include (a) filtration of PFAS from ground or surface water, (b) in situ fixation of PFAS in contaminated soil, (c) washing PFAS from contaminated soil, followed by filtration, or (d) incineration of contaminated soil. All filtration and fixation technologies serve to capture PFAS molecules, but they do not destroy PFAS molecules. End-of-life disposal with complete defluorination (cleaving all C-F bonds) is needed to eliminate the risk of subsequent environmental re-contamination, or future liability.
Many military installations and airports have lined fire training ponds (FTPs) where PFAS-based firefighting foams are sprayed during firefighter training drills. The remediation of liquids in FTPs is a significant expense and a significant technical challenge, due to the significantly high levels of PFAS in the surface water (often >1 ppm) and sediment (often >1 g/kg). Discharge limits for PFAS in many locations are currently set at the EPA's Health Advisory Level of 70 ppt of PFOS and PFOA combined, thus FTP surface water remediation requires significant reduction in PFAS levels.
Hydrothermal alkaline treatment (HALT) is a promising PFAS destruction technology which has been proven to mineralize PFAS compounds without producing toxic byproducts, short-chain PFAS, or HF. Previous studies have leveraged batch reactors to study HALT reactions, often requiring long residence times (>>60 min) to achieve significant levels of destruction. In this study, a continuous flow, tubular HALT reactor is fabricated and employed to study the reaction behavior of PFAS in a contaminated FTP water sample, under continuous HALT processing conditions. In the continuous processing regime, >99% total PFAS destruction is achieved in ~5 min, a significant improvement over batch processing. This paper will present treatment data at several NaOH concentrations and several residence times. Overall, this is a first-of-its-kind study investigating PFAS destruction in a continuous HALT reactor.

Discusser: Siddharath Patel, Worley, Meridian, MS

IWC 22-39: Technologies for Effective Treatment of Ultra-short Chain PFAS

Christopher Bryan, 3M, Maplewood, MN ; John Berry, ECT2, Portland, ME; Sean Smith, 3M, Maplewood, MN

Much of the published work to date has been on treating per- and polyfluoroalkyl substances (PFAS) compounds having 4 or more carbons. The performance of the treatment systems varies significantly when comparing ultra-short chain PFAS (C=2-3) to the longer chains (C>=4). The objective of this study was to develop a system for effective treatment of PFAS, including ultra-short chains, and demonstrate the capability through pilot testing. The treatment system included a combination of ultrafiltration, reverse osmosis, granular activated carbon, and regenerable ion exchange media. The streams tested in the pilot system included groundwater, stormwater, and process wastewater to determine the effects of varying levels of non-PFAS constituents in the water.
The results of the pilot study showed that the proposed configuration of treatment technologies can remove PFAS to below analytical limits of detection with starting concentrations in the parts per million range. Both reverse osmosis and ion exchange were effective at removing the ultra-short chain PFAS, however, the concentrations of non-PFAS anions in the water had a significant impact on the ion exchange removal efficiency. The amount of energy used in the process and the waste generated also varied based on the water quality and target concentrations. The successful regeneration of the ion exchange media was demonstrated in the pilot study using an alcohol and brine mixture, as well as the recovery of the alcohol through a distillation process.

Discusser: Kristen Jenkins, Brown & Caldwell, Atlanta, GA

IWC 22-40: PFAS Water Treatment: A Perspective on Pretreatment

Andy McCabe, Barr Engineering Co., Minneapolis, MN ; Katie Wolohan, Barr Engineering Co., Minneapolis, MN, ; Ali Ling, Barr Engineering Co., Minneapolis, MN,

Cost-effective removal of per- and polyfluoroalkyl substances (PFAS) from both drinking water and wastewater is often accomplished using granular activated carbon (GAC) or anion exchange (AIX). Operational and maintenance costs of these processes are driven by the frequency of media change-out (i.e., the process wherein exhausted media is removed from service and either regenerated/reactivated or replaced with new media). Ideally, this frequency is driven by exhaustion of the PFAS removal capacity. Because both types of media are susceptible to fouling, pore blockage, and competition for surface-sites, media change-out may be required before the full PFAS removal capacity has been reached. In some cases, media bed backwashing may be an acceptable practice to temporarily alleviate fouling and pore blockage, but it is not ideal in all instances due to the potential to disrupt mass transfer zones and cause premature PFAS breakthrough.

Pretreatment targets are commonly established for process influent total suspended solids, suspended solids particle size, iron, and total organic carbon to protect GAC and AIX. Unit processes to remove these parameters are not novel technologies (e.g., rapid sand filters, bag and cartridge filters, greensand filters, softening ion exchange resins, clarifiers, and aeration basins), but careful management of the process residuals is required due to the presence of PFAS within the pretreatment residuals. These residuals can include backwash water, regeneration solutions, spent filters and media, and slimes and sludges.

Pretreatment strategies and residuals management options differ by industrial sector and are informed by site-specific treatment goals. With any pretreatment strategy, there is a need to balance the cost and complexity of pretreatment with the expected benefit to operation and maintenance costs of the GAC and AIX media. Four case studies will be discussed that address a range of pretreatment and residuals management strategies:

•Treatment of groundwater impacted by industrial landfill leachate implementing oxidation and chemical precipitation to manage iron and manganese,
•Industrial process wastewater treatment implementing coagulation, bag filtration, and reactivated GAC pre-filtration,
•Treatment of intruding groundwater during decommissioning and demolition of a power plant using pH adjustment, bag filtration, and reactivated GAC pre-filtration, and
•Industrial stormwater impacted by aqueous film-forming foam treated through a primary, secondary, and tertiary wastewater treatment system.

Discusser: Andrew Hodgkinson, FIChemE, Worley, Clifton Hill, VIC, Australia

Tuesday, 11/8/2022; 8:00am

T4 Innovation

IWC Rep: Patricia Scroggin-Wicker, Burns & McDonnell, Kansas City, MO

Session Chair: Patrick Randall, Aquatech, Tampa, FL

Discussion Leader: Beeta Saha, Ph.D., Stantec, Walnut Creek, CA

Innovation
Innovation in water treatment takes on many forms. In this session we will look at municipal metals removal to improve equity, a unique desalination technique and carbon capture. Recently the focus on CO2 and carbon capture have dominated the headlines, and quite frankly are changing our approach to energy. Fossil fuels have quickly become challenging to further project execution due to contribution of CO2 as a greenhouse gas and its potential effect on climate change. This session will demonstrate smart ideas using innovative technology to improve the sustainable use of water while protecting this critical resource.

IWC 22-41: Using Innovative Solutions to Remove Lead and Improve Equity

Stephen Waldvogel, GHD, Buffalo, NY ; Oluwole McFoy, P.E., General Manger, Buffalo Sewer Authority, Buffalo, NY, ; Bhavin Bhayani, GHD, Syracuse, NY, ; Ryan Stotz, GHD, Buffalo, NY,

For many years, Buffalo Water (BW) has been compliant with all water quality standards for lead, yet in 2016, BW initiated a comprehensive program aimed at minimizing lead exposure and equitably removing Lead Service Lines (LSL). This presentation will examine some of BW's proactive and innovative approaches to reduce and eliminate potential lead exposure throughout it distribution system. Specifically, our presentation will explore BW's use of Data Science (DS) and Artificial Intelligence (AI) to lower costs, improve equity and protect the public health.

BW's challenges associated with lead and equity are significant. There are approximately 30,000 known LSLs and between 30,000 to 40,000 service lines of unknown materials. All of the service lines are privately owned and often very costly to replace, averaging almost $9000/each. Unfortunately, much of the City is within an Environmental Justice area and over 30% of Buffalo's population falls below the federal poverty line. Consequently, it is financially impossible for many homeowners to replace LSLs or upgrade plumbing. Moreover, due to its older housing stock, Buffalo has experienced some of the highest childhood blood lead levels in NYS, despite consistent water sampling results well below the EPA's Action Level.

In light of these severe health and affordability concerns, BW has worked diligently to find innovative solutions. Although, BW on its own, cannot solve all of the problems associated with lead and poverty, they are determined to be part of the solution.   Towards this end, Buffalo has developed a cutting-edge AI model which uses machine learning to predict the likelihood of several important factors including (1) the probability of a lead service line, (2) the relative cost for replacement (3) the likelihood that service will be disrupted due to watermain breaks and (4) an a "equity index" for each block group to help identify the most vulnerable customers. This comprehensive analytical approach incorporates property, parcel, service, income, demographic and other data at a household and community level to assist BW's LSLR and capital investment strategies. Ultimately, the custom algorithms help to identify specific homes within economically challenged districts, that have a higher likelihood of lead and the relative cost for replacement. This approach has identified up to 25% savings when selecting specific service lines for replacement as compared to the historic practice of reactionary replacements.   This unique tool provides a basis for BW to prioritize its LSLR plan such that it can replace the greatest number of

Discusser: Devesh Bharadwaj, Pani Energy, Victoria, BC, Canada

IWC 22-42: Desalinating Brines such as Seawater using Super Capacitive Electrodes

Kevin Slough, P.Eng., Ionic Solutions Ltd., Calgary, AB Canada; Jordan Grose, P.Eng., Ionic Solutions Ltd., Calgary, AB, Canada

Traditionally, conventional electrodialysis systems are not applied to seawater systems due to their poor electrical efficiencies for highly saline brines. Ionic Solutions innovative new technology aims to change this. Conventional electrodialysis also suffers from produced gases at the electrodes, typically hydrogen, oxygen and chlorine gas due to reactions at the electrode-brine interface. The high electric potential between the electrodes and electrolyte also leads to corrosion of common metallic electrodes, which adds to maintenance activities and performance degradation cycles for the system. Between the management of combustible gas production and use of expensive electrode materials such as platinum to prevent corrosion, significant costs are incurred in electrodialysis systems to control these phenomenon. The use of highly capacitive, non-corrosive electrodes in the system not only eliminate these two engineering problems, but also aid in step-change increases to the electrical efficiencies of the system. The resulting capacitive electrodialysis systems efficiently desalinate brackish water, sea water and higher salinity brines with performance metrics that can shatter comparable state of the art reverse osmosis systems.

This paper will present comparative data of capacitive electrodialysis reversal systems (C-EDR) vs reverse osmosis and illustrate the drastic operational improvements possible in terms of clean water yield, reduced concentrate, dramatically lower power consumption, reduced anti-scalant chemical usage and more. It will discuss the increased operating flexibility of the resulting systems and their applicability to a much wider range of desalination applications than previously contemplated for electrodialysis. The comparative analysis will demonstrate how C-EDR systems can outperform comparable reverse osmosis systems in virtually every performance category and ranges of brine salinities, while ultimately demonstrating a step change improvement in desalination performance for the desalination marketplace.

Discusser: Jillian Flanagan, P.Eng., Stantec, Halifax, NS, Canada

IWC 22-43: Carbon Capture: A Water Overview

Andrew Erickson, Sargent & Lundy, Kansas City, MO

Climate change and water scarcity are two of the largest and overlapping challenges facing countries, businesses, and people from across the globe. The impact of greenhouse gas emissions is being felt, with decarbonization efforts continually expanding and evolving at a rapid pace. The United States has set ambitions of net-zero greenhouse gases emissions by no later than 2050, and reductions of greenhouse gases by 50% in 2030. As part of this effort, the implementation of carbon capture systems at power and industrial facilities will be essential to help reduce carbon dioxide emissions. While the incentive to employ carbon capture systems has increased with decarbonization efforts and economic drivers, installation of these systems creates complex challenges for facilities to solve. Capture systems are utility intensive processes requiring large demands of energy, power, and water. Facilities must understand the requirements of these systems and evaluate the current and future availability of resources that will be demanded by capture systems and the subsequent impact on the existing facility.

This paper will provide an overview of the water requirements within carbon capture technologies with a primary focus on amine based systems and a comparison against other available capture technologies. It will discuss of the challenges that power and industrial facilities are faced with when evaluating carbon capture while considering water quality requirements, environmental regulations, and types of base facilities. The paper will review available options to help minimize water demands and increase water reuse within the capture system and associated equipment.

Discusser: Phillip Benson, Geosyntec Consultants, Inc., Washington, DC

IWC 22-44: Repurposing Boiler/Cooling Tower BD Water to Capture Carbon Dioxide

James Van Camp, Emergent Solutions, Glen Ellyn, IL ; Daniel Murray, Deep Tech Consulting, United Kingdom

Technological advancements in what is referred to as “industrial phycology” are making it a useful candidate for the sequestration of carbon dioxide, a process being brought into discussion in response to Climate Change events and threats to global stability. Algae can be grown in bioreactors to remediate and remove toxic substances and deliver cleaned up water for reuse or proper regulated disposal. Particularly attractive to ESWP members is the prospect of using typical Cooling tower and boiler water blowdown as a valuable process raw material instead of a costly waste stream. The chemistry of these streams is such that even food grade strains of algae such as Spirulina can be produced and channeled into high value market segments. Ongoing demonstration projects indicate that modular bioreactors can capture as much as 400 tons of carbon dioxide per year and convert it into useful biomass on a footprint no larger than a tennis court. The paper will describe the processes and range of benefits and value to facilities that (a) routinely discharge water of known chemistry and flow rate or (b) have retention basins or tankage with process waters that need to be treated to remove contaminants and reclaim and repurpose to meet regulatory or financial objectives.

Discusser: Rebecca Maco, Brown and Caldwell, Seattle, WA

Tuesday, 11/8/2022; 1:15pm

T5 ESG Pathways to ZLD

IWC Rep: Bradley D. Wolf, P.E., BRG, Pittsburgh, PA

Session Chair: Krystal Perez, Brown and Caldwell, Seattle, WA

Discussion Leader: Dave Guinta, Burns & McDonnell, Kansas City, MO

This session will share current approaches across several industries to jointly achieve zero liquid discharge (ZLD) and environmental, social and governance (ESG) goals. The presentations will discuss the various water management and treatment methods used to successfully achieve ZLD and the unique ESG impacts surrounding these installations, including water scarcity, land application, waste-to-energy, and secondary municipal reuse.

IWC 22-46: Preparation for Conversion to Zero Liquid Discharge Operation

Dennis McBride, Burns & McDonnell, Kansas City, KS ; Raquel Onsurez, El Paso Electric Co., El Paso, TX

El Paso Electric (EPE)- Newman Station operates five steam generating units as well as a future simple cycle system. It has been operating in a Near Zero Liquid Discharge (NZLD) mode with the wastewater generated being sent to a combination of evaporation ponds, a partial reclaim system, and land application. In the future, the station will lose access to the property for the land application. The existing reclaim system was determined to not be capable to address the future projected needs. As such, EPE commissioned a study to determine what changes needed to be made to their systems to reduce wastewater flows to a level the existing evaporation ponds are capable to handle.

This paper will describe the study's approach to address the need to convert the site to a true Zero Liquid Discharge (ZLD) operation. Various steps were included to fully understand the site's needs including water demands (water mass balance),the evaporation pond's annualized average net evaporation, and an understanding of the various water qualities around the plant so that changes to operation could be evaluated. The paper will discuss some of the criteria evaluated to determine limits for reclamation (e.g. chemistry, metallurgy). Since award of the future treatment system has not yet been made, the planned changes may not be included in this paper (possibly a future IWC paper).

Discusser: Rena Bae, Stantec, Charlotte, NC

IWC 22-47: Integration of Advanced Treatment Technologies to a Zero Liquid Discharge Design at Sierra Biofuels Facility

Arun Mittal, Aquatech International LLC, Canonsburg, PA ; Simone Callioni, Aquatech International LLC, Canonsburg, PA, ; Lee Rich, Fulcrum Bioenergy, Clemson, SC, ,

Carbon Recycling projects play a paramount role in reducing GHGs and improve energy sustainability. However, their water footprint should be also considered as a critical part of the environmental impact which they aim to minimize. Within this context, at Fulcrum's new facility near Reno, NV, the company's unique process to turn MSW into SynCrude has been coupled with a complete Zero Liquid Discharge arrangement. The 99.9% of the wastewater produced by the site is recovered and recycled back to the process thus minimizing the water impact of the industrial site on the local community. Especially due to the uncertainties about the composition of the future wastewater, the process to design the wastewater treatment scheme went through several iterations. In particular, during the design phase, three different process-related topics were explored. First, the opportunity to have an anaerobic treatment to pretreat the most organically loaded streams of wastewater. Although some extensive testing showed a potential consistent generation of biogas, the cost analysis showed that with the wastewater characteristics the benefits in terms of carbon intensity were minimal if compared to the efficiency in terms of space, safety, costs and reliability of the process. Second, how to find the most resilient and reliable biological aerobic treatment. Since the composition of the MSW may show some variation, the composition of the wastewater is expected to be subject to some fluctuations too. In order to deal with such a level of variability, a fully integrated two-step treatment process with a Moving Bed BioReactor (MBBR) followed by a Membrane BioReactor (MBR) was selected as the most robust, efficient, compact and cost-effective solution. Third, which was the most convenient and robust way to concentrate the treated effluent and integrate a RO membrane process with an ultimate thermal evaporation technology. The final design prioritized the maximization of the RO recovery and the minimization of the size of the crystallizer downstream. The solution consisted of a HERO system (High Efficiency Reverse Osmosis) followed by a direct evaporation on a Forced Circulation Crystallizer. Ultimately, the 99.9% of the wastewater is recovered and recycled back to the process thanks to an Electrodeionization process (FEDI) which allows to achieve a boiler-quality level. The project accomplishes the unique goal to harmonize the reduction of the carbon footprint associated with the production of sustainable fuels with the minimization of the water impact related to industrial operations. Its ultimate Zero Liquid Discharge process integrates

Discusser: Paul Brandt, P.E., Burns & McDonnell, Kansas City, MO

IWC 22-48: Zero Liquid Discharge System – An Advanced Water Reuse System for Oil & Gas Refinery

Srikanth Reddy Muddasani, Civil & Environmental Consultants, Inc., Pittsburgh, PA ; Anthony Lester, Cenovus Energy, Lima, OH

An Oil & Gas Refinery located in Midwest, US treats secondary effluent to a quality suitable for reuse as boiler feed water, cooling tower make up water and wet gas scrubber make up water quality. The main challenges associated with the treatment of refinery secondary effluent at the facility are high concentrations of total hardness and organics (COD) that remain in the water after primary and secondary biological treatment. Refinery goal is to maximize the water available to reuse and to minimize the amount of water required for deep well injection.
The water reuse system utilizes advanced water treatment technology to produce clean water for reuse. In order to recovery the refinery wastewater as boiler feed, the water must be treated with reverse osmosis for reduction of total dissolved solids(TDS). There are several challenges associated with the treatment of refinery wastewater with RO, including fouling due to organics, particulates, biological growth, and scaling due to calcium salts and metals. The main challenge is organic fouling at the high RO water recovery (>92%). In order to overcome the organic fouling issue, RO process is operated high pH condition so that organics stays in soluble condition rather than precipitating on the membrane surface. And biological growth is inactive at high pH condition. The other challenges are addressed with good pretreatment upstream of the reverse osmosis (RO) process.
The water reuse system utilizes high ph reverse osmosis (RO) treatment process, which consists of chemical softening process that removes scale formers and some organics, ph adjustment, filtration to remove suspended and colloidal solids, Ion exchange to remove any residual hardness and metals that are left over after softening process, reverse osmosis (RO) to remove total dissolved solids and sludge thickening and dewatering. The solid waste generated in the treatment process is landfill offsite. The liquid waste (RO Reject) is used as make up water for wet gas scrubber treatment. The final waste from the wet gas scrubber treatment is sent to deep well injection. Because no liquid and waste leaves the system, this plant is called Zero Liquid Discharge (ZLD) facility.
Treatment plant is operating for last four years. Our Paper will describe various treatment steps, challenges and present operational data.

Discusser: Emily Holbrook, P.E., Stantec, Alpharetta, GA

Tuesday, 11/8/2022; 1:15pm

T6 Development of Alternative Chemical Treatment Technologies for Cooling Water Systems

IWC Rep: Brandon Delis, Electric Power Research Institute (EPRI),

Session Chair: Thomas Gurley, Chemtreat, Inc., Glen Allen, VA

Discussion Leader: Rebecca D. Osteen, Southern Company, Birmingham, AL

With ever-increasing pressure on water management for industrial water systems, cooling water treatment must adapt with novel technology to address scale and corrosion issues. Concurrently, recent cooling water raw material disruptions have necessitated alternate chemistries to relieve increasing costs. Papers in this session will address recently developed scale and corrosion inhibitors, as well as approaches to modeling alternate chemistries.

IWC 22-49: A New Polymer A for Calcium Carbonate Deposit Control for Cooling Water Systems

Suresh Patel, Ph.D., CREST Water, Singapore, Singapore

A laboratory study was conducted on a new polymer A as a calcium carbonate deposit control agent for use in cooling water systems. This new polymer A was compared with traditional phosphonates that are in use today. Laboratory methods designed for calcium carbonate formation were used to determine the inhibition properties in the bulk solution phase and a dynamic test (Deposition Monitoring Unit, DMU) to determine deposition on heat exchanger surface by Polymer A, HEDP, ATMP and PBTC. The results from these tests show that Polymer A is able to match the calcium carbonate inhibition to the phosphonates tested. To further elucidate the performance characteristics of these inhibitors an additional dispersion test was conducted which showed Polymer A to have the best dispersion control. From these findings an explanation on the differences between these inhibitors investigated will be discussed based on the mechanisms of these inhibitors in the control of calcium carbonate deposition.

Discusser: Bingzhi Chen, Nalco Water, an Ecolab Company, Naperville, IL

IWC 22-50: In-situ Detection and Online Monitoring of Tagged Scale Inhibitors in Cooling Water Systems

Chelsea Eaton, Baker Hughes, Sugar Land, TX ; Swamy Margan, Baker Hughes, Sugar Land, TX, , ,

Scale formation and deposition are one of the primary problems encountered in cooling water systems. Failure to mitigate scale formation can lead to flow restrictions and plugging, reduced heat transfer efficiencies, and underdeposit corrosion. Consequently, for operators, such events can contribute to lost production and increase operating and capital equipment costs.

Typically, the formation of mineral scales in industrial water systems is inhibited by using water-soluble polymers. However, using such polymers is highly dependent on the actual amount available for inhibition. If too small of a concentration is added to the water system, scaling and deposition will occur. Conversely, if too large of a concentration is added to the water system, the cost and performance efficiency of the water system maybe adversely affected.

There are several routes available to determining the concentration of water soluble polymers in aqueous water systems. Such methods include turbidimetry and colorimetry. These approaches rely on specific calibration curves that are normally affected by changing water composition and system conditions. To improve accuracy, others have implemented the use of tagged polymers where the polymer is functionalized with a derivative that can easily be detected using immunoassay technique. This method does not align though with the attempts to automate the precise addition of scale inhibitors in cooling water. To enable online detection of the scale inhibitors, other operators have added a fluorescent tracer to scale inhibition products.

This paper details the development and performance of a tagged polymer that allows for in situ detection and online monitoring and control in cooling water systems. The functionalized polymer effectively inhibits and disperses mineral scales in various cooling water conditions.

Discusser: Prasad Kalakodimi, Ph.D., ChemTreat

IWC 22-51: Development of a New Multifunctional Closed-loop Corrosion Inhibitor

Haiping Lu, Ph.D., Baker Hughes, Sugar Land, TX ; Swamy Morgan, Baker Hughes, Sugar Land, TX; Brent Lugo, Baker Hughes, Sugar Land, TX; Kristen Curry, Baker Hughes, Sugar Land, TX; Chelsea Eaton, Baker Hughes, Sugar Land, TX

Closed-loop cooling systems provide reliable temperature control for numerous types of industrial equipment and processes. For an effective operation of closed loop cooling system, the coolant should not promote scaling, corrosion, and biological issues. The application of corrosion inhibitors is one of the most essential approaches to maintain good conditions of closed loop. In the past, the traditional corrosion inhibitor are either metal-based (molybdate) or nitrite-based, which are not environmental friendly or promote bacterial growth. A new generation of closed loop corrosion inhibitor is needed for sustainability of the environment with superior mild steel and copper corrosion control and good long-term biodegradability.

This paper will present the laboratory development of a new multifunction corrosion inhibitor for closed loop cooling system. The testing results include the linear polarization Resistance tests for product screening compared with molybdate based and nitrite based corrosion inhibitors; Jar tests for long-term performance evaluations; and small pilot testing results for further evaluating the corrosion inhibitor under the simulated flow conditions. The testing results show that the new corrosion inhibitor can effectively prevent the corrosion on both mild steel and yellow metal. In the absence of metal and nitrite components in its formulation, it also shows more environmental friendly properties.

Discusser: K. Anthony Selby, Water Technology Consultants, Inc., Evergreen, CO, USA

IWC 22-52: Modeling Substitute Inhibitors and Replacement Formulations in Times of Raw Material Shortages

Robert Ferguson, French Creek Software, Phoenixville, PA ; Chelsea Farmer, Radical Polymers, Chattanooga, TN

Raw Material shortages require innovative solutions to maintain a product line cost performance and efficacy. This paper describes modeling alternative scale inhibitors and blends as substitutes for inhibitors in existing cooling water treatment formulations. Evaluations can be performed based upon existing models or through the incorporation of new laboratory and.or field data. Minimum effective dosages, limits, synergy and antagonism are explored. The methods can be employed using existing scale inhibitor models, new models based upon laboratory data for individual inhibitors and blends, and field experience and data. Test methods are referenced. The theory and application technology supporting the evaluation approach is described. The methods illustrated are in general usage by many major water treatment service companies, AWT companies, inhibitor manufacturers, researchers chemists, and consultants. Practical examples are included which compare inhibitors and blends. The technology applied to modeling alternate materials and blends received the first ever AWT Innovation Award in 2020.

Discusser: Brad Buecker, Buecker & Associates, Lawrence, KS

Tuesday, 11/8/2022; 1:15pm

T7 CCR Water Management – In the Plant, In the Pond, and Underground

IWC Rep: Paul Pigeon, P.E., WSP Golder, Lakewood, CO

Session Chair: Riley Flowers, Ph.D., Southern Co., Birmingham, AL

Discussion Leader: Megan Nevill, Duke Energy, Cayuga, IN

Water management related to coal combustion residuals at electric generating plants is a diverse topic that continues to develop. Bottom ash handling systems are maturing, ash pond dewatering treatment systems are now in operation, and coal combustion residual groundwater compliance programs are underway. This session will examine case studies and experiences from the multifaceted world of coal combustion residual wastewater management that will continue to provide challenges and opportunities to utilities in the years to come.

IWC 22-53: Remedy Selection Alternatives for Groundwater Corrective Action: An Example of an Integrated Approach Used at Coal Combustion Residual (CCR), Mining, and Contaminated Sites

PJ Nolan, Ph.D., WSP Golder, Farmington Hills, MI ; Rens Verburg, Ph.D., WSP Golder, Redmond, WA; Greg Lehn, Ph.D., WSP Golder, Lakewood, CO

Groundwater remedy selection at power generating facilities, mining sites, landfills, and other industrial sites presents a challenge to regulators and other stakeholders in determining defensible, and scientifically appropriate corrective measures. Implementation of remediation approaches may lead to unexpected outcomes. However, through integrating advanced geochemical and groundwater modeling with cutting edge analytical tools, unexpected consequences associated with remedy selection can be minimized and the selection process becomes more transparent.

In this presentation, we will provide real-world examples from Coal Combustion Residuals (CCR) sites, mining sites, and a contaminated uranium processing site where various advanced analytical techniques and novel modeling approaches were utilized as part of remedy selection. Test methods that should be considered to support attenuation demonstrations, such as sequential extraction of metals from aquifer solids, will be discussed. We will then present the process of applying and incorporating the results of these test methods to develop accurate, site-specific attenuation capacities of groundwater aquifers or thermodynamic constants for evaluation of contaminant attenuation through mineral precipitation.

Various approaches to integrated geochemical and groundwater flow modeling, ranging from 1-D static to advanced 3-D models, will be presented for a number of sites. Examples will then be provided of modeling conducted in support of evaluation of several remedies, including (enhanced) monitored natural attenuation (MNA), in-situ injection of reagents, capping, barrier (slurry) wall installation, source removal, pump and treat, or combinations thereof.

Based on the modeling results, the potential for long-term success of each corrective measure can be determined and ranked as part of the remedy selection process. This includes the identification of unintended consequences resulting from certain remedies, such as increases in concentration in groundwater due to changes in redox/pH conditions. Although the modeling and its results may be challenging to understand for many stakeholders, as we will demonstrate, effective methods of conveying advanced results have been developed and are integral to a successful remedy selection process.

In conclusion, advanced site investigation methods combined with geochemical and groundwater modeling have proven very effective in support of remedy selection. This cutting-edge approach is gaining increasing recognition and will become the standard for identifying and determining the applicability of potential remedial strategies at sites requiring corrective measures.

Discusser: Wayne Weber, Burns & McDonnell, Chesterfield, MO

IWC 22-54: A Comparison of Several Coal Combustion Residual (CCR) Pond Closure Water Treatment Systems

Dallas Torgersen, WesTech Engineering, Salt Lake City, UT ; Harley Schreiber, WesTech Engineering, Salt Lake City, UT

Owners of coal combustion residual (CCR) impoundments frequently require the treatment of water discharged during the process of closing or dewatering these ash ponds. However, water quality, discharge requirements, and other factors mean that one size does not fit all when it comes to temporary wastewater treatment systems. This paper presents four case studies from different ash pond dewatering projects, demonstrating several possible different process flow diagrams, and provides some considerations for different configurations selected.
Case study 1 is a 250 gpm system at a decommissioned power plant. Circular clarifiers, pressure filters, bioreactor, and disc filter were used to comply with TSS, pH, Arsenic, Iron, Mercury, Selenium, and Nitrates requirements.
Case study 2 is a 4000 gpm system. Larger flow rates led the selection of non-mobile ballasted flocculation clarifiers followed by gravity filters for TSS, pH, and Arsenic compliance.
Case study 3 is a 750 gpm system at a decommissioned power plant. This system consists primarily of mobile trailer mounted equipment including ballasted sand flocculation clarifier and a 5-cell compartmentalized pressure filter. The required treatment considers TSS, pH, Arsenic, and Iron.
Case study 4 is a 1500 gpm system requiring the treatment of TSS, pH, Antimony, Arsenic, Copper, Lead, Selenium, and Thallium. Ballasted flocculation clarifiers followed by pressure filtration, ion exchange columns for non-biological selenium removal and an electro-reduction regeneration system are used.

Discusser: Charles Smith, P.E., Duke Energy, Charlotte, NC

IWC 22-55: Lessons Learned Executing Coal-Fired Power Plant Outage Washwater Treatment using Bottom Ash Dewatering Infrastructure – Three Years and Going

David Donkin, UCC Environmental, Waukegan, IL ; Bernie Evans, UCC Environmental, Waukegan, IL; Jack Ma, Ph.D., P.E., UCC Environmental, Waukegan, IL; Joseph Woodley, UCC Environmental, Waukegan, IL

The coal-fired electrical utility sector is faced with the regulatory requirement to retire their coal ash sluicing ponds under the finalized Coal Combustion Residuals (CCR) regulation. Wet-to-dry ash handling solutions are being implemented throughout the fleet to allow ponds to come out of service. One area of wastewater treatment need that still remains, once the ponds are retired, is the management and treatment of boiler, air pre-heater, economizer and precipitator wash wastewater. Historically these washwaters were simply directed to the CCR pond along with other ash materials and basically diluted with other materials prior to discharge. Because these ponds are being retired, and because new CCR regulations carry recirculation requirements for all ash transport water, this option is no longer available. The wide variety in flow and contaminant loading present extra treatment challenges and lend themselves to employment of existing Bottom Ash Dewatering Systems. Lessons learned and design considerations formulated through over 3 years of system retrofits and onsite washwater management will be reviewed.

Discusser: Mike Surface, Dominion Energy, Richmond, VA

IWC 22-56: Process and Technical Details of Two Bottom Ash Sluice Water Treatment Systems

Harley Schreiber, WesTech Engineering, Salt Lake City, UT ; Chloe Grabowski, HDR, Missoula, MT; Dallas Torgersen, WesTech Engineering, Salt Lake City, UT; Tiana Hiatt, WesTech Engineering, Salt Lake City, UT

Due to the required closure of a coal combustion residual (CCR) impoundment, a temporary bottom ash treatment system was implemented in a short amount of time at a large coal fired power plant in North America, followed by another system that was also temporary but was less complex. Lessons learned from design, startup and commissioning of the temporary system were published in IWC 21-47. The reference paper focused on implementation and logistical details but did not have sufficient space to also cover the technical aspects of the wastewater treatment process and equipment design. This paper will provide the technical details of the implemented systems, including performance criteria, bench scale laboratory testing results, treatment process selection, equipment sizing basis, process flow diagrams, and water quality data. An update on the startup and commissioning of the second system and operating performance data which was not available until recently will also be presented.

Discusser: Shane Powell, P.E., Southern Company, Birmingham, AL

Tuesday, 11/8/2022; 1:15pm

T8 Technical Business of Reverse Osmosis

IWC Rep: Jane Kucera, NALCO Water, an Ecolab Company, Naperville, IL

Session Chair: Craig Mills, WesTech, Inc., Salt Lake City, UT

Discussion Leader: Juan Pinto, Energy Recovery, San Leandro, CA

RO membranes, we know them, we love them. Troubleshooting, cleaning, and maintenance programs to enhance performance and extend the life of your membranes.

In this session we will be hearing from experts in the industry on membrane cleaning optimization, a new stabilized chlorine biofouling control for seawater, effects of long term high-temperature sanitizations, and wholistic troubleshooting of RO performance.

IWC 22-58: Hot Water Sanitizable Membrane

John Peichel, Veolia Water Technologies & Solutions, Minnetonka, MN

Membranes have found useful application in a variety of processes across many industries over the years. The ability to withstand higher temperatures has been a desired feature to maintain performance. Typical membrane materials of construction are composed of a mostly polymer types not designed to be stable when exposed to higher temperatures. Often times, the performance degradation is part of the system design such that minimum operation is achieved even after exposure to multiple hot water sanitization cycles. The paper looks to detail the commercial experience of a RO membrane system exposed to periodic water sanitization over a year of operation. In addition, the author will highlight some of the design constraints, operational approach and areas for future study.

Supporting informational details are still being reviewed for public disclosure. Should this approval be granted, we will add authors and related experience to this submission. We anticipate this approval to take place with 2-3 weeks.

Discusser: Erik Desormeaux, Energy Recovery, San Leandro, CA

IWC 22-59: Membrane Cleaning Optimization; a Discussion on the Impact of Temperature, pH, Time and Chemical Selection on Cleaning Efficacy

Joshua Utter, American Water Chemicals, Plant City, FL

Membrane fouling and scaling are two of the primary issues membrane-based systems must contend with to ensure efficient water treatment. Membrane scaling can be solved with appropriate antiscalant selection, while fouling can be mitigated by good system design. As membrane systems are called on to treat more challenging water sources, and existing systems are asked to increase production, both of these challenges become even more difficult. Inevitably most systems will foul requiring cleaning to reverse the losses in membrane performance. Unfortunately, membrane cleaning is an expensive and time-consuming procedure. To mitigate these costs, membrane cleanings are often put off until operational costs become excessive, or equipment limits are reached. This can lead to exceedingly tenacious foulants that standard protocols cannot clean effectively. Insufficient cleaning will lead to more rapid fouling in the future, increasing the required cleaning frequency. It is therefore important that an optimal protocol for each membrane system be determined. Cleaning performance is significantly impacted by the specifics of the foulants in question, cleaning chemical selection, cleaning pH, temperature, and exposure time. All of these factors need to be weighed against the CIP system design and operational constraints. A case study will be presented to demonstrate this optimization process. The case study describes the evaluation of the membrane fouling, identifying the cause of the performance decline, demonstration of the impacts each factor has on the determination of an appropriate protocol to recover performance.

Discusser: John Korpiel, P.E., Veolia Water Technologies, Wexford, PA

IWC 22-60: Investigation of the New Generation of Stabilized Chlorine Biofouling Control Agent in Seawater Reverse Osmosis (SWRO): From Laboratory Scale to Pilot Plant

Yinghong Lu, Ph.D., Kurita R&D Asia Pte. Ltd, , Singapore; Brandon Chuan Yee Lee, Kurita R&D Asia Pte. Ltd, Singapore; Hideyuki Komori, Kurita R&D Asia Pte. Ltd, Singapore; Kunihiro Hayakawa, Kurita Water Industries Ltd, Japan; Kuan Yi Tan, Lee Nuang Sim, Tzyy Haur Chong

Biofouling is one of the most critical challenge faced by SWRO systems globally. Generally, chemical treatment in SWRO could help control biofilms and biofoulant. However, current biofouling control agents were either too expensive or ineffective. Herein, the performance of a new generation of NSF certificated biofouling control agent, KURIVERTERTMIK-220 was reported for the first time. This will be benchmarked against KURIVERTERTMIK-110, which has already been proved its efficacy in many RO applications.

Firstly, Bacillus sp. BF1 strain extracted from a biofouled SWRO membrane and real wastewater with bacteria mixtures were used as two model samples to culture biofilms on membrane coupon inside laboratory flow-cell unit. Subsequently, membrane foulant was characterized after IK-110 and IK-220 exposure. Both agents were able to inhibit the biofilm growth on membrane surface. With same dose, total cell count was suppressed up to 63% by IK-220 and 18% by IK-110. Adenosine triphosphate (ATP) after IK-220 exposure was observed 5-fold lower than IK-110. When achieving similar bacterial suppression and extracellular polymeric substance (EPS) inhibition, IK-220 required 50% less chemical concentration compares to IK-110.

To further understand potential membrane degradation from IK-220 exposure, accelerated membrane soaking tests were performed in laboratory. RO membrane was evaluated upon completion of the 135-hours exposure of IK-220, equivalent to 12.8 years of continuous dosing at a concentration of 5 mg/L. Membrane salt rejection and permeability before and after soaking test were observed to have insignificant changes, indicating negligible membrane degradation from IK-220 soaking. FTIR spectra further supports this statement with intact RO membrane functional group (amide N-H bending and N-C stretching, aromatic amide, and amide C=O stretching) before and after soaking.

IK-220 was further evaluated in a SWRO pilot system next to a seawater desalination plant in Singapore. The pressure drop (dP) was used to evaluate the performance of two RO trains with IK-220 and IK-110 dosing. The study has shown that 5 mg/L of IK-220 was able to effectively suppress the increment of dP, while double dosage (10 mg/L) of IK-110 was required to achieve the equivalent performance. Meanwhile, both RO trains achieved the stable salt rejection with sodium rejection >99%, calcium and magnesium overall rejection >99.8% and boron rejection 76.3+/-3.8%, indicating IK-220 have no impact on the long- term SWRO operation.

In summary, IK-220 as an on-line dosing agent in SWRO was demonstrated to have superior performance, with less chemical dosage, competitive biofouling suppression, and negligible membrane degradation.

Discusser: Seong Hoon Yoon, Ph.D., P.E., Nalco Water, an Ecolab Company, Naperville, IL

Wednesday, 11/9/2022; 8:00am

W1 High Recovery RO

IWC Rep: Scott C. Quinlan, P.E., TetraTech, Pittsburgh, PA

Session Chair: Wayne Bates, Hydranautics, Rockton, IL

Discussion Leader: Richard (Rick) L. Stover, Ph.D., Gradiant Corporation, Woburn, MA

High Recovery RO is becoming more prevalent as a design goal. MLD and ZLD systems are becoming more popular as the industry is being asked to maximize water recovery and minimize the volume of liquid concentrate (brine) that requires disposal. This session reviews current concentration methods with an emphasis on the use of RO membrane technologies upstream of industrial waste thermal, evaporative and salt precipitation methods and in seawater brine mining for the recovery of valuable minerals.

IWC 22-61: Case Study: 96% Recovery of Power Plant's Cooling Tower Blowdown with an Advanced Reverse Osmosis Demonstration Plant

Liron Ophek, IDE Technologies, Kadima, Israel Israel, IDE Water Technologies, Kadima, Israel, Israel

The power industry is considered one of the most intensive water consuming industries in the world. However, due to water shortage, growing regulations and related effluent discharge and makeup water costs, power plants require to manage their net water consumption in the most efficient way.
The major water consumer in a power plant are the cooling towers, which are also producing the majority of wastewater as cooling tower blowdown (CTBD).
During the cooling process the water is significantly concentrated inside the cooling towers, resulting in water effluents characterized by high scaling potential arising from Silica, gypsum, hardness and alkalinity, as well as high bio-fouling potential resulting from the open nature of the cooling towers.
The straight-forward way for power plants to save water is to efficiently treat the CTBD and reuse it back to the cooling towers as makeup water. However, due to the challenging water composition of the CTBD, conventional membrane technologies are limited with achieving high water recovery.
IDE developed a membrane-based technology, The MAXH2O DESALTER, that allows achieving high recovery of CTBD and reuse most of it back as makeup, thus reducing the OPEX associated with cooling towers in a power plant.
The technology contains a single stage reverse osmosis system, with an integrated salt precipitation unit. This technology operates by recirculating the CTBD through RO system followed by a fluidized bed reactor in which controlled precipitation of supersaturated sparingly soluble salts is performed.
This cyclic process, which occurs in small and controlled intervals, allows for a continues concentration and precipitation of the salts that are limiting the recovery without increasing the scaling and biofouling potential seen inside the membranes, therefore, enabling extremely high recovery rates beyond 95%.
The produced by-product solids contain over 90% solids, which lead to easy and cost-effective disposal without additional sludge minimization processes.
This paper presents the results of a 48m3/day MaxH2O Desalter demonstration unit in a power plant in Chile which operated for 60 days (24/7) to achieve a 96% recovery of the CTBD.
With conventional technologies, scaling of the membranes would have limited recovery to ~55-60%. At 96% recovery, the theoretical saturation indices reach to LogSI ~3.2, $CaSO_4$ SI ~ 2990% and SiO_2 SI ~ 1400% therefore, achieving such a high recovery at these conditions presents a viable and revolutionary solution that can significantly affect the

costs and operation associated with CTBD in power plants and in the industry.

Discusser: Kurt Blohm, Gradiant, San Diego, CA

IWC 22-62: Hollow Fiber Nanofiltration for Reuse of Municipal Wastewater: A Techno-economic and Lifecycle-based Comparison to Conventional Membrane Treatment

Joris de Grooth, Ph.D., NX Filtration B.V., , Enschede The Netherlands; Dennis Reurink, Ph.D., NX Filtration B.V., Enschede, The Netherlands; Umang Yagnik, NX Filtration B.V., Enschede, The Netherlands

Reuse of municipal wastewater has been recognized as a method to relieve regional water scarcity problems. Several techniques are available to treat the effluent to desired water quality standards. Especially, deploying dense filtration membranes is promising as it achieves high removal rates for all contaminants, including pathogens and contaminants of emerging concerns (CEC). Traditionally, this is done by a cascade of membrane filters, where the effluent is first pre-treated with a more open hollow fiber ultrafiltration (UF) membrane, followed by a dense spiral wound nanofiltration (NF) or reverse osmosis (RO) membrane. Next-generation hollow fiber NF membranes based on polyelectrolyte multilayers have become available. These membranes are suitable for direct treatment of municipal wastewater effluent, without any pre-treatment or addition of flocculants and coagulants.

In this paper, we compare the overall operational costs including energy consumption and conduct carbon footprint analysis between direct NF with conventional UF+RO based membrane treatment processes. For both treatment processes, operational expenditures have the dominant contribution to overall treatment cost and environmental impact. We will show that by using direct hollow fiber nanofiltration, a significant lower total cost of ownership (TCO) can be obtained, attributed to both lower chemical consumptions and lower operational transmembrane pressures, while still meeting the appropriate water quality standards. We also highlight how this directly reduces the carbon footprint of the process, resulting in an affordable and a more sustainable option for water reclamation.

Discusser: Omkar Lokare, Gradiant Corporation, Woburn, MA

IWC 22-63: Zero Liquid Discharge of Oilfield Produced Water via a Hydrophilic-Omniphobic HF Membrane-Based DCMD and Crystallization Process

Jianjia Yu, New Mexico Tech, Socorro, NM ; Stephen White, New Mexico Tech, Socorro, NM; Guoyin Zhang, New Mexico Tech, Socorro, NM; Gabriela Torres Fernandez, New Mexico Tech, Socorro, NM

Direct contact membrane distillation (DCMD) is a promising desalination technology to remediate high-salinity oilfield-produced water with theoretically 100% salt rejection. However, low water recovery and high-energy consumption still prevent the DCMD process from commercial-scale application in the petroleum industry. In this study, a novel crosslinked polyvinylidene difluoride (c-PVDF) hydrophilic-omniphobic hollow fiber (HF) membrane was prepared to desalinate actual produced water with different chemistry and composition. The DCMD performance was evaluated in terms of permeate water flux, salt rejection, and energy efficiency. The concentrate stream from DCMD was introduced into a crystallizer, in which the dissolved solids were recovered as minerals mixtures; and the remaining water in the crystallizer was recycled back to the DCMD process for further clean water recovery. The results show that the hydrophilic-omniphobic HF membrane exhibited promising anti-wetting properties compared to the conventional PVDF membrane. The permeate water flux in DCMD is around 17.5 kg·m-2·h-1 when the feed solution salinity and temperature differentials were 155,000 mg/L and 40°C, respectively. The salt rejection was higher than 99.9% during at least 5 rounds of 12-hours DCMD operation. The integration of a crystallizer with DCMD can simultaneously recover dissolved minerals and high purity clean water (TDS<50 mg/L), and achieve zero liquid discharge of high-salinity oilfield produced water (TDS>150,000 mg/L).

Discusser: Ali Ling, Ph.D., P.E., Barr Engineering, Minneapolis, MN

IWC 22-64: A High-Level Guide for Designing High Recovery SWRO and Ultra-high Pressure RO Systems

Eli Oklejas, Fluid Equipment Development Company, LLC, Monroe, MI ; Rory Weaver, Fluid Equipment Development Company, LLC, Monroe, MI, ; Craig R. Bartels, Ph.D., Hydranautics, Oceanside, CA, ; Juan de Beristain Ruiz, Fluid Equipment Development Company, LLC; Rich Franks, P.E., Hydranautics

RO membranes capable of operating at pressures up to 1,800 psi creates new opportunities for minimal- and zero liquid discharge, opens new horizons for the extraction of minerals from waste streams. By relying on membrane processes to concentrate a feed solution to 120,000 ppm – far beyond the limit of 90,000 ppm for conventional SWRO membranes – the energy efficiency, affordability and reliability of MLD, ZLD and brine mining are greatly increased.

This paper demonstrates the use of turbochargers for pressure management in a pilot facility extracting minerals from seawater in Saudi Arabia. Located in Jubail, this facility uses a two-stage RO array incorporating multiple turbochargers to concentrate pretreated seawater from 47,000 ppm to 120,000 ppm. Effective pressure management is key to enhancing the RO membrane performance in this multi-stage, high pressure, high recovery operating environment.

The pilot unit demonstrates the following benefits to using multiple turbochargers:
•Flux balancing: the interstage turbocharger achieves flux balancing across the two-stage RO array, improving membrane performance and reducing membrane replacement
•Energy savings: The pilot in question operates with an SEC of approximately 4 kWh/m3. This is made possible by the use of turbochargers to reduce the pressure boost required from the high pressure pump.
•Equipment and capital savings: Turbochargers provide a pressure boost by capturing hydraulic energy from a brine stream. This means that no auxiliary equipment (motors, drives etc) are required.
The pressure boost is sufficient to enable a conventional high pressure pump (rated to 1,200 psi) can be used to drive an ultra high pressure RO system.
Results from the pilot unit in Jubail show that multi-stage RO designs using ultra high pressure RO membranes and effective pressure management through feed and interstage boosting open up new horizons for industrial wastewater

management, and for recovery of valuable resources from brine streams or seawater.

After exploring the design and significance of the DTRI pilot unit in Jubail, this paper explores wider design options for high recovery RO. The use of turbochargers to distribute pressure across a multi-stage array means that it is now possible to concentrate any feed solution to 120,000 ppm by using straightforward, continuous RO designs.

Discusser: Ken Robinson, Avista Technologies, San Marcos, CA

Wednesday, 11/9/2022; 8:00am

W2 What's Hot in Cooling Water Monitoring and Treatment

IWC Rep: Jeff Easton, WesTech, Inc., Salt Lake City, UT

Session Chair: Michael Bluemle, Ph.D., Solenis LLC, Wilmington, DE

Discussion Leader: Mary Jane Felipe, SI group, Houston, TX

Cost-effective mitigation of mineral scaling, fouling, corrosion and microbial growth is the fundamental objective of treatment of once through and recirculating cooling water systems. Management of these interrelated processes has become progressively more challenging due to increasingly stringent discharge limits and expanding water scarcity. The four presentations in this session describe the application of innovative phosphorus-free treatment technologies, an online Legionella monitoring system and the development of new corrosion inhibitor dosage models.

IWC 22-65: Field Experiences Using a Novel Non-Phosphorus Cooling Water Treatment Technology

Timothy Eggert, Veolia Water Technologies & Solutions, Portland, OR ; Robin Wright, Veolia Water Technologies & Solutions, Ponte Verde, FL, ; Robert Hendel, Veolia Water Technologies & Solutions, Trevose, PA, ; Paul DiFranco, Veolia Water Technologies & Solutions, Trevose, PA,

For decades, cooling water chemical treatment programs have relied mainly on organic and/or inorganic phosphorus-containing compounds. In recent years, phosphorus has become the target of increasing environmental scrutiny resulting in environmental regulators requiring many industrial facilities to drastically reduce the amount of phosphorus in their discharge streams. These environmental pressures and other drawbacks associated with phosphorus-based treatment programs have driven chemical providers in developing substitute cooling water treatment programs that contain less or no phosphorus at all. The non-phosphorus treatment technologies had to not only eliminate phosphorus, but also deliver equivalent or better corrosion and deposit control at an acceptable cost when compared to phosphate-based programs. In addition to this challenging design task, developers needed to provide treatment technologies flexible enough to meet sustainability goals and individual needs of users in various industries. For example, oil refinery and chemical plant users may be focused primarily on phosphate deposition on heat transfer equipment; while an electric power producer may be most concerned about excessive algae growth caused by phosphorus which can negatively impact the cooling tower and downstream water bodies. Several of the programs that have been implemented thus far are adaptations of existing technologies and some utilize chemistries that are less environmentally acceptable than phosphorus itself. This paper describes a novel, non-phosphorus cooling water treatment technology that has shown equivalent or improved performance over a wide range of operating conditions and in different industrial environments. Case studies are presented that describe how the new technology was able to provide transformational improvements that met the unique needs of individual users. Application lessons learned are also reviewed.

Discusser: David Fulmer, Athlon, A Halliburton Service, Houston, TX

IWC 22-66: Use of Polymers for Deposit Control in Once Through Utility Systems

Michael Standish, Radical Polymers, LLC, Chattanooga, TN

For decades, polymers have been used in conjunction with phosphonates to control mineral scale and deposits in a wide range of applications. With the recent supply shortages and logistics issues for phosphonates along with the drive for zero phosphorous, polymers are being used as stand-alone treatments for this purpose. One critical use of phosphonates in the water industry is the control of mineral deposition in once through utility systems. Unlike recirculating cooling water systems, once through systems, are unique in that the scale inhibitor is only required to delay the onset of precipitation (induction time) for a few seconds to effectively control deposition onto condenser tubing. As such, the dosage of scale inhibitor is typically fed in parts per billion levels. This paper covers the methods development and use of a Quartz Crystal Microbalance (QCM) to evaluate a combination of an Enhanced Polymaleic Acid (EPMA) and a high purity sulfonated polymer (HPSP) versus phosphonates and untreated blank samples in synthetic waters representing three separate once through systems in the USA. The data show that the EPMA + HPSP treatment has comparable performance to traditional phosphonate treatments and demonstrates the utility of the use of QCM for evaluating scale inhibitors in ultra-low induction time applications.

Discusser: Jannifer Sanders, Nouryon, Chattanooga, TN

IWC 22-67: An Innovative, On-line, Automated Field qPCR Legionella Test Device

Loraine Huchler, P.E., CMC®, FIMC, MarTech Systems, Inc., Exmore, VA ; Etienne Lemieux, Ph.D., MBA, BioAlert Solutions, Sherbrooke, Canada

The use of an innovative, on-line, automated field qPCR legionella test device provides the most robust approach to manage the risk of Legionellosis infections. This paper describes the simple operation of this technology, including routine replacement of reagents, maintenance and remote programming, operation and data management. This system has provisions for a maximum of four on-line samples and/or multiple bottles containing grab samples . This paper also documents the results of a field study for an evaporative cooling water system serving a comfort cooling application at the headquarters of a medical device company on the East Coast of the United States. This study compares the automated, on-line field qPCR test results with manual field qPCR test results and laboratory legionella culture test results. This study confirms that very frequent qPCR testing for legionella in evaporative cooling water systems provided important information about the effect of operating and environmental changes.

Discusser: Kaylie Young, Ph.D., Champion X, Sugar Land, TX

IWC 22-68: Developing Corrosion Models That Include the Impact of Inhibitors

Robert Ferguson, French Creek Software, Valley Forge, PA ; Kaylie Young, ChampionX, Sugar Land, TX

Volumes of information are available in the literature for the computer modeling of scale formation and its control, but few studies have been published on the modeling of corrosion and its inhibition in aerated cooling water systems.
Frequent questions from users of water chemistry modeling software include:
What corrosion rates can be expected for carbon steel and common alloys as a functions of water chemistry, temperature, pH, and inhibitor dosage?
What inhibitor dosage will be required to achieve a target corrosion rate?
Can you profile corrosion rate as a function of water chemistry parameters and inhibitor dosage?
What are the relative costs projected to achieve different degrees of corrosion control?

This paper describes experimental designs for the development of the data required to develop models for relative corrosion rates, and the models used to correlate water chemistry to corrosion rates and inhibitor dosage. The model projections are validated through comparison to field observations in the wild. Significance levels for various parameters tested for inclusion in the correlations are discussed.

The models are directed towards aerated cooling water systems.

Discusser: Mary Jane Felipe, SI group, Houston, TX

Wednesday, 11/9/2022; 8:00am

W3 PFAS 2: PFAS – Prescription For Annoying Situations

IWC Rep: Derek Henderson, Duke Energy, Raleigh, NC

Session Chair: Brandon Kern, DuPont, Midland, MI

Discussion Leader: Kristen Jenkins, Brown & Caldwell, Atlanta, GA

Per- and polyfluoroalkyl substances (PFAS) are long lasting chemicals that break own very slowly over time. They have been widely used and have become quite persistent in the environment. Papers in this session will dive into treatment technologies reviewed and installed to address this growing concern, with a focus on destruction technologies having the potential to make PFAS no longer “forever chemicals”.

IWC 22-69: Ultra-Low Level PFAS Regulatory Requirements and Operational Learnings in PFAS Removal at Water & Wastewater Plants

Elaine Towe, Veolia Water Technologies & Solutions, Trevose, PA ; Elaine Towe, P.Eng., Veolia Water Technologies & Solutions, Oakville, ON, Canada

The nation and world have become aware that PFAS is in our drinking water, and that its prevalence and impact are growing. Discharge, drinking, handling, and disposal regulations are on the rise globally, and are expected to be issued by central government authorities, such as the US EPA, in more comprehensive forms, within a few short years. The challenge involves both the remediation of spill sites and the augmentation of many existing drinking water facilities.

This paper presentation will provide a comprehensive examination of the traditional and new treatment steps and technologies to achieve complete removal. The key action categories are: Test, Pilot, Treat, Concentrate, Destroy. Best available technologies (BAT) will be reviewed for each step in the process, with an emphasis on efficiency, cost/benefit analysis, and new technologies to enable superior economics. Promising new technologies now under study will be described with some evaluation of their utility and breadth of practical application. Process steps with case studies will also be included, covering the spectrum of influent PFAS concentrations, from lower concentrations, such as in drinking water, to higher concentrations, such as at an air base.

Some technologies that will be explored are: 1) state of the art laboratory testing & identification, 2) concentration of PFAS via ion exchange, reverse osmosis, carbon adsorption; 3) required adjunct technologies such as coagulation, ultrafiltration, chemistry management, and zero liquid discharge.

Discusser: Cathy Swanson, Purolite, Fullerton, CA

IWC 22-70: Destructive Treatment Technologies for Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous Media

Jim Claffey, Ph.D., P.E., Brown and Caldwell, Ramsey, NJ ; Kevin Torrens BCEEM, Brown and Caldwell, Ramsey, NJ, ; Krystal Perez, P.E., Brown and Caldwell, Seattle, WA, ; Andrew Safulko, P.E., Brown and Caldwell, Lakewood, Colorado,

A major challenge associated with PFAS propagating through the environment, largely as part of the water cycle, is their high recalcitrance to conventional water treatment processes, including coagulation, media filtration, biological or chemical oxidation. Current best available technologies for PFAS treatment are mainly based on adsorption and separation, including granular activated carbon, anion exchange resins, other novel adsorbents, and reverse osmosis. However, these processes do not destroy PFAS, but instead concentrate them in the form of residual wastes (e.g., exhausted adsorbents, RO concentrate). These wastes require additional management and treatment, which is often costly and not without risk.
In order to break PFAS cycling to the environment, PFAS must be either sequestered or destroyed. Placement of separated PFAS in secure landfills that incorporate PFAS removal from leachate is one approach for sequestration but the PFAS compounds remain in their original form. For this reason, there is an urgent need to develop destructive treatment technologies that can disrupt the movement of these contaminants in the water cycle by breaking PFAS down into less toxic, potentially biodegradable products, and ultimately mineralizing them into water, hydrofluoric acid, and carbon dioxide.
Numerous destructive treatment approaches have been proposed in recent years. However, their mechanisms, effectiveness, and applicability are not yet well understood. Performance demonstration projects to date have been limited and continue to be of interest to regulated and potentially regulated parties. Further, the economics of these technologies are largely expected to be driven by power requirements since the processes required to break the powerful carbon-fluorine bonds in all PFAS compounds are generally energy intensive, but economic demands are currently an afterthought. Quantitative comparison of energy demands is warranted.
This presentation will highlight the progress on the efficacy of various emerging PFAS-destructive treatment technologies. Additional information on new technologies that are or could soon be available for PFAS treatment and that will reflect consideration of site-specific treatment conditions, including PFAS concentrations, matrix effects, and treatment objectives, will be provided. New insights regarding treatment mechanisms, kinetics, and factors that impact treatment performance of each process will be discussed based on our experience leading recent performance demonstration projects. We'll share insights on pretreatment that may be required to couple destructive treatment processes with conventional adsorptive or separative treatment processes. Additionally, information on the scalability, economic feasibility, and market readiness of each treatment technology will be provided.

Discusser: John Sherbondy, Newterra, Coraopolis, PA

IWC 22-71: PFAS Destruction in Water using BDD Electrodes Electrooxidation: Cost-Effective? In Which Conditions?

Valérie Léveillé, WSP Golder, Montréal, Québec Canada; Éric Bergeron, WSP Golder, Montréal, Québec, Canada; Giovanna Llamosas, WSP Golder, Montréal, Québec, Canada; Imad Touahar, WSP Golder, Montréal, Québec, Canada; Jinxia Liu, McGill University, Montréal, Québec, Canada

This paper will discuss lab-scale treatment results of ground and industrial waters using a novel electrochemical oxidation (EO) process employing long-lasting boron-doped diamond (BDD) electrodes. The goal is to present the water matrix dependent treatment efficiency and costs of this process on Per- and Polyfluoroalkyl substances (PFAS), assess its effects on PFAS precursors, perchlorate generation, and water pH and temperature.
A lab-scale commercial EO reactors mimicking full-scale operating conditions was used. Five groundwaters and one textile water were treated with individual PFAS concentrations varying from ppt to ppm. For treated water quality targets, drinking water advisory levels of US EPA, state of Michigan and Health Canada were used. Current density, treatment time and pH were varied to quantify their effects on PFAS destruction efficiency. A process was implemented to prevent perchlorate formation. Water analysis conducted on raw and EO treated waters included a comprehensive suite of individual PFAS (including precursors), Total Organic Fluorine (TOF), Total Oxidizable Precursor (TOP) Assay and physicochemical water parameters.
Among the findings that emerged from this research, the key ones are:
• The EO BDD process is cost-effective for waters with high PFAS concentration, low daily water volume or with negligible concentrations of PFAS precursors.
• It is more cost-effective to use EO followed by a polishing step for waters with elevated concentrations of PFAS precursors.
• As expected, perchlorate formation depends on chloride ions concentration in water, but in some waters, the measured perchlorate concentration was higher than the theoretical perchlorate concentration.
• The EO process seems to oxidize free (in water) and bonded (attached to particles) PFAS and their precursors while the TOP Assay oxidation did not.

It is concluded from this research that 1) the EO BDD process alone can be cost-effective for PFAS destruction, with a polishing unit recommended in some cases; 2) quantifying the water matrix and setting discharge standards are essential to determine the EO BDD process applicability for PFAS destruction in water; and 3) a scale-up model was developed to size and estimate the cost of a full-scale unit for PFAS destruction in water.

The next steps on this EO BDD process development are:
• Continue optimizing approaches to reduce perchlorate formation.
• Continue optimizing conditions to minimize capital cost of the process.
• Demonstrate the efficiency and robustness of the process at pilot scale: A pilot unit is built and will be tested in 2022.

Discusser: Francisco Barajas Rodriguez, AECOM, Austin, TX

IWC 22-72: Electrochemical Destruction of PFAS in Concentrated Waste Streams

Orren Schneider, Ph.D., P.E., Aclarity, LLC, Plainsboro, NJ

PFAS contamination of water streams has become ubiquitous. In order to deal with this contamination, treatment has been focused on removal of these pollutants, chiefly by granular activated carbon or anion exchange. When exhausted, the spent media is sent to landfills or incinerators. With changing regulations pending, there is ongoing development of destructive technologies that can actually degrade or even mineralize these persistent compounds rather than transferring them from water to another phase.

While several different types of destructive technologies are being developed, electrochemical oxidation has begun to emerge from labs to become commercially available. Both academic and commercial research has shown that these systems can degrade these compounds to below detection limits. While electrochemical treatment for low concentration streams is not yet cost effective, treatment of high concentrations in waste brine or landfill leachates can be a cost-effective solution. This paper will present lab and field data showing destruction of a variety of PFAS compounds in several different water matrices and present economics for these systems relative to existing removal solutions.

Discusser: Beth Landale, P.E., P.Eng., GHD, Farmington Hills, MI

Wednesday, 11/9/2022; 8:00am

W4 Wastewater 2: Wastewater Treatment Innovations, Improvements, and Optimizations

IWC Rep: Max Brefeld, Toyota Motors North America, Georgetown, KY

Session Chair: Julie Horan, HDR, Inc., St. Louis, MO

Discussion Leader: Jaron Stanley, WesTech, Salt Lake City, UT

What's new in wastewater? Innovation and optimization of treatment technologies is necessary to address water scarcity, improve treatment economics, and comply with new and tightening quality requirements. This session's papers will discuss innovative technologies and improvements to existing technologies for wastewater treatment. The papers in this session will focus on case studies from recent projects. Treatment technologies covered in this session's papers include membrane bioreactors, high recovery membrane desalination, advanced oxidation processes, and bioaugmentation.

IWC 22-73: 15 Years of Membrane Bioreactor (MBR) Experience for Industrial Wastewater Treatment

Sara Arabi, Ph.D., P.E., BCEE, MBA, Stantec, Fort Collins, CO

In the last 15 years, Membrane Bioreactors (MBRs) have become common for industrial wastewater treatment. This paper presents the progress and applications of MBRs which provides the benefit of biological treatment process in a compact footprint and solids liquid separation for a high-quality effluent. In this paper, lessons learned and challenges from design and operation of MBR plants for industrial wastewaters are presented. MBRs provide the pretreatment required for other treatment technologies such as Reverse Osmosis (RO) where wastewater reuse and recycle or PFAS removal is targeted.

The key design considerations for MBR include selection of membrane flux rates for cold temperature operations, influent characterization, and design of equalization basins. Some of the key operational considerations for MBR plants are nutrient balance for macro-nutrients (where nitrogen or phosphorus are limiting the biological growth) and micro-nutrients, membrane fouling mitigation, and foaming issues. Short case studies for MBR operation for landfill leachate and pharmaceutical wastewater are presented.

Discusser: Srikanth Muddasani, C.E.C., Inc., mcdonald, Pa

IWC 22-74: High Recovery Electrochemical Desalination for Tertiary Wastewater Treatment

Chad Unrau, MI Systems, Houston, TX ; Sunil Mehta, MI Systems, Houston, TX,

Minimum and Zero Liquid Discharge applications often require high recovery membrane desalination to make treatment and performance targets economically feasible. Water recovery in membrane desalination is typically limited by scale formation from silica and partially soluble salts such as calcium sulfate. In addition, chemical and energy consumption can often make the operating cost of a project prohibitive. The latest evolution of electrodialysis reversal enables high recovery desalination of brackish waters without concentrating silica due to its neutral charge. Polarity reversal naturally mitigates scaling from partially soluble salts and energy consumption is minimized with the lastest innovations of the technology. Finally, electrodialysis reversal enables the tuning of the product output to deliver the required user treatment level. This feature minimizes over-treatment of the water which in turn minimizes energy consumption and it minimizes the amount of scaling ions transferred to the brine. As such, higher recoveries can be achieved with lower risk of scale formation.

An exemplary project that highlights the capabilities of the latest advancements in electrodialysis reversal is a pilot project conducted by MI Systems for tertiary treatment of a California WWTP effluent. The water quality for the plant is 1600 ppm TDS, 187 - 200 ppm chloride and ~30 ppm silica. The objective of the pilot study was to reduce chloride concentrations to meet effluent discharge limits <100 ppm chloride and to demonstrate 95% water recovery. Water recovery is critical for this client as opex limitations necessitated the need for onsite handling of the brine with minimal space available to do so. The system operated at an average water recovery of 95% and an average SEC of 0.5 kWh/m3. The system was able to consistently meet target chloride concentrations < 100 ppm within the pilot study period by tuning the applied voltage without over-treating the water. The concentration of silica remained unchanged in the influent and effluent streams of the system due to its neutral charge. As a comparison, for this type of water, a typical RO system would operate at a maximum of ~90% recovery due to high silica concentrations and would require the use of antiscalant. Demonstrating 95% water recovery was critical for this client as this level of recovery enables the use of small onsite evaporation ponds to handle the minimal brine production at full scale. A 200 gpm system is currently be constructed and installed for this client in 2022.

Discusser: Nicole Bartoletta , McKim & Creed, Inc., Sewickley, PA

IWC 22-75: Ultraviolet Advanced Oxidation Processes for 1,4-Dioxane Destruction In Bench-Scale and Pilot-Scale Units

Roberto Silva De Faria, Evoqua Water Technologies LLC, Pittsburgh, PA ; Mohsen Ghafari, Ph.D., Evoqua Water Technologies LLC, Pittsburgh, PA, ; Simon Dukes, Evoqua Water Technologies LLC, Tewksbury, MA, ; Joshua Griffis, Evoqua Water Technologies LLC, Tewksbury, MA

The identification of sustainable water treatment processes becomes urgent as the quality and quantity of available water sources reduces. Increased attention is given to those alternatives that promise a scalable, cost-effective solution to our water problems while meeting public health demands. Advanced oxidation processes (AOPs) have proven to be effective for toxic contaminant removal when compared to more conventional treatment processes. AOP has been applied successfully to degrade or remove toxic pollutants of emerging concern such as 1,4-dioxane, a major recalcitrant and toxic contaminant.
1,4-dioxane has been detected in many water resources and municipal wastewater influents due to discharge from chemical industries. Given that several US states have established drinking water guidelines as low as 0.3 ppb, it is imperative to develop efficient and sustainable technologies for its destruction. Currently, municipalities are expanding their treatment capabilities for indirect potable water reuse by implementing conventional and advanced technologies. Specifically, Evoqua partnered with a municipality in Maryland, USA to implement an improved AOP technology with onsite hydrogen peroxide generation.
In this study, UV-activated AOPs were investigated for the destruction of 1,4-dioxane in both laboratory scale and pilot scale systems. At the laboratory scale, hydrogen peroxide (H_2O_2) and sodium hypochlorite (NaOCl) were used as oxidants. Results showed increased reduction of 1,4-dioxane when using H_2O_2 over NaOCl. At the pilot scale, 1,4-dioxane destruction was tested in a reactor equipped with 0.8 kW low pressure UV lamp. An onsite H_2O_2 generation unit was used for introduction of oxidant to the reactor influent water. The results showed complete destruction of 1,4-dioxane when H_2O_2 to 1,4-dioxane mass ratio greater than 10 was used. This study demonstrates the potential of UV-H_2O_2 for destruction of recalcitrant compounds for safe indirect potable reuse.

Discusser: Harley Schreiber , WesTech Engineering, Salt Lake City, UT

IWC 22-76: Improved Biological Nutrient Removal by integrating bioaugmentation in the wastewater collection system

Dimitris Chrysochoou, Tradeworks Environmental, Mississauga, ON Canada

A Rotating Biological Contactor [RBC] wastewater treatment plant was facing challenges with meeting the effluent ammonia criteria. It is a 1.2 MGD wastewater treatment plant located in a residential area in Nova Scotia region. It utilizes screening, primary clarification, 2 parallel RBC trains, secondary clarification, and disinfection prior to discharge. The wasted sludge from the system is co-thickened in the primary clarifier and pumped into the anaerobic digester. Waste sludge from the anaerobic digester is hauled away for further processing and disposal. Due to the challenges, the facility was scheduled to be decommissioned and be used as a lift station to divert the flow to another facility nearby. The facility has different effluent ammonia criteria for the winter and summer seasons [5mg/l and 3mg/l respectively].

For this project it was suggested to apply the bioaugmentation in the wastewater collection system. This way, the sewage conveyance system is leveraged to precondition the wastewater prior to its introduction into the treatment plant, which is also enhanced by the microbial addition. The project started in August 2020 and is still undergoing today as part of the standard operations. The primary objective of this project was to enhance nitrification.

During the first year of application, it was demonstrated that the bioaugmentation assisted with enhancing the nitrification process, which was able to meet the ammonia effluent criteria and have the primary objective satisfied. As the system has different effluent criteria for winter and summer seasons, for the period of November 1st, 2019, to April 30th, 2020 [before the bioaugmentation] the average effluent ammonia values were 4 ppm, while for the period of November 1st, 2020, to April 30th, 2021 [after bioaugmentation] the average ammonia effluent values were 1.75 mg/l. Furthermore, for the period of May 1st, 2020, to August 31st, 2020 [before bioaugmentation] the average effluent ammonia was 2.92mg/l, and for the period of May 1st, 2021, to August 31st, 2021 [after bioaugmentation] the average effluent ammonia values were 1.38 mg/l. The daily ammonia removal rate increased by 28%.
Secondary objectives included optimization of the system in various stages. It was shown, that after bioaugmentation application the biogas production was increased compared to the same months the year prior to the application, by 20-50% and the sludge hauling reduced by 15%.
This application in the collection system was able to provide a sustainable solution to the wastewater authority saving the facility from being decommissioned.

Discusser: Bridget Finnegan, P.E., CDT, ENV SP, GHD, Allison Park, PA