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**8<sup>th</sup> WWF – INTERNATIONAL COOPERATION AGREEMENT – “COLOMBIAN – DUTCH ACADEMIC AND RESEARCH PARTNERSHIP (ARP)”**

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Jules VanLie Universidad de Buenos Aires Netherlands	Jeroen Vos Wageningen University Netherlands	Erik Mosselman Deltares
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The Netherlands Embassy in Colombia with the objective of Strengthen the relationship between Colombia and the Netherlands in the fields related to water financed a cooperation project named “Colombian – Dutch Academic and Research Partnership (ARP)”. This project was focus to reinforce research, as well as Colombian capabilities in managing water resources, sanitation and drinking water, through training excellent Colombian experts on water issues, and the exchange of knowledge and experience in the region by the developing an ARP that links the Colombian and Netherlands academic and knowledge communities in the wide field of integrated water resources and water related risks management.

Four Colombian and four Dutch universities and entities are members of the ARP. From Colombia are, Universidad de los Andes, Universidad de Antioquia, Universidad Del Norte, d) Universidad del Valle. And from The Netherlands, e) Technical University of Delft, f) IHE Delft, g) Wageningen University and h) Deltares.

Working with Water Resources Management is a challenging task. Between all the eight institutions was created a strong link to develop research projects and academic courses and programs. Analyzing the main needs of Colombia and its similarities with The Netherlands, five main work areas where included in the ARP: 1) Hydraulic of Coasts and Coastal Zone Management, 2) Groundwater and Hydrology, 3) River Hydraulics and Morphology, 4) Water Distribution, Urban Drainage Systems Residual Water Treatment and 5) Governance and social management of water and Risk Management.

This article will present the main conclusions related to the 5 work areas mentioned above and the interaction between all the ARP members.

**Thursday, December 6, 2018 | Water Resources II**

**8<sup>th</sup> WWF – MAIN DRINKING WATER AND SANITATION ISSUES FOR THE SOUTH AMERICAN REGION**

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The Water Supply and Sewer Systems Research Center (CIACUA) from Universidad de los Andes join with the Inter development Bank (IDB) developed a methodology in order to present the main aspects of the region within the framework of the 8th World Water Forum. The South American document addresses the aspects that should be part of the policies for drinking water and sanitation for the thirty years. This region includes the following countries, Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Perú, Uruguay and Venezuela.

The methodology consisted on three steps: 1) Review the national reports from each country. On the documents was related the main issues for each of the seven topics defined as the thematic framework: climate, people, development, urban, ecosystems and finance. 2) The issues found on each national document and some other proposed by our working team were ranked from the most to the least relevant, this by all the team members and experts on each country. Giving as a result the main issues related to each of the seven themes. 3) Considering those issues and the national reports our team proposed the short, medium and long term actions that the region should consider as a priority.

This article will describe the issues determined along the process, and the guidelines about drinking water and sanitation for the next five years in the South American region. Their importance, and the actions that can drive these countries to an improvement about water governance and management.

**Wednesday, December 5, 2018 | Climate Change**

**ADAPTIVE STRATEGIES FOR URBAN RAINWATER DRAINAGE SYSTEMS IN CLIMATE CHANGE SCENARIOS**

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The effect of climate change on the rainwater regime is very noticeable and is evidenced in a significant way in the urban floods generated by runoff, conditioned by changing rainfall intensities, which sewer systems cannot adequately control. This research focuses on the definition of a methodology to determine the feasibility of implementing temporary storage structures (AquaCells structures) in any big city as an alternative to reduce peak flow rates, optimizing its location and volume to adapt cities to the conditions of climate change and not replacing its current drainage infrastructure to the new hydrology conditions. Using the software Storm Water Management Model (SWMM), the problem was attacked using two approaches: the first one looks how to establish the optimal tank's size passively, without considering real-time control, known as Optimization Without Hydraulic Control and the second approach considered within its decision variables the diameter of the orifice at the tanks' outlet, being this is the way to consider real-time control strategies in the network, known as Optimization with Hydraulic Control. This control was analyzed through three real-time control techniques: Model predictive control (MPC), Evolutionary games (EG), and Differential games (MFG). The obtained results indicate that the adopted approach for the project has been proper and urban drainage systems floods could be minimized through the implementation of temporary storage structures and real-time control strategies, even when climate change effects occur within the established time framework. Additionally, this project tested a methodology to calculate future rain intensities, so cities can be better prepared to face future challenges.

**Friday, December 7, 2018 | Water Supply and Sanitation II**

**ANALYSIS OF HUNTER'S METHOD FOR DESIGN OF PUMP SYSTEMS IN MULTIFAMILY BUILDINGS FOR SOCIAL STRATA 3 AND 4 IN BOGOTA, COLOMBIA**

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Nowadays the construction of dwelling is developed, in its large majority, in multifamily buildings with central pump systems for the water supply, observing, in general, oversize in them. It is convenient to have a methodology that allows the selection of the systems that meets the actual conditions of use and consumption habits of the population. An alternative to accomplish the latter is to put forward an adjustment of the probability  $p$  of being found " $r$ " fixtures of a total of " $n$ " in use, described in Hunter's method for estimating loads in plumbing systems, applied to multifamily buildings social strata 3 and 4 in the city of Bogota. For this purpose, measurements of instantaneous maximum flow rate in the discharge of pressure equipment with hydro pneumatic systems of five multifamily buildings was carried out using a portable ultrasonic flowmeter. With these measurements, the maximum instantaneous and maximum average flow were obtained; from which the  $p$  value was evaluated to propose new estimated curve for design purposes where it can be found the expected flow rates in relation to  $n$  fixtures, to design pumps systems, achieving better sizes of equipment, efficient systems, at lower costs, with lower energy and water consumption.

**Thursday, December 6, 2018 | Modeling and GIS II**

**ANALYSIS OF SYNTHETIC DAILY RAINFALLS IN THE BASIN OF THE STREAM CALLED “SAN ANTONIO”. VALLEDUPAR – CESAR, COLOMBIA**

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This paper presents analysis, calculations, results and recommendations about the use of a simplified model for the generation of synthetic rain series in the basin: “Arroyo San Antonio” for the exploitation area in the department of Cesar, Colombia. In this analysis, it was used as basis of the investigation, the reanalysis method developed for the University of Chile (2015). Based on the hydrological characteristics of the study area and with the purpose of reducing the differences between the pattern generated by synthetic rain and the pattern of historical series, the method has been optimized. These generation methods reproduce the sequence of magnitudes of several variables, safeguarding the characteristics of the historical series. The aim of generation of these synthetic data, is to reproduce values with particular patterns to perform hydrological analyzes, using these series as real rainfall records.

**Friday, December 7, 2018 | Fluvial Structures**

**ANALYSIS OF THE BEHAVIOR OF A HYDRAULIC JUMP BASED ON FRACTAL STUDY**

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This research focuses on the study of a hydraulic jump based on the analysis of fractal theory and basic concepts of chaos theory.

**Friday, December 7, 2018 | Groundwater**

**Application of adjoint methods for the protection of contaminated aquifer**

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Traditional groundwater flow and transport models simulate the transport of a contaminant downgradient from its source, in the direction of groundwater flow. In other words, information in the form of contaminant concentrations is propagated from one or a few sources to all possible downstream receptors. These traditional models are useful if there is one or a few sources and many receptors. For example, if there is one source of contamination and many drinking water supply wells that the source can contaminate, we can use a traditional model to estimate the time when the

contaminant concentration at each well will exceed the drinking water standard. In some applications, we have many possible sources of contamination and one or a few receptors of interest. For example, if we want to protect a single, existing drinking water supply well from contamination from septic fields, the drinking water supply well is our one receptor and each septic tank represents a potential source of contamination to that well. For this type of application, adjoint simulations are more appropriate. In an adjoint simulation, information is propagated upstream from the receptor to all possible sources, so with a single adjoint simulation, we can obtain information about the likelihood of each possible source to contaminate the one well of interest. This presentation will introduce the adjoint approach for groundwater flow and transport simulations and will demonstrate several applications of the adjoint method for protection of water supply wells in contaminated aquifers.

**Thursday, December 6, 2018 | Modeling and GIS II**

**Application of an analytical model to obtain daily flow duration curves for different hydrological regimes**

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This work assesses the performance of an analytical model framework to generate daily flow duration curves, FDCs, based on climatic characteristics of the catchments and on their streamflow recession coefficients. According to the analytical model framework, precipitation is considered to be a stochastic process, modelled as a marked Poisson process, and recession is considered to be deterministic, with parameters that can be computed based on different models. The analytical model framework was tested for three case studies with different hydrological regimes located in Switzerland: pluvial, snow-dominated and glacier. For that purpose, five time intervals were analyzed (the four meteorological seasons and the civil year) and two developments of the model were tested: one considering a linear recession model and the other adopting a nonlinear recession model. Those developments were combined with recession coefficients obtained from two different approaches: forward and inverse estimation. The performance of the analytical framework when considering forward parameter estimation is poor in comparison with the inverse estimation for both, linear and nonlinear models. For the pluvial catchment, the inverse estimation shows exceptional good results, especially for the nonlinear model, clearing suggesting that the model has the ability to describe FDCs. For the snow-dominated and glacier catchments the seasonal results are better than the annual ones suggesting that the model can describe streamflows in those conditions and that future efforts should focus on improving and combining seasonal curves instead of considering single annual ones (keywords— analytical streamflow distribution, stochastic process, linear and non-linear recession, hydrological modelling, daily discharges)

Thursday, December 6, 2018 | Climate Change II

**Application of Statistical Downscaling Technique to Predict Rainfall and Its Spatial Analysis Over Subansiri River Basin of Assam, India**

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The River Subansiri is the major north bank tributary of river Brahmaputra. It originates from the range of Himalayas beyond the Great Himalayan range at an altitude of approximately 5340m. Subansiri basin extends from tropical to temperate zones and hence exhibits a great diversity in rainfall characteristics. In the Northern and Central Himalayan tracts, precipitation is scarce on account of high altitudes. On the other hand, Southeast part of the Subansiri basin comprising the sub-Himalayan and the plain tract in Arunachal Pradesh and Assam, lies in the tropics. Due to Northeast as well as Southwest monsoon, precipitation occurs in this region in abundant quantities. Particularly, Southwest monsoon causes very heavy precipitation in the entire Subansiri basin during May to October. In this study, the rainfall over Subansiri basin has been studied at 24 different locations by multiple linear and non-linear regression based statistical downscaling techniques and by Artificial Neural Network based model. APHRODITE's gridded rainfall data of  $0.25^\circ \times 0.25^\circ$  resolutions and climatic parameters of HadCM3 GCM of resolution  $2.5^\circ \times 3.75^\circ$  (latitude by longitude) have been used in this study. It has been found that multiple non-linear regression based statistical downscaling technique outperformed the other techniques. Using this method, the future rainfall pattern over the Subansiri basin has been analyzed up to the year 2099 for four different time periods, viz., 2020-39, 2040-59, 2060-79, and 2080-99 at all the 24 locations. On the basis of historical rainfall, the months have been categorized as wet months, months with moderate rainfall and dry months. The spatial changes in rainfall patterns for all these three types of months have also been analyzed over the basin. Potential decrease of rainfall in the wet months and months with moderate rainfall and increase of rainfall in the dry months are observed for the future rainfall pattern of the Subansiri basin.

Friday, December 7, 2018 | Water Resources V

**BIOINDICATORS OF WATER QUALITY AS A TOOL OF ENVIRONMENTAL IMPACT ASSESSMENT IN THE RIO TOLEDO WATERSHED/BRAZIL**

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Biomonitoring by means of benthic macroinvertebrates has been considered an adequate tool in the evaluation of environmental impacts of water bodies. This study aimed to identify and quantify environmental impacts under the Toledo River watershed by means of biological monitoring and to evaluate the accumulation of toxic metals in benthic macroinvertebrates. Six samplings were carried out at seven points determined from possible potentially polluting activities. The macroinvertebrates were sorted and identified according to order and taxonomic family. All of them were analyzed from the biological metrics, biological index, and submitted to statistical analysis (CCA, NMDS), in order to carry out water quality assessment. In addition, after screening and identification, the total concentrations of the metals were determined in the macroinvertebrate tissues by means of atomic absorption spectrometry, flame mode (FAAS). The results show that the quality of the Toledo River is negatively impacted by the activities (agricultural and urban) carried out in the watershed since the concentrations of toxic metals in the benthic macroinvertebrates were high reaching 8.28 mg kg<sup>-1</sup> of Cd and 374.59 mg kg<sup>-1</sup> of Pb, indicating bioaccumulation of toxic metals in these organisms. Moreover, due to the continuous receiving contaminants along the river and the lack of adequate riparian forest, low rates of richness, organisms susceptible to contamination, and diversity of families were observed, and a high rate of dominance of the Chironomidae species, indicating a highly polluted environment. However, when faced with the biological index the results score showed that the quality of the river as acceptable, which suggests an update on the methodology of water quality assessment.

**Wednesday, December 5, 2018 | Pollutants**

**Carbon dioxide switchable polymers as draw agents for forward osmosis**

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Current methods for obtaining potable water from wastewater or seawater include distillation, pervaporation, reverse osmosis (RO) and forward osmosis (FO). Forward osmosis utilizes a draw solution containing a draw agent, which is usually a dissolved salt that can be easily removed. The water to be treated and the draw solution are placed on opposite sides of a membrane. The draw solution has a higher osmotic pressure than the feed water so that water will diffuse, without added pressure, from the feed solution to the draw solution, thereby diluting the draw solution and concentrating the feed solution. The draw agent is then removed from the draw solution to give fresh water. In existing FO systems, the major energy costs are associated with the separation of the draw agent from the diluted draw solution. An ideal draw agent would require little energy to be removed or the energy required could be supplied largely by low-grade waste heat or even solar heat. To meet these demands we are developing novel draw agents based on carbon dioxide switchable polymers, whose properties can be changed simply with the addition or removal of carbon dioxide gas at atmospheric pressure. Under air or inert atmosphere, the polymers are neutral and hydrophobic but under a carbon dioxide atmosphere the polymers become positively charged and dissolve in water with bicarbonate counteranions. Osmotic pressure is generated by the bicarbonate ions in solution plus the swelling pressure of the polymers, allowing the FO process to occur. After the FO step has been completed, the carbon dioxide is removed

and the polymers, now neutral and insoluble in the water, can be readily separated to yield purified water.

**Thursday, December 6, 2018 | Climate Change II**

**Comparative Analysis of Statistical Downscaling Methods In Tolima Department**

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A comparison of different statistical downscaling methods is presented in this work and their application in the Tolima Department. Two sources of climatic information were used in the process: The first corresponds to rainfall gauges stations selected from IDEAM (Institute of Hydrology, Meteorology and Environmental Studies, Colombia) (1970-2016, daily) and the second is derived from the information of the global climate model MPI-ESM-MR of the Max Planck Institute for daily precipitation data in its first historical realization (1850-2005) with the RCP4.5 and RCP8.5 experiments (2006-2100) in their first realization with a spatial resolution of  $1.875^\circ \times 1.875^\circ$ . A wide variety of statistical downscaling methods were used in the region, for a total of 15 techniques, including: CSD (Chaotic Statistical Downscaling), k-NN Bootstrapping, Delta methods, Analog methods, Quantile Mapping methods, Weather Type methods and Generalized Linear Methods, most of the methods were include in the Meteolab toolbox in MatLab. These methods were evaluated under four different measures of error (Mean Absolute Error (MAE), Root-Mean Square Error (RMSE), Max value difference and Nash-Sutcliffe efficiency (NSE)). Finally, it was possible to compare the monthly multiannual precipitation, the annual precipitation, and the return period for all the downscaling techniques with a reference period, and show which statistical downscaling methods were able to reproduce reliable rainfall value for the region.

**Thursday, December 6, 2018 | Water Supply Infrastructure**

**COMPARISON BETWEEN THE DESIGNS OF WDNs PRESENTED IN THE PROJECTS VIABILITY MECHANISM OF THE MVCT AND THE OPTIMIZED DESIGNS OF THE SAME NETWORKS**

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Improvement of the water and basic sanitation sector has been one of the main objectives of the national development plans of the former governments of Colombia. However, the investment resources are scarce which limits the projects of this sector that can be executed in a given period. Ministerio de Vivienda, Ciudad y Territorio (MVCT) of Colombia is the institution in charge of the regulation of the water and basic sanitation sector. As part of this regulation, MVCT has implemented a standardized evaluation mechanism exclusive for projects of this sector. This mechanism considers technical, financial, legal, socioeconomic and environmental aspects of every project and determines which projects in the water and basic sanitation sector are viable for being implemented with national resources. The construction of new Drinking Water Distribution Networks (WDNs) in urban and rural areas of Colombia has been part of the actions carried out in search of the improvement of the water

and basic sanitation sector. Traditionally these networks have been designed by trial and error method based on the designer's experience and the restrictions established by the corresponding regulation of this sector. Because this method does not implement any formal economic optimization criteria, WDNs designs in Colombia turn out to be hydraulically feasible as they do not guarantee the minimization of the costs associated with their construction, operation and maintenance. Therefore, this traditional design philosophy seems not to be effective in addressing the problematic associated with the scarcity of investment resources and the great interest in the construction of new WDNs in Colombia. However, today there are many optimization design methodologies that could be applied successfully in the solution of this problem. The objective of this research is to quantify the impact that the demand of optimized design of WDNs would have on costs and hydraulic parameters of WDNs in Colombia. For this, a sample of WDNs designs presented in the Projects Viability Mechanism of MVCT are compared with the optimized designs of the same networks considering two design methodologies: Optimal Power Use Surface (OPUS) and Genetic Algorithms (AG).

**COMPARISON OF RANS AND LES TURBULENCE MODELS, AND PHYSICAL AND NUMERICAL MODELING**

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Recent studies show that the accuracy levels of Computational Fluid Dynamics (CFD) are approaching to that of physical model solutions provided that benchmark model test are performed. However the physical model is not able to capture some specific effects, as turbulence. And CFD modelling provides this possibility; through solvers that use standard Reynolds averaged Navier-Stokes (RANS) approach  $k-\omega$  approximations and LES schemes. Where the turbulence is treated more in more detail. With the growth of computing resources and, in particular, the availability of powerful computer clusters, application of Large Eddy Simulation (LES) emerges as an attractive option in modelling of turbulence process. The LES model is compared against a RANS based RNG  $k-\omega$  model which is routinely used for engine simulations, all this, accompanied by validations are performed against experimental data. In this case is modelled the flow through the complex spillway hydrodynamics behaviour. The results show using the same computing performance, with LES schemes best results are obtained, and physically based. In addition the LES approaches are compared with each other and with the experimental measurements.

**Wednesday, December 5, 2018 | Modeling and GIS**

**Comparison of two methodologies to estimate flood footprints based in GIS using hydrological data**

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Historically, Colombia and many regions of the world have been severely affected by floods, which may cause health, economic, social and environmental problems on the influence area and its population. This project seeks to contribute to the estimation of flood zones, by comparing two methodologies to estimate flows and their corresponding flood footprint, through GIS (Geographic Information Systems). For this research, information will be used from rainfall and hydrological stations of the IDEAM (Institute of Hydrology, Meteorology and Environmental Studies), mainly because of the lack of resources to support a detailed study of each area of interest within the country. The two methodologies of flow estimation will be: the peak flow method, widely used to estimate floods and return periods; and the flows measured by the limnigraphic stations of the IDEAM (stations that record the flow over time). With the modeling of the two flood footprints in a determined Colombian river, after a Niña phase, these methodologies will be compared with the actual flood footprint obtained from satellite images. The analysis of these images will be through GIS software. It is expected to be able to compare the quality of these modeled flood footprints with the real flood footprint of the river, to have an estimation of how reliable these two methodologies are and which presents de best approximation of real flood footprint.

**Thursday, December 6, 2018 | Water Supply and Sanitation**

**Creating Flood Warning Systems Using HEC-RTS Software**

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WEST Consultants is currently implementing a flood forecasting systems for the County of San Diego and other cities and counties using the U.S. Army Corps of Engineers' HEC-RTS (Real Time Simulation) software (free for download from the Corps HEC website). The flood forecasting system provides timely information on potential flooding to support emergency response planning and operations. The flood warning system produces near real-time forecast streamflow at designated locations within river basins and displays real-time inundation maps based on current streamflow forecasts or static inundation maps to show a range of inundation conditions. The presentation will cover how the comprehensive HEC-RTS system works and its application to the 420 square mile San Diego River Watershed. I will describe how RTS retrieves precipitation, river stage, and other data from field sensors, and validates, transforms and stores those measurements in a database. The measurements are used for calibration and adjustment of hydrologic and hydraulic models to reflect current conditions. Once the models have been adjusted to reflect current hydro-meteorological conditions within the watershed, they can be executed to produce forecasts of hydrologic conditions, including potential inundated areas and overtopping of road crossings. The lead time provided by the forecast model will allow the County to mobilize field crews to

close hazardous crossings and possibly issue flood warnings. We will also briefly describe the HEC-RTS components used for this application: the Command and Visualization Interface (CAVI), HEC-HMS (Hydrologic Modeling System) for rainfall-runoff forecasting and hydrologic routing, and HEC-RAS (River Analysis System) for hydraulic routing.

**Wednesday, December 5, 2018 | Coffee Break & Posters**

**Curve number estimation (CN-NRCS) for different antecedent moisture conditions (AMC) in semiarid catchment**

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The objective of this study was to investigate the changes in the number of curves (CN) -NRCS due to changes in vegetation cover and different soil moisture conditions in the Brazilian semi-arid zone. The work was developed in an experimental catchment located in the city of Iguatu, Ceará, Brazil. It was evaluated with natural vegetation Dry Tropical Forest (Caatinga) (2009 and 2010) and after the application of cutting and weeding management of the vegetal remains (2011 and 2012). The hydrological events monitored were classified according to the previous rainfall of the last 5 days in the three soil conditions: Dry Soil (AMC I), Normal Soil (AMC II) and Wet Soil (AMC III). The results showed higher CN value in the AMC I and AMC II conditions in the catchment when covered with Caatinga vegetation, but after application of the management the AMC III condition presented higher values. The CN values measured in the AMC I and AMC III conditions and compared to the CN obtained by means of the equations to transform in the conditions AMC I and AMC III, respectively presented errors of 35.0% and 25.3% for the covered watershed Caatinga and 10.2% to -1.1% after managed vegetation cover.

**Friday, December 7, 2018 | Water Resources V**

**Delta of the Magdalena River: Perspective for developing an integrated management plan for a natural system anthropogenically modified**

Humberto Avila Universidad del Norte Colombia
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The delta of the Magdalena River is a fluvio-marine system in Colombia with major anthropogenic interventions and environmental complexity which have had an important economic, social and cultural influence for the country. The management and use of this system requires knowledge of the natural

conditions and the effect of the existing and projected hydraulic works, the needs and economic interests of the region, climate variability and the potential effects caused by climate change. Since 1930, hydraulic works have been carried out, such as the Bocas de Ceniza cutwaters, the construction of dikes and spurs, capital and maintenance dredging, among other works and land use changes for navigation, flood management control, enabling land for agricultural activities, among others interests, which have caused changes and significant impacts on the river system and coastal areas. This article shows an analysis of the evolution of the Magdalena river delta system and a perspective based on scientific evidences and historical events related to the fluvial and coastal hydromorphological conditions, economic projections of the port sector, social and environmental impacts that allow identifying guidelines for developing an integrated management plan for the Magdalena river delta system.

**Wednesday, December 5, 2018 | Pollutants**

**Designing a photocatalytic reactor to remove chlorpyrifos from industrial wastewater.**

Karel Sanchez Hernandez Universidad de Cundinamarca Colombia	Johana Orjuela Ramos Universidad Nacional de Colombia Colombia	Rolando Mendoza Rincon Universidad de Cundinamarca Colombia
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Chlorpyrifos is widely used as insecticide in agricultural crops and it is classified as an emerging contaminant (endocrine disruptor), highly toxic. However, trace quantities are found in water sources, suggesting that chlorpyrifos remains on the ground and reaches the water reservoirs. Currently, heterogeneous photocatalytic oxidation using titanium dioxide as catalyst has been proposed as a promissory technology to remove chlorpyrifos from industrial wastewater. In this work, a continuous photoreactor design was proposed to decrease chlorpyrifos concentration in wastewaters from a chlorpyrifos production factory. To develop the design, kinetic data of photocatalytic chlorpyrifos oxidation were taken from available literature using a first-order equation, calculating a reaction rate constant of 0.005 L/mg h. For an estimated flowrate of 0.4 L/s with an initial concentration of chlorpyrifos of 400 µg/L, the designed photoreactor has a volume of 9,3 m<sup>3</sup>, and UV lamps amount of 198 units, obtaining a total power of 1984 kW. The reactor dimensions are 2,2 m x 2,7 m. With the designed reactor, chlorpyrifos removal was calculated in 0,1 ppm in order to comply with Colombian environmental regulations. Total cost of the photoreactor was estimated in \$ 80.000 US, which includes costs of manufacturing material, agitation system and flow regulators. The results show that the reactor is capable to oxidize chlorpyrifos at desirable levels. However, its estimated dimensions are still too large and for this reason, additional treatments can be necessary.

**Friday, December 7, 2018 | Groundwater**

**DETECTION OF PRESENCE OF PSEUDOMONA AERUGINOSA AND CONTROL MEASURES IN THERMAL WATERS**

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Thermal waters in Colombia are not tested for quality to ensure users' health and their aesthetic quality, because of the high prices these procedures demand. This study shows the results of water tests performed in three thermal water pools in Cundinamarca, randomly chosen to estimate the presence of *Pseudomonas aeruginosa*; these tests are not statistical due to the available resources. Results were compared with international standards because Colombian regulations have yet to be passed as laws. The results showed the presence of *Pseudomonas aeruginosa* in one of the analyzed thermal water sources, as a hypothesis, it was established that this is a consequence of an inadequate protection of the aquifer or waste discharge in the thermal water spring. Besides, the concentration of *Pseudomonas aeruginosa* in wells and pools was found to be under 1 UFC/100 ml for pH values under 7.00, while for pH values above 7.00, the presence of the pathogen can be counted, which is why control measures were formulated to keep in line the levels of contamination of thermal water pools; these measures comprise medical, hygiene, and usage restrictions.

**Friday, December 7, 2018 | Water Reuse-SUDS**

**DETERMINATION OF THE FEASIBILITY OF IMPLEMENTING SUSTAINABLE URBAN DRAINAGE SYSTEMS – SUDS IN COLOMBIAN CITIES FOR REDUCING URBAN FLOODING**

Juan Carlos Burgos Universidad de los Andes Colombia	Camilo Salcedo Universidad de los Andes Colombia
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Historically, urban drainage systems have been designed under the assumption of a forecast population with increasing tendency. However, due to the rapid urbanization processes and the effect of climate change in the environment, most of these drainage systems are losing their hydraulic capacity leading to several consequences such as urban floods. A widely used solution to these problems are the Sustainable Urban Drainage Systems (SUDS), which seeks to resemble the natural regime of the hydrological cycle in a non-development condition once the urban infrastructure have been developed. Thus, SUDS can reduce the volume and peak flow of runoff before it enters into the drainage systems, avoiding flooding and saturation downstream the system. Based on the above, a methodology is proposed to determine the feasibility of implementing SUDS in order to help the operation of the conventional drainage systems. To accomplish this, different combinations and distribution of SUDS (mainly green roofs and permeable pavements) were tested using case studies in two important Colombian cities. The hydraulic and hydrological modeling was developed using SWMM 5.1 and ArcGIS, including both actual and projected scenarios, incorporating the long-term effects of climate change within the latter.

**Thursday, December 6, 2018 | Water Resources IV**

**Development and Application of Reflectance-SSC models for the Middle-Mississippi River**

Amanda Cox Saint Louis University United States
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Suspended sediment plays a significant role in river systems. Sediment is constantly being transported and deposited, affecting the geomorphological and chemical characteristics that maintain river

navigability and ecological health. Methods for estimating suspended-sediment concentration (SSC) in fluvial systems have evolved over several decades from in-situ measurements to remote sensing techniques. The United States Geological Survey (USGS) has a limited number of stations that measure SSC within the Middle-Mississippi River (MMR) basin; however, they are located several miles apart and some have discontinued collection. Further, small tributaries that feed into the MMR have never been monitored. The objective of this study was to develop a model to estimate SSC using remote sensing surface reflectance. USGS field measurements were used with Landsat surface reflectance data to develop the regression equations. The Landsat project, a joint initiative between the USGS and NASA, provides freely available remote sensing data with appropriate spatial resolution for the MMR. Three reflectance-SSC regression equations were developed corresponding to Landsat 8 OLI/TIRS, Landsat 7 ETM+, and Landsat 4-5 TM. The reflectance-SSC models provide comprehensive spatial resolution using Landsat imagery, unlike the USGS stations which have higher temporal resolution. The developed equations were then applied to investigate SSC characteristics in the MMR basin. Applications included the observation of mixing at the Mississippi-Missouri River confluence, detection of high SSC areas along the MMR, and observation of increasing SSC moving downstream at different discharge conditions. Sediment rating curves were also developed for the four largest tributaries of the MMR: the Missouri, Meramec, Kaskaskia and Big Muddy Rivers.

**Thursday, December 6, 2018 | Water Resources II**

**DRINKING WATER REGULATION IN COLOMBIA**

David Celeita Universidad de los Andes Colombia	Manuel Serna Comisión de Regulación de Agua Potable y Saneamiento Básico Colombia
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Drinking water regulation in Colombia is divided amongst three different institutions; the responsible for tariff regulation is the Drinking Water and Sanitation Commission (Comisión de Regulación de Agua Potable y Saneamiento Básico – CRA, in Spanish). They are responsible for the economic regulation for the operation of drinking water systems, whether if they are public or privately owned, or whether if they are monopolies or not. This commission makes suggestions to the Vice Ministry of Water, a dependency of the Ministry of Housing (Ministerio de Vivienda, Ciudad y Territorio in Spanish), about regulatory aspects of the service. The third institution is the Superintendency of Domiciliary Public Utilities (Superintendencia de Servicios Públicos Domiciliarios, in Spanish), who is responsible of surveillance and control of water utilities, and thus, for the enforcement of CRA’s regulations.

For tariff regulation, water utilities are classified in two groups according to the number of users they serve: large utilities are those with more than 5000 subscribers, and small providers are those with less than 5000 subscribers. Because of this distinction, there are different technical and service standards for each provider category. This article focuses on large providers, which are regulated by CRA Resolutions 688/2014 and 735/2015. These resolutions state how drinking water and wastewater utilities must assess the tariff. This tariff is assessed in terms of the amount of water they produce, the volume of lost water, administrative and operational costs, user’s growth, future investment costs (e.g. expansion, rehabilitation or reposition costs) and environmental costs (in terms of fees for the use of water, or pay rates for water final disposal).

Before 2014, Colombian water utilities were regulated by a different tariff scheme, where lost water

was measured in terms of the Unaccounted for Water index. However, this methodology had several problems, as it was not a technical index, but a financial index. This index was not comparable between different water utilities, and it did not allowed to assess the impacts of leakage reduction programs defined by water utilities. For this reason, the methodology to measure lost water was changed to a different one based in the volume of lost water, normalized by the number of billed users. This article describes, analyzes and criticizes several aspects of this new scheme for leakage regulation, which is important for tariff definition.

**Friday, December 7, 2018 | Solid Waste Management**

**Dyes adsorption in water from charcoal (biochar)**

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Santiago Builes Universidad EAFIT Colombia	Juan F. Saldarriaga Universidad de los Andes Colombia	

The textile industry produces high quantities of water with the presence of dyes in their processes, these are discharged into water bodies receivers, affecting the ecological balance of aquatic ecosystems, by the decrease in the water oxygenation, as an alternative to this problem, the adsorption of the biochar obtained from the biomass combustion from olive stone, pine sawdust, rice husks and rumex was studied. The biochars were used to adsorb the methylene blue dye in synthetic waters, the characterization of the material was carried out by SEM, pH<sub>pzc</sub>, BET, Infrared-Spectroscopy and the ash percentage was determined. The experiments were developed at 30°C, constant agitation and with dye concentration of 20 to 60 mg/L, the final concentration of the dye was obtained in the UVVis spectrophotometer. The Langmuir isotherms were adjusted to relate the physical characteristics of the biochar with the dye removal capacity. The biochar that obtained the best results was the olive stone with a BET surface area of 157.2m<sup>2</sup>/g, an ash content of 24.4% and a fibrous morphology that favored the. Followed by removal capacity by the rumex biochar with properties similar to that of olive stone such as the low ash content of 39.0% and the similarity of functional groups, then that of rice husk with the smallest area of 1.1m<sup>2</sup>/g and 84.9% ash and finally sawdust pine with an area of 3.4m<sup>2</sup>/g, but with a high ash content of 95.5%, which decrease the adsorption of the dye. It is concluded that the optimal dose of biochar is 0.1g, which allows the greatest use of biochar.

**Friday, December 7, 2018 | Water Supply and Sanitation II**

**EFFECT OF DIFFERENT CLUSTERING SCENARIOS ON DEMAND AND PRESSURE UNIFORMITY**

F. Javier Martínez-Solano Universidad Politécnica de Valencia Spain	Pedro L. Iglesias-Rey Universidad Politécnica de Valencia Spain	Andrés Olmedo Abril-Orellana Universidad Politécnica de Valencia Spain
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Efficiency of water distribution networks is an increasingly important matter. Efficiency accounts for both energy and water resources, and water saving has become a main objective of the utilities.

Clustering the network in district metering areas (DMA) has shown its usefulness in controlling water losses. For that reason, in the last edition of the WDSA held in Cartagena (Colombia) in 2016, the Scientific Committee proposed the Battle of Water Networks District Metering Areas (BWNDMA). The aim of the contest consisted on produce a segmentation of the network so that the demand was equally distributed among the clusters (DMAs) and the pressure was as uniform as possible inside them. Some of the participants chose a solution with a small number of clusters, prioritizing economic aspects. Some other groups preferred to define more clusters to ensure a more uniform distribution of demands and pressure. All of them found that one of the problems in this contest was derived of its troubled orography. Furthermore, the restrictions related to water resources availability reduce the solution space. With these conditions, engineering judgment took advantage with respect to automatic clustering. In this paper, a comparison of both strategies is made. The methodology presented selects the methodology depending on the hydraulic characteristics of the network. That is, the selection of the clustering method is based on the hydraulic complexity of the network. So, in the areas where the differences in elevation is not very high, an automatic graph partitioning algorithm based on METIS will be used. On the contrary, where the terrain is steep, or the network layout is rigid, engineering judgment needs to be applied to find segmentation solutions that accomplish the different constraints. Both methods are then compared using different parameters, such as the demand similarity among clusters, pressure uniformity inside them or capacity to accomplish with pressure limits. This methodology is applied to the southern part of the E Town network. Engineering judgment will use hydraulic relations to choose the geometry of the clusters and the most suitable places to close pipes or install valves and flowmeter. On the other hand, a graph partitioning algorithm will be used in the places where the hydraulic restrictions are no so severe. As a result, the relation between the number of clusters and the different criteria is obtained. This relation might be used as a decision support tool for the utilities in cases where the problem is highly constraint.

**Thursday, December 6, 2018 | Waterborne Pathogens and Disease**

**Enterococci project in the Fúquene Lagoou**

Bryam Sánchez Escobar Escuela Colombiana de Ingeniería Colombia	Gladys González Leal Escuela Colombiana de Ingeniería Colombia
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This project was made in the Colombian Engineering College "Julio Garavito", advised by the microbiologist Gladys Gonzáles.

The topic is about the detection of enterococci in the Fúquene Lagoon in Colombia and looking its environmental impacts.

**Wednesday, December 5, 2018 | Pollutants**

**Environmental conditions for the ochre formation in geotextile filters**

Luiza Gabriela Cruz dos Santos Correia COPPE, Federal University of Rio de Janeiro Brazil	Maurício Ehrlich COPPE, Federal University of Rio de Janeiro Brazil	Marcos Barreto de Mendonca POLI, Federal University of Rio de Janeiro Brazil
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Clogging by ochre may be considered a major threat in the performance of filters and drain-age systems. The environmental conditions including the chemo-microbiological aspects involved for the ochre formation and clogging of geotextile filters used in drainage systems are discussed. Column tests are being carried on using samples of geotextiles as filters with the inoculation of iron bacteria under three different filter submersion conditions. The concentration of dissolved oxygen, pH, and iron retention rate are being monitored during the column tests. Biofilm formation on the geotextile filters is being evaluated through the analysis of EDS (Energy Dispersive X-ray detector) and scanning electron microscopy.

**Thursday, December 6, 2018 | Water Resources IV**

**EVALUATION OF THE "CARBON FOOTPRINT" (OF DIFFERENT FLUVIAL STRUCTURES)**

Gerardo Fracassi Maccaferri do Brasil Ltda. Brazil	Carlos Enrique Moreno Martinez Maccaferri de Colombia Ltda. Colombia
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The following summary shows us the comparison that was made of CO2 emissions to the environment through the construction of a wall in a gravity in gabions and a concrete wall. Measuring the emissions generated repectively.

**Friday, December 7, 2018 | Modeling**

**Fairfield Marine Terminal Hydraulic Modeling and Infrastructure Planning**

Francisco Rivera Whiney Bailey Cox Magnani United States
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Fairfield Marine Terminal (FMT) is a specialized terminal for handling and processing Ro/Ro cargo for the Maryland Department of Transportation Maryland Port Administration (MDOT MPA). Providing sustainable infrastructure development for the Terminal is critical to the economic growth of the Administration and the state of Maryland. Both hydraulic engineering and stormwater management represent major components during design and planning for the continuous terminal expansion. Most of the terminal is developed from land reclamation areas developed from the dredged material collected during navigational channel maintenance. Other portions of the Marine Terminal are developed on historic stormwater infrastructure that requires continuous maintenance, retrofitting or replacement for

all proposed development. The Administration has developed a comprehensive hydraulic model to explore the most cost-effective capital investment for the terminal. The hydrodynamic model analysis storm runoff of approximately 100 acres of the 150-acre terminal using Interconnected Channel and Pond Routing (ICPR) Modeling Software to map the tidal and flooding of the terminal for existing conditions. The model includes storm detention ponds, water quality treatment BMPs, swales and underground pipe systems discharging into the Chesapeake Bay. After the critical surcharging elements and future development of the terminal is integrated into the model, the design team provides observations and recommendations to the administration for infrastructure improvements during terminal expansion; while fulfilling tenant needs and strict environmental regulations.

**Friday, December 7, 2018 | Water Supply and Sanitation II**

**Fate of Minjur, Duranallur - Panjetty And Tamaraiakkam Aquifer For North East Water Supply of Chennai Metro**

Ramachandiran Raja Shri Sitheswarar Engineering College India	Sathish Kumar Aon Consulting Private Ltd India
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Abstract All available water resources are from a practical viewpoint, fully utilized in Madras City. There is insufficient additional groundwater to meet the increasing demands of the city of Madras and within the immediate area of the city there is no suitable source of groundwater. The only possible exploitable aquifer formation is available at Minjur, Duranallur - Panjetty and Tamaraiakkam areas, northwest of the city, it should be possible to extract about 125 thousand cubic meters (Tm<sup>3</sup>) (27.5 mgd.) from the Quaternary alluvium during years of normal rainfall. The overdraft of the aquifer formation was identified in addition to pumping by Chennai metro private bore wells, water pumped for irrigation purposes and industrial requirement. Integrating the exploitable amount of groundwater and recharge of the aquifer against the pumping it can observe that the possibility of long-term overdraft and intrusion of sea water can be observed. A suggestion can be recommended that the aquifer can be further recharged by routing storm water into the aquifer formation.

**Friday, December 7, 2018 | Fluvial Structures**

**FINAL REALIGNMENT SAN ANTONIO RIVER, DESIGN. STRUCTURES ON THE RIVER BED AND BANKS**

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Frank Velasco Ávila Escuela Colombiana de Ingeniería Julio Garavito Colombia	Andrés Humberto Otálora Carmona Escuela Colombiana de Ingeniería Julio Garavito Colombia	Romeo Lenin Ramos Quintero Drummond Ltd. Colombia Colombia

In all open-pit mining activities show different alterations of the natural conditions of the system intervened, therefore, it is necessary to implement mitigation plans for the preserving the environment

and the dynamics of rivers. In particular, The Drummond Ltd. company developing a mining operation in the south of the department of Cesar. The San Antonio river is a natural stream that runs through the exploitation area. It is necessary study, define and design the realignment of a section of the stream to give continuity to the drainage system and as part of the environmental management plan proposed by Drummond Ltd. company. These activities had been designed to preserve the morphological, hydrological, hydrographic and geometric characteristics of the natural stream and the realignment the San Antonio river. Its meandriform conception allows to keep up the natural conditions of the stream maintain the fluvial processes. The studies, designs and works on the bed and banks of the new realignment channel allowing its stability in the time.

**Wednesday, December 5, 2018 | Modeling and GIS**

**Flood Discharge Estimation by Synthetic Methods**

Halil Ibrahim Burgan Istanbul Technical University Turkey	Hafzullah Aksoy Istanbul Technical University Turkey
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Floods affect humanlife through ecological, financial and social factors. Therefore, it is quite important to observe and record flood discharges when possible. In case no measurements are available, flood discharges can be estimated by synthetic methods for any given return period. There are however, some limitations of synthetic methods considered. Well known methods are Snyder, Synthetic SCS, and Mockus among many others are widely used to estimate flood hydrograph. Also, the rational method can be used to estimate the flood discharge in drainage areas smaller than 1 km<sup>2</sup>. For derivation of a synthetic hydrograph, the drainage area, hydrograph rising time and concentration time of the basin are needed. In this study, Tacin River, a sub-basin in Seyhan River Basin, southern Anatolia, Turkey, is selected as study area. Seyhan Basin is of great agricultural importance for the country. The sub-basin has 9.9 km<sup>2</sup> drainage area. An observation longer than 50 years is available. The Mockus method is selected as the synthetic method because of its suitability to watersheds at the range of 1-10 km<sup>2</sup>-drainage area. Geographic Information Systems (GIS) tools are widely used in hydrological modeling studies due to the fact that estimation of extreme events linked to morphology is not an easy task. Morphological characteristics are calculated in the Mockus method using the new Multi-Error-Removed Improved-Terrain (MERIT) DEM data which are more accurately developed from the Shuttle Radar Topography Mission (SRTM). The calculated and observed flood discharges are compared. It is expected that such a study will guide hydrological studies in Seyhan Basin.

**Friday, December 7, 2018 | Solid Waste Management**

**Fly ash reactivity of waste in lime pastes in order to reduce its environmental impact**

Jorge Gene Universidad de los Andes Colombia	Ximena Gaviria Universidad de Medellín Colombia	Juan Fernando Saldarriaga Universidad de los Andes Colombia
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The annual global production of fly ash is estimated at about 780 million tons per year and has been used successfully in the cement industry for more than 50 years, mainly as a mineral additive in Portland cement concrete and also as a component of mixed cement. In this work, the ash reactivity from

hazardous waste, bituminous coal and sugarcane as supplementary cement material was evaluated. For this, the ashes reactivity in lime pastes was analyzed, centered on thermogravimetric tests as a characterization technique to determine the phases present. Part of the ashes of hazardous waste was pretreated, in order to eliminate chlorides and sulfates from the incineration process. The ashes were characterized by means of DRX and FRX, finding low content of SiO<sub>2</sub> and Al<sub>2</sub>O<sub>3</sub> in the ashes of hazardous residues, while in the coal and sugarcane high contents were found. The pastes were prepared according to the ASTM C-305 standard, using a water/lime ratio of 0.4. The hydration process was stopped with acetone at the ages of 1, 3, 7, 14, 28 and 56 days. It can be concluded that only mixtures of sugarcane ash and untreated hazardous waste ash are more attractive to be used as replacements in the production of construction inputs. In spite of this, it must be taken into account that untreated hazardous waste ash comes from incineration processes of hazardous waste, so it is advisable that when a replacement is made, metal leaching analyzes are carried out in order to avoid negative environmental impacts.

**Friday, December 7, 2018 | Water Resources V**

**Geographic distribution of ecosystem functions and services in territorial management of urban municipalities. Case study: La Presidenta Watershed (Medellin, Colombia)**

JC Valdés Colombian Polytechnic Jaime Isaza Cadavid Colombia	JF Escobar University of Antioquia Colombia	JC Parra Colombian Polytechnic Jaime Isaza Cadavid Colombia
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Current trends in the processes associated with territorial management show specific needs aimed at strengthening the decision-making oriented to development and investments in regions and localities. One of the main drawbacks is the lack of models that allow the characterization and mapping of ecosystem functions and services that can be implemented in the scope of land management and planning processes. In this work, a model of ecosystem service stability of hillsides in a hydrographic basin of Medellin City, Colombia, was carried out, trying to determine the geographically distributed behavior of the associated ecosystem functions and the mapping of the flow of the aforementioned service. Erosion control, morphodynamic activity and surface water runoff were considered as relevant ecosystem functions. One of the most important results of the project consisted of a software application development that allow the decision makers to carry out such modeling in a practical and efficient way.

**Friday, December 7, 2018 | Water Reuse-SUDS**

**GREEN INFRASTRUCTURE TO ALLEVIATE WATERLOGGING IN DHAKA, BANGLADESH**

SUFIAN KHONDKER ARCADIS of New York, Inc. United States
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GREEN INFRASTRUCTURE TO ALLEVIATE WATERLOGGING IN DHAKA BANGLADESH By Sufian A. Khondker, Ph.D., PE, D.WRE, F. ASCE1 ABSTRACT Dhaka was first established as a trading center in 1604. The drainage system, consisting of about 300 canals, was one of the best. The canals would collect the

surface runoff resulting from monsoon rain in the months of June through September and convey the waters to the surrounding three rivers: Turag; Balu and Buriganga. The waterlogging was never a problem. Bangladesh became an independent country in 1971 with Dhaka as the capital. Over the next 47 years, Dhaka became a mega city with a population of 12 million. The infrastructure consisting of roads and bridges; storm sewer system; drainage canals and above all the housing could not keep up with rapid population growth. People started to grab the canal areas filled them up and built housings and industries, thereby destroying the center piece of the drainage system. Now, even a small rainfall causes unprecedented waterlogging. The water depths in some areas reach as much as 400mm and take over 16 hours to recede. The transportation system becomes completely interrupted resulted in huge economic loss together with large damages of property. Design and implementation of green infrastructure offer a cost effective, innovative solution to alleviate the waterlogging of Dhaka City like that of the New York City. In New York, Department of Environmental Protection (DEP) embarked on an ambitious program to design and build about 7,000 Right-of-Way Bioswales (ROWBs) on the sidewalks of the City streets to capture at least 25 mm of initial rainfall. A typical ROWB has curb cuts (inlets and outlets) to divert surface runoffs from the street into the ROWB before it enters into the sewer system; stores the runoff and then infiltrates into the broken stone layers and surrounding subsoil strata. The paper discusses the use of ROWBs on the sidewalks of Dhaka City to alleviate the waterlogging problem.

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**Wednesday, December 5, 2018 | Coffee Break & Posters**

**HISTERESE INDEX APPLIED IN A TROPICAL SEMIARID HYDROGRAPHIC BASIN**

Matheus Magalhães Silva Moura Federal University of Ceará – UFC Brazil	Helba Araújo de Queiroz Palácio Federal Institute of Education, Science and Technology of Ceará, Brazil – IFCE Brazil	Marcos Makeison Moreira Sousa Federal University of Ceará – UFC Brazil
José Bandeira Brasil Federal University of Ceará – UFC Brazil	Diego Pereira Araujo Federal Institute of Education, Science and Technology of Ceará Brazil	

Monitoring of suspended sediment concentrations (SSC) is essential to determine the state of erosion of a river basin. This information can be obtained by analyzing hysteresis patterns in the concentration-discharge relationship of suspended sediments (SS). Therefore, the objective was to quantitatively analyze the SS dynamics in a basin in the Tropical Semiarid. The Iguatu Experimental Basin (BEI) (16.74 km<sup>2</sup>) is located in the state of Ceará, Brazil. The climate of the region is of the semiarid hot type. Flow data (Q) and CSS were collected during the years 2014 to 2017. For analysis, a non-dimensional index (IH) was applied, which quantifies the magnitude and direction of the hysteresis in the relation of three types of loops: clockwise (H), counterclockwise (AH) and figure eight (8). Among the 15 events, minimal IH (-35.10), maximum IH (0.69) and mean HI (-1.22) were observed, indicating that the predominant EI process is AH. Result of SS delivery from distant river sources during the descending member of the hydrograph, and the effect of soil erosion on the EIB slopes. The IH helped to quantify very simply, directly and intuitively the magnitude and direction of hysteresis.

## HYDRODYNAMIC CHARACTERIZATION OF CELMM THROUGH THE IPH-ECO MODEL ZONING THE SURURU

Luiza Gabriela Cruz dos Santos Correia Universidade Federal de Alagoas (UFAL) Brazil	Carlos Ruberto Fragoso Jr. Universidade Federal de Alagoas Brazil	Josiane de Brito Gomes IFMT Brazil
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The estuaries are historically and contemporaneously important for all human activity surrounding them. It can be confirmed by the fact that two-thirds of the large cities of the world are located in estuaries. In several countries, estuaries are attractive for the installation of ports, fisheries and tourism due to its high productivity and capacity for renewal of water. The Mundaú Manguaba Estuarine-Lagoon Complex (CELMM), located in Alagoas, is habitat of a mussel (*Mytella Charruana*), typical specie of the region and source of food and income for thousands of families who lives around the lagoons. Its occurrence is directly influenced by the hydrodynamic patterns and concentration of salinity in the estuary. This study aimed to characterize the hydrodynamics of CELMM using the hydrodynamic module of the IPH-ECO model for unstructured grids. In the CELMM domain discretization was used an unstructured grid composed only for triangles. The finite volume method was applied to solve the system of equations composed for momentum and continuity equations. For the calibration of the model were used bathymetry data from Instituto Nacional de Pesquisas Hidroviárias. The scope of work is to present a systematic understanding over water motion on Mundaú and Manguaba lagoons. The characterization of the hydrodynamics of CELMM plays an important role to assist in studies on the possible occurrence of the behavior and mussels, as well as the implementation of measures for the sustainable use of resources offered by the estuarine complex.

Thursday, December 6, 2018 | Water Resources III

## HYDROLOGICAL BALANCE FOR FILLING THE PITS, TRANSFORMATION DAILY RAINFALL TO DAILY FLOW RATE FOR THE BASINS THAT DRAIN TO THE PITS. MODEL GR4J AND MODEL HEC-HMS

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William Ricardo Aguilar Piña Escuela Colombiana de Ingeniería Julio Garavito Colombia	Romeo Lenin Ramos Quintero Drummond Ltd. Colombia Colombia

This paper presents a conceptual model, calculations, results, conclusions and recommendations for different pit filling scenarios, model used particularly in the mining project “La Loma”, located in the department of Cesar and operated by Drummond Ltd. The goal of pit filling is to restore the natural state of the area and mitigate the effects on the biosphere. It was necessary to evaluate the daily hydrological balance in the basins that discharge to the pit in the northern and southern areas. The estimation of daily runoff flows was made using GR4J rain runoff model, methodology developed in France, and the integrated model of the successive of tanks of the Hec-Hms software. The topographic limit of the contributing watersheds to the system was defined based on the anthropic state, taking into account the mining exploitation.

**Wednesday, December 5, 2018 | Coffee Break & Posters**

**Hydrosedimentological impacts due to modification of the vegetation cover in a catchment in the tropical semiarid**

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Eunice Maia Andrade Federal University of Ceará – UFC Brazil	Conceição Maria Albuquerque Alves University of Brasilia Brazil	Helba Araújo de Queiroz Palácio Federal Institute of Education, Science and Technology of Ceará Brazil

Indiscriminate deforestation for agricultural expansion, associated with successive fires, overgrazing and inadequate management of the soil has contributed considerably to the alteration of water flows and sediments in the Brazilian semiarid region. In this context, using as a tool the hydrosedimentological modeling, the objective was to evaluate the hydrosedimentological impacts caused by possible changes of the vegetation cover in a semiarid catchment. The catchment has an area of 0.03 km<sup>2</sup>, average altitude 217.8 m, average rainfall 880.1 mm year<sup>-1</sup> and average potential evaporation 1,988.0 mm.year<sup>-1</sup>. The vegetation was deforested, burned and planted with grass (*Andropogongayanus*, Kunt). The hydrosedimentological modeling was performed through the SWAT model (Soil and Water Assessment Tool). It was considered the replacement of pasture by thinned Dry Tropical Forest - DTF, regionally denominated as thinned “Caatinga” and by agriculture. It has been found that grazing replacement by thinned DTF causes a reduction of up to three times in runoff and achieves a 36-fold decrease in sediment yield. The substitution by agriculture generates positive increments in the hydrosedimentological processes in the catchment in the order of 50% and 291% in the surface runoff and sediment production, respectively. These scenarios highlight the importance of reforestation and rearrangement of vegetation cover in the control of erosion processes in the semiarid region.

**Wednesday, December 5, 2018 | Modeling and GIS**

**Identification of Hydrologically Sensitive Areas present in the Santa Maria-Torto sub-basin**

Dandara Jucá Kokay Mariano University of Brasilia Brazil
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The Hydrographic Unit (HU) called Santa Maria-Torto, located in Brasilia, Brazil, is of great importance for the region, given that it covers the Santa Maria reservoir, responsible for 25% of the region's water supply. Despite the utmost importance of the Brasilia National Park, some problems have already arisen. The methodology Hydrologically Sensitive Areas (HSA) was chosen to identify critical areas for preservation of water supply sources, as well as evaluate and prevent negative impacts on water quality. In order to perform this methodology, the ArcGIS tool was used. Initially, the land use was classified.

Then, the topographic index, composed of the moisture and the storage indexes, was calculated. Finally, using some thresholds, the HSA were identified. In this study, the HSA were considered a good environmental management tool for evaluating areas with potential runoff generation, which might help to reduce environmental liabilities.

**Wednesday, December 5, 2018 | Climate Change**

**Impacts of climate change on the hydrological regime in the Pamplonita river basin in Norte de Santander**

Darwin Mena Rentería Universidad Santo Tomás Colombia	Abel Solera Universidad Politécnica de valencia Colombia	Miguel Cañon Universidad Santo Tomás Colombia
Ana Maria Suarez Universidad Santo Tomás Colombia	Freddy Santiago Duarte Escuela Colombiana de Ingeniería "Julio Garavito" Colombia	

The results of the hydrological modeling carried out in the Pamplonita river basin are presented, in order to determine the potential impacts of climate change on its hydrological regime, implementing the Hydro-BID modeling tool. The variables of precipitation, temperature and flow assessed for current conditions and for different climate change scenarios were integrated. The future climatological series, from 2015 to 2100, were generated from the reduction of scale by applying a method based on chaos theory, based on the global circulation model CCMS4. The percentages of variation of flow of each one of the scenarios with respect to the current conditions were obtained, giving as a result that a decrease in the flow is expected between 7.61% and 12% for the RCP 2.6 scenario, between the 1.82% and the 10.28% for the RCP 4.5 scenario and between 6.83% and 13%.

**Wednesday, December 5, 2018 | Water Resources**

**Integrated Water Resources Management – A Return on Investment for Wake County’s Future**

Joseph Threadcraft Wake County Government United States
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This presentation provides an overview of Wake County’s investment into its water quantity and water quality future. This perspective is based on an evaluation of a return on investment of the County’s approach to establishing an Integrated Water Resources Management Strategy. A synonymous term for this strategy is the “One Water Concept.” The premise of this concept is that all water, regardless of its source is interconnected and should therefore be managed. The residents of Wake County obtain drinking water from various sources such as municipal water providers, community water systems, or private wells. N.C.G.S 143-355(l) requires that all units of local government and large community water systems prepare a Local Water Supply Plan. The planning window for this document is 50 years. County leadership established a Water Partnership Committee that is composed of community leaders. Its purpose is to advise the elected officials on matters related to water. Wake County is not required to

submit a 50-year plan; however, a strong influencer to develop such a document is population growth. The current population of approximately one million residents is expected to double within the next 40 years. Staff will prepare the scope of work for a Request for Proposals to retain a consultant that will advance the One Water Concept. A primary consideration will be an evaluation of groundwater capacity relative to other water sources. The results will be utilized to develop a dynamic strategy for a sustainable and resilient supply of water to meet the needs of a growing population for the next 50 years regardless of a resident's source of water.

**Wednesday, December 5, 2018 | Climate Change**

**Investigating Streamflow Trends in Canadian Rivers Using Bootstrap Resampling Technique**

MOHAMMED SHARIF Jamia Millia Islamia Central University India	Donald Burn University of Waterloo Canada
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Trends in four measures of streamflows at 129 hydrometric stations in Canada are investigated using a bootstrap resampling approach. The hydrometric stations considered in the present analysis include only stations that are free from the influences of regulation, diversion, or land use changes. A vital component of the present research is the investigation of streamflow behavior based on Peaks Over Threshold (POT) data. Two major issues in implementing a POT approach are: (i) determining an appropriate threshold, and (ii) ensuring the independence of flooding events above the chosen threshold. The present research addresses these issues comprehensively through application of a semi-automatic methodology for implementing a POT approach. Different measures of flood behaviour that have been analyzed for trends using bootstrap resampling approach include (i) duration of POT events, (ii) flow volume in POT events, (iii) annual sum of durations in POT events, and (iv) annual sum of volumes in POT events. Results from 129 stations clearly indicated a predominance of increasing trends on an annual basis, whereas the trends on event basis were generally decreasing. The number of statistically significant trends was greater than those expected to occur by chance for all the flow measures considered.

**Friday, December 7, 2018 | Groundwater**

**Laboratory channel 2D hydrodynamic modeling in non- permanent flow of the “Escuela Colombiana de Ingenieria” using ANSYS FLUENT**

Jorge Alejandro Mora Uscategui Student of the Escuela Colombiana de Ingeniería Julio Garavito Colombia	Germán Ricardo Santos Granados Escuela Colombiana de Ingeniería Julio Garavito Colombia	Antonio Arenas Amado The University of Iowa United States
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The work carried out deals with the modeling of computational fluid dynamics in permanent flow from a laboratory channel to a free surface with energy dissipation plus a corrective ramp of current lines, at the entrance. To create the domain mesh we used the tools of ANSYS Mesh-Workbench for 2D and ICEM CFD for 3D. The ANSYS FLUENT software was used to model the water-air interface with the fluid volume model (VOF) and the "Baseline (BSL) k-w" model for turbulent flow. The results were compared

and analyzed with measurements made in a physical model. Comparative modeling of water surface height, mechanical energy, flow symmetry, velocity magnitude distribution and static pressure was performed.

**Wednesday, December 5, 2018 | Water Resources**

**MANAGEMENT OF AGUAS DE MANIZALES**

Alejandro Estrada Aguas de Manizales Colombia
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This year, Aguas de Manizales S.A. E.S.P., received the Award for MEJOR ENTORNO AMBIENTAL of Andesco. Recognition that rewarded the effort of the Company in environmental matters with the with the implementation of initiatives that give continuity to the integrated management of the municipality's water heritage.

In environmental management, we work on the implementation of telemetry in the supply sources of the aqueduct system, to obtain information related to precipitation, flows and climatic variables in real time. Information that allows the organization to take timely actions and decisions focused on improving the efficiency and sustainability of the system.

In water and energy, in the NIZA Drinking Water Treatment Plant, we work on the generation of energy for self-consumption, clean, accessible and non-polluting. The Project of unconventional sources of renewable energies, which takes advantage of the existing infrastructure of the company, to give double use to drinking water and contribute to the reduction of polluting emissions.

And in the fight against deforestation, protection of biodiversity and climate change management, we participate directly as the constituent corporation of the CUENCA RÍO CHINCHINÁ -VivoCuenca CORPORATION, together with the Caldas Hydroelectric Plant, the Autonomous Regional Corporation of Caldas and the Metropolitan Company of cleanliness, to articulate strategies, policies and actions in the conservation and restoration of the strategic ecosystems of the region.

We are sure that preserving the natural heritage, water, as raw material of life, guarantees the quality of life of the residents of the city and the sustainability of the company.

**Friday, December 7, 2018 | Solid Waste Management**

**Management of sterile gold mining waste as construction aggregates**

Efrain Casadiego-Quintero Fundación Universitaria Agraria de Colombia Colombia	Andres Geovani Gutierrez Bayona Fundación Universitaria Agraria de Colombia Colombia	ELKIN CUBIDES Fundación Universitaria Agraria de Colombia Colombia
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Mining in Colombia produces a high content of sterile waste, the waste is made up of fragments of rock with no economic value for the company that exploits the mine. These residues end up being deposited in terraces that change the soil conditions, in slopes of little space, where the material can generate landslides or rock fall, and the most worrying is when the sediments extracted from the mines end up in the water sources, increasing the erosion of the bases of the drainages, in addition increasing the content of acids or minerals that can change the pH of the water or increasing the probability of contamination. To mitigate the environmental impact, it is proposed to generate a sustainable system for gold mining, where companies can propose a final disposal of waste sterile and improve the production process with innovation, seeking to reduce the use of pollutants and reduce as little as possible, sediment to the water sources complying with environmental regulations in Colombia. The following article will focus on the reuse of waste sterile mining, which serves as material for construction if it complies with the corresponding standards, are also an incentive for mining companies that may have another source of income selling slag. This type of study seeks to improve the system to dispose of waste and reuse the material. It is also an option to use high quality mechanical construction material in the rural sector or around the cities, with better characteristics than those exploited in the quarries, which overexploit the soil and damage the landscape, and in some cases the water sources.

**Friday, December 7, 2018 | Water Reuse-SUDS**

**METHODOLOGY FOR SELECTING RAINWATER RECYCLING SYSTEMS FOR SMALL SCALE RESIDENTIAL CONSTRUCTIONS**

Sergio Borda Fundación Universitaria Agraria de Colombia Colombia	Laura Bustos Fundación Universitaria Agraria de Colombia Colombia	Harold Chavez Fundación Universitaria Agraria de Colombia Colombia
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Methodologies for the selection of the more efficient rainwater recycling systems was proposed for small scale constructions in Colombia. Even though different policies in Colombia aim for the rainwater systems implementation, as well as several design guides and installation manuals are available, there is still uncertainty among engineers and policy makers. There is no record of any methodology to select a rainwater recycling system for small scale residential constructions. This study proposes a methodology based on key variables involved in the design of rainwater recycling systems such as structure’s architecture, hydrology and topography. Variables such as soil, and impermeable area of the roof were also considered. Selecting the most efficient rainwater recycling system was performed through a multi-criteria decision matrix, which assigns different weights to each identified variable. The methodology was verified by evaluating ten different scenarios, modifying rain data and constructive features. This study concludes that the application of multi-criteria matrix is effective in the selection of a suitable rainwater reuse system based on the results from the modeled scenarios, and represents a useful tool to facilitate decision-making processes for designers and administrative planning entities.

Thursday, December 6, 2018 | Water Supply and Sanitation

**Methodology for the development of projects to improve the water and energy efficiency of supply networks using a heuristic optimization model**

Pedro L. Iglesias-Rey Universitat Politècnica de València Spain	Jessica V. Lozano Cortés Universitat Politècnica de València Spain
F. Javier Martínez-Solano Universitat Politècnica de València Spain	Gonzalo López-Patiño Universitat Politècnica de València Spain

The important drought affecting Spain and the increasing increases in energy costs have generated, in recent years, an increase in projects to improve the water and energy efficiency of water distribution networks. This paper presents a methodology for the development of this type of projects based on a heuristic optimization model. The objective of the method is to select all the potential operations that can contribute to improve the water and energy efficiency of a water distribution network: improvement of the operation of the pumping groups, closing of pipes, rehabilitation of pipes, installation of reducing valves of pressure, etc. All these actions become variables to be optimized by the heuristic model. The methodology uses as a starting point a calibrated model model of the network in which the leakage flows existing in the system have been represented as consumption dependent on the pressure. Prior to the heuristic optimization the hydraulic model is simplified in order to reduce the necessary calculation times. From here, the optimized heuristic optimization algorithm determines the best combination of the decision variables. The objective is to find a balance between water and energy consumption. Finally, to validate the proposed methodology, the method applies to the case of the water supply network of L'Olleria (Valencia).

Thursday, December 6, 2018 | Water Supply and Sanitation

**Methodology for the selection of pumping stations considering its mode of operation**

Pedro L. Iglesias-Rey Universitat Politècnica de València Spain	Francisco A. Arango-Gil Universitat Politècnica de València Spain
F. Javier Martínez-Solano Universitat Politècnica de València Spain	Jassica V. Lozano Cortes Universitat Politècnica de València Spain

Classical projects of pumping stations are carried out taking as a starting point the maximum flow to supply and the necessary head. Based on these parameters, pumps are selected and pumping stations are designed. Subsequently, the most appropriate operation mode is established depending on the expected consumption and the energy requirements. This paper proposes an alternative methodology in which the selecting process of pumping groups includes the way in which the different pumps will operate. For this, it is necessary to estimate the operating expenses (OPEX) based on the study of the different operation modes of the pumps: fixed speed pumps (FSP) that can drive or stop, variable speed pumps (VSP) controlled by pressure and flow setpoints, or combinations of FSP and VSP. On the other hand it is also necessary to make an estimate of the investment costs or capital expenditures (CAPEX):

pumping equipment, hydraulic installations, measuring and control devices and electrical equipment and components. The proposed method is applied to several actual pumping stations of which water demands and pressure requirements are known. The result presents a Pareto diagram in which all the possible solutions and all the potential modes of regulation are illustrated.

**Thursday, December 6, 2018 | Climate Change II**

**METHODOLOGY OF LOCALIZATION OF STORM WATER TANKS IN SECTORS OF BOGOTÁ AND MEDELLÍN**

Gina Rincón Universidad de los Andes Colombia	Karen Bustos Universidad de los Andes Colombia	Laura Pulgarín Universidad de los Andes Colombia
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The urban centers are characterized by having a high percentage of impervious surfaces which leads to an increase in the volume and flow of runoff. This implies that there must be a drainage system capable of evacuating effectively the water in cities, to prevent floods and thus avoid economic losses and / or the spread of diseases. Traditionally, drainage systems are designed considering the importance of the areas to be drained and the damages that may be generated by the floods, considering the return period of the design rain and the lifespan of the system. However, the climate change will increase the amount of rain and the frequency of intense events, this implies that the drainage systems will reach their lifespan sooner than stipulated. Therefore, there are two solutions, the first one consists in making expansions of the system, which can be very expensive, and the second one is to use Sustainable Drainage Systems (SUDS). The implementation of SUDS is a more economical and innovative alternative than the solutions that are traditionally considered. So, in this study the use of storm water tanks was evaluated. Specifically, the location methodology was tested in sectors of Bogotá and Medellin using two programs known as OptSU and OptiTank, the first one has hydraulic control while the second doesn't.

**Friday, December 7, 2018 | Fluvial Structures**

**Mobile App for the Logistics and Management of Waste Electric and Electronic Equipment (WEEE)**

Luis Alejandro Turriago Romero Universidad EAN Colombia	Andrés Esteban Galindo González Universidad EAN Colombia	Nicolás David Valencia Reina Universidad EAN Colombia	Carlos Andrés Montoya Marentes Universidad EAN Colombia
Juan Steban Sánchez Ramírez Universidad EAN Colombia	Paula Fernanda Moreno Aconcha Universidad EAN Colombia	Andrés David Ochoa Moreno Universidad EAN Colombia	Alberto Uribe Jongbloed Universidad EAN Colombia

A solution is proposed to the problem of logistics for WEEE within the Colombian territory. For this, a methodology is presented, which is based on a mobile application that facilitates the process of collection, storage and final treatment, involving the relationship between the producer, user and manager, to have control and monitoring, in real time, of the WEEE to be managed. All these studies were developed taking into account the law 1672 of 2013, Colombian regulations established for the

integral management plan, in addition to the European Directive 2012/19, Annex II, for the classification of Electrical and Electronic Residues.

**MODELING HYDRAULIC STRUCTURES WITH COMPUTATIONAL FLUID DYNAMICS**

Cesar Garces Universidad Javeriana Colombia	Heber Alejandro Escobar Pineda INTEGRAL S.A. Colombia
Juliana Andrea Alzate Gómez INTEGRAL S.A. Colombia	Jorge Alberto Escobar Vargas Universidad Javeriana Colombia

Generally, design of hydraulics structures consists of empirical assumptions and physical model experiments. In most cases are derived from empirical studies. Sometimes the physical model can be expensive in time and cost, even some cases physical modelling can be useless, because measurements of the scale relationships are too difficult or not feasible (turbulence phenomena). However, with the developing in computer technology and numerical solutions methods, appear Computational Fluid Dynamics (CFD) as the tools that allow the description of many cases of study, with better resolutions and better scale relationships. In this case is presented a methodology using OPENFOAM, it is a CFD open source code, is a powerful tool that is capable of representing many scenarios, which allows to complement physical model. The objective was to validation stilling basin designed with CFD modeling, and comparison with physical model The CFD models, showed that are able to represent properly hydraulic structure, more than physical models and theoretical approaches. So could be a better tool to validate and optimise the design and help with making a decision and reduce uncertainty.

**Thursday, December 6, 2018 | Water Quality**

**Monitoring of Improvements to Rural Water System Disinfection in Ecuador**

Robert Hoeksema Calvin College United States	Bruce Rydbeck Life Giving Water International Ecuador	Sarah Bradley Life Giving Water International Ecuador
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Rural Ecuadorian communities rarely disinfect their water supply despite government requirements, due to the use of difficult chlorination methods which do not adequately control the chlorine dose. In response, Life Giving Water International together with Calvin College Clean Water Institute, is installing and monitoring precision chlorine dosing systems in Chimborazo Province to determine whether issues of chlorine concentration variability and low public acceptance can be successfully resolved. A mathematical computer model was constructed for several water systems to predict chlorine levels and the model checked against actual field measurements. This paper summarizes learning in the areas of public taste response, management of the chlorine feed solution, chlorine degradation modeling for rural water systems, training, appropriate chlorination equipment for rural communities, and public response.

Thursday, December 6, 2018 | Water Quality

**Monitoring Seasonal Variations in Disinfection Performance In A Wastewater Stabilization Pond With Algal Blooms and pH Fluctuations**

Shuang Liang Queen's University Canada	Lei Liu Queen's University Canada
Geof Hall Queen's University Canada	Pascale Champagne Queen's University Canada

In 2012, Environment Canada updated the Wastewater System Effluent Regulations in an effort to reduce the 150 billion litres of untreated wastewater being discharged into Canadian waters annually. The revised regulations will result in the commissioning of over \$20 billion in wastewater infrastructure upgrades for municipalities. Many small, rural and remote municipalities use passive wastewater treatment systems, such as wastewater stabilization ponds (WSPs), as sustainable alternatives to conventional wastewater treatment due to their ease of operation, minimal energy input and low costs (Al-Hashimi and Hussain, 2013; Steinmann et al., 2003). WSPs can effectively attenuate nutrient loads while also providing environmental conditions suitable for the removal of pathogens through naturally occurring biological, chemical and physical treatment mechanisms (Crites & Tchobanoglous, 1998; Jiménez, 2007; Maynard et al., 1999). However, since WSPs are open systems, they are susceptible to variations in external conditions. In particular, they are conducive to algal blooms and high pH events during the summer seasons, with warmer temperatures and higher hydraulic retention times. Water chemistry and climatic parameters were collected from a WSP system in eastern Ontario, with excessive algal growth and pH fluctuations, over a 12-month period. Four organisms, *E. coli*, Enterococci, *C. perfringens* and Enterococci, were selected as biological indicators to assess the disinfection performance of the pond. The removal efficiency of various water quality parameters and indicator organisms for each season were used to determine seasonal treatment and disinfection performance of the system. As anticipated, removal rates of orthophosphate, total phosphorous, ammonium, nitrate, total nitrate and COD were higher during the warm season than during the cold season. For all the indicator organisms, both the influent and effluent concentrations were higher during the cold season compared to the warm season. Multivariate statistical analysis, specifically principal components analysis (PCA), was used to determine significant water quality parameters influencing the treatment performance of the pond during the warm and cold seasons. The analyses showed strong positive correlations between chlorophyll and water temperature, pH, and DO, and strong negative correlations between water temperature and *E. coli*, Enterococci, and *C. perfringens*. However, no strong correlations were noted between nutrient parameters and bacterial indicators. PCA also revealed that temperature and pH were the most critical parameters involved in the treatment performance of the site. Low cost and effective wastewater treatment options, such as WSPs, are especially important for resource-limited rural and Indigenous communities. This research will be used directly in a the establishment of a monitoring program for the wastewater treatment system at the site and contributes to the continued improvement of WSPs design and performance. The multivariate statistical methodologies presented in this research offer an insightful approach in the monitoring of water treatment systems where large datasets are generated and the extraction of key parameters and their relationships is critical in informing system design and operation.

## Thursday, December 6, 2018 | Water Supply Infrastructure

### Multi-Criteria Decision Analysis Methodology for the Selection of New Water Supply Infrastructure

Henry Amorochó Universidad de los Andes Colombia	Sergio Cabrales Universidad de los Andes Colombia	Juan Saldarriaga Universidad de los Andes Colombia
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Reliable and safe access to drinking water is a necessary condition to ensure economic and social sustainable development of human communities. Some times this safe access can create conflicts between interstate communities and other users as national parks, indigenous communities, and other users. Additionally, Climate Change can impose restrictions to one or several water sources. This task requires a Multi-Criteria Decision Analysis (MCDA) methodology to select alternatives for new water supply infrastructure. These alternatives are strategic decisions that represent significant amount of financial resources and are made for a long lifespan. In order to support the decision-making in the context of building new water supply infrastructure, this research develops an MCDA methodology that integrates a hierarchy of non-economic benefits and the expected costs into a global index. Our methodology was implemented in the city of Santa Marta, Colombia. This city is currently facing a 60% drinking water shortage and urgently needs to expand its capacity to meet the increasing water demand. Our results were validated with a previous Multi Attribute Utility Theory (MAUT) model developed for the same problem. The results of this research support the implementation of the best alternative for tackling Santa Marta's water supply problem by taking stakeholders' preferences into account.

## Thursday, December 6, 2018 | Water Quality

### MULTI-TEMPORAL ANALYSIS OF THE WATER QUALITY OF THE CARIBBEAN SEA IN THE INFLUENCE AREA OF THE SUBMARINE OUTFALL OF CARTAGENA DE INDIAS (COLOMBIA)

Raquel Godoy Villegas University of Cartagena Colombia	Luz Arango Méndez University of Cartagena Colombia	Mónica Eljaiek Urzola University of Cartagena Colombia
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The objective of this research was to analyze the variation of water quality in Punta Canoas, in the zone of influence of the submarine outfall of Cartagena de Indias. For the study, historical data (2013-2018) of physical, chemical and biological parameters measured by Aguas de Cartagena S.A E.S.P were used. To determine the variation in water quality, the parameters for each season from 2013 to 2017 were evaluated, using the INVEMAR Marine Water Quality Index for the preservation of flora and fauna (ICAMPFF). The results were on a water quality scale between "acceptable and adequate" in the period from 2013 to 2016, while in the dry season of 2017 there was an affectation of the index due to the high concentration of Total Coliforms at the point of discharge (near field). The study also contemplated the comparison of the parameters measured in the discharge with the permissible limits, as well as the water quality criteria for recreational use with primary and secondary contact in comparison with the maximum admissible values established in the current legislation in Colombia. The results of the study show that the sea in the Punta Canoas area has self-purification capacity to eliminate contaminants that are currently discharged. For the most part, the parameters evaluated comply with the limits established for the recreational use of primary contact.

**Thursday, December 6, 2018 | Water Resources IV**

**NEW CONCEPT OF DURABILITY AND DESIGN FOR THE GABIONS STRUCTURES**

Gerardo Fracassi Maccaferri do Brasil Ltda. Brazil	Carlos Enrique Moreno Martinez Maccaferri de Colombia Ltda. Colombia
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The following summary of a small sample of the walls in gabions and their durability. The relationship that the world has with the structures in containment and how it intervenes in its development for infrastructure.

**Thursday, December 6, 2018 | Water Resources III**

**Proposal of a new water index for automatic coastline detection in a Mediterranean Delta**

Sandra Viaña Borja Universidad de Granada Spain
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Coastline detection is a complex task since it is necessary to have enough accurate information along a given period of time to better understand the coastline changes that occurred and the drivers involved in those changes. The methods that have been used the most up to now to map the coastline are (1) field surveys and (2) aerial photographs; however, in recent years remote sensing began to be widely used due to the cost, improvements in data processing time and the complementary information that can be extracted from the images along extended periods of time.

Landsat project is the longest and continuously acquired dataset of moderate resolution remote sensing images. Many researchers have been using Landsat images to extract coastline through remote sensing techniques such as segmentation, single band thresholding and spectral water index, among others. In order to take advantage of the bunch of information given by the Landsat images since 1972, it is necessary to develop automatic methods to analyze the largest quantity of images available.

This study proposes a new spectral water index in order to automatically extract the coastline from different dates. This index has been developed for the Guadalfeo River Delta (Southern Spain), although it can be applied to other sites. This new index was compared to NDWI, MNDWI and AWEI, three spectral water index widely used and accepted in the literature for coastline extraction.

The results showed a relevant improvement in RMSE calculated between coastline extracted by water index and coastline obtained by DGPS field surveys. The automatic process also allows a multitemporal analysis along 30 years of the Delta of Guadalfeo River. Detailed results will be shown at the Conference.

**Wednesday, December 5, 2018 | Pollutants**

**Proposal of management policies for contaminated sites - Case Study: Santa Elena Lot in Cartagena, Colombia**

Carolina V. Boaglio Toniolo Facultad de Ciencias Exactas, Físicas y Naturales - Universidad Nacional de Córdoba Argentina	Alberto Uribe-Jongbloed Facultad de Ingeniería - Universidad EAN Colombia
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The process followed in the development of the environmental assessments and remedial procedures of the Santa Elena site in Cartagena, Colombia have been taken as a case study for the proposal of a management procedure for contaminated sites that can be implemented in the country. The study takes into consideration the actions taken at the site, regulatory restrictions and is justified in the lack of specific regulation regarding the management of contaminated sites. The proposed procedure gives a step-by-step, standardized approach to the management of such sites.

**Thursday, December 6, 2018 | Water Quality**

**REMEDIATION OF CONTAMINATED WATERS WITH LEAD USING ACTIVATED CARBON FROM TOBACCO SEIZED IN BRAZILIAN BORDER REGIONS**

Jéssica Manfrin State University of West Paraná Brazil	Affonso Celso Gonçalves Jr. State University of West Paraná Brazil	Daniel Schwantes Federal University of Paraná Brazil	Gabriel José Klassen State University of West Paraná Brazil
Élio Conradi Junior State University of West Paraná Brazil	Juliano Zimmermann State University of West Paraná Brazil	Ariane Bazzo Santorum State University of West Paraná Brazil	Andréia da Paz Schiller State University of West Paraná Brazil

Currently, one of the major concerns in the world is the quality of water given its importance in the most diverse human needs and activities. This work aimed to develop adsorbent materials from tobacco to remediate Pb<sup>2+</sup> from contaminated water. Three materials were used: tobacco in natura and two chemically activated carbons (CT NaOH and CT ZnCl<sub>2</sub>). The adsorbents studied were characterized by chemical composition, zero charge point (pHPZC), infrared spectra (FT-IR), scanning electron microscopy (SEM), and porosimetry of BET and BJH. Studies were also conducted to evaluate the relationship between pH and adsorbent masses and equilibrium studies with the objective of evaluating the adsorption capacity of the different materials. The mathematical models of Langmuir, Freundlich and Dubinin-Radushkevich were used in the results. The results showed that the lower adsorbent masses (0.200 mg) present higher efficiency of Pb<sup>2+</sup> removal from the aqueous solution. The models of Langmuir and Freundlich presented excellent adjustments, suggesting the occurrence of adsorption in mono and multilayer. The highest adsorption rate was found for the adsorbent CT ZnCl<sub>2</sub> (Q<sub>m</sub> = 84.7458 mg g<sup>-1</sup> and K<sub>f</sub> = 7.1598 mg g<sup>-1</sup>), presenting higher adsorption capacity when compared to the precursor material (T in natura). In this way, the results obtained lead to the conclusion that the remediation of water contaminated by Pb<sup>2+</sup> using chemically activated carbon presented high efficiency. Moreover, the

technology developed enables an excellent alternative of destination for tobacco seized in Brazil border regions, in addition, to satisfactorily promoting water remediation.

**Wednesday, December 5, 2018 | Water Resources**

**Return Flow and Well Depletion: Protecting Streams From Groundwater Impact**

Collin Robinson Guide Water United States
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Overdevelopment of water resources makes careful allocation vital to sustain environmental function and protect stable economic activity, both essential to our way of life. Administration of highly utilized stream-aquifer systems must account for groundwater return flow and also for stream depletion from well pumping. The attenuation and delay dynamics of these aspects of conjunctive use have long been understood; however, they are seldom given detailed explanation. Engineering analysis of delayed impact is based on treatment of the groundwater flow equation. Available methods of impact schedule calculation include: direct simplified solutions, developed by Robert Ellsworth Glover; specialized modeling software, developed by the United States Geological Survey; and the Delayed Impact Calculator, an Excel spreadsheet, programmed by the author to perform the calculations. Resulting schedules of stream impact from groundwater change give basis to replacement plans adjudicated to protect flow. The proposed presentation would introduce the topic, describe impact schedules and replacement plans, give a brief overview of each calculation method, and show live calculation of examples. Attendees will be empowered to make their own calculations to inform their water savvy with custom quantitative information. The presentation should be of special interest to attendees with concerns located in regions where overdevelopment of water resources is an issue of growing significance.

**Wednesday, December 5, 2018 | Coffee Break & Posters**

**Sediment transport in different land uses in the semi-arid region of Brazil**

Helba Araújo de Queiroz Palácios Federal Institute of Education, Science and Technology of Ceará Brazil	Jacques Carvalho Ribeiro Federal University of Ceará – UFC Brazil
Eunice Maia Andade Federal University of Ceará – UFC Brazil	Daniel Lima Santos Federal Institute of Education, Science and Technology of Ceará Brazil

The exploitation of natural capital requires an understanding not only of the factors influencing erosion but also of the conditions of transport. The objective of this study was to investigate the factors related to sediment transport capacity in areas with caatinga vegetation and area undergoing deforestation, burning and pasture planting. The study was developed in two experimental microbasins smaller than 2.06 ha, located in Iguatu, Ceará, Brazil. The variables investigated in the period from 2009 to 2014 were: rainfall intensities, rainfall intensities, previous soil moisture, previous precipitation of the last 5

days, dry consecutive days, peak flow, runoff and sediment production. During the study period, 70 rainfall events were recorded that generated runoff. With the aid of Principal Component Analysis, three Principal Components (CP) were formed, explaining more than 80% of the total variance. In CP1, CP2 and CP3, variables related to the energetic power of rain in disaggregating soil particles were framed; to energy for sediment transport and soil water content. For the different uses of the studied soil the sediment production presented a high correlation with the drained layer, indicating limiting conditions of sediment production by the energy of the mass flow.

**Thursday, December 6, 2018 | Water Resources III**

**SKIMMING FLOWS DESIGN IN A STEPPED STRUCTURE. DISCHARGE IN A RESTORED RIVER**

Héctor Alfonso Rodríguez Díaz Escuela Colombiana de Ingeniería Julio Garavito Colombia	Andrés Humberto Otálora Carmona Escuela Colombiana de Ingeniería Julio Garavito Colombia	Mónica Andrea Vargas Solla Escuela Colombiana de Ingeniería Julio Garavito Colombia
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The environmental management of an open pit mining project in Colombia, requires the development of actions that ensure to keep and preserve the conditions of the natural environment. The Drummond Ltd. company performs mining operation in the southern department of Cesar and environmental management plan, must build different structures that ensure the restoration of the basin, especially in the intervened zone. Part of the works include the design and construction of the realignment of the main channel and therefore the corresponding management of the deliveries of the tributaries, given the best environmental and hydraulic practices to solve the changes in the new levels of delivery to the river, to ensure the right functioning of the drainage system of the basin and additionally allow the free movement of its aquatic fauna by the drainage system.

**Thursday, December 6, 2018 | Water Supply Infrastructure**

**Smart Technologies for Improved Management of Urban Water Infrastructure**

Zoran Kapelan Delft University of Technology Netherlands
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The talk will start with an overview of key pressures for future water management in cities. This will be followed by the presentation of several advanced technologies as possible solutions. These will include the new technology for the automated detection and location of pipe bursts, equipment failures and other failure events in water distribution systems. This technology detects events by processing pressure, flow and other data in near real-time and is now used companywide in a large UK water company resulting in major operational cost savings. The rest of the talk will present a number of hydroinformatics type technologies that are being developing with several large water companies including advanced demand forecasting, prediction and detection of water quality (discolouration) events, real-time predictions of combined sewer overflows and corresponding blockage detections and automated asset condition assessment in wastewater systems. The talk will end with a summary of future research challenges in the management of urban water infrastructure.

## **Sociological studies on low impact development of Chennai watershed for Chennai Metro Water Corporation**

Ramachandran Raja  
Shri sitheswar Engineering College  
India

Chennai city, the fourth largest metropolitan city of the country, finds 157th rank in the list of urban areas categorized by developed land area. The review of quantity and quality of Chennai water supply was, till 1870 the people depends on their sources of water supply without public water supply and sanitation. The first public water supply for the Chennai was the weir constructed across Kosathaliyar River at Tamaraiakkam and conveyed the water to Cholavaram tank followed by the water transported to Redhills Lake through an open channel. The unfiltered water from Redhills tank to Kilpauk and distributed to the Chennai public through the cast iron pipes. The stages water supply scheme has attained three surface water resources Poondi, Cholavaram and Redhills and six ground water wells from Minjur, Panjetty, Tamaraiakkam, Poondi, Flood Plains and Kannigaiper with a total capacity of 318 MLD from which public water supplies is about 273 MLD and to full fill the industrial demand of 45 MLD to the manali area. In addition to that hiring water from agriculture wells and drawing water from veeranam tank to fulfill the requirement water supply demand, currently twelve water distribution stations were effectively functioning for public water distribution. The secondary data collected from Institute for water studies (IWS), it can be arrived that the total dissolved salt content of the groundwater is high and formation is hard rock, the water yielded from the indigenous bore well is not self sufficient. Based on the various sources water supply to Chennai with future expansion of Metro into consideration, a social study has been conducted for Chennai watershed. The outcome of the study reveals that in addition to depend on the water resources from other watershed, it could feasible and cause the low impact on environmental, energy required to transport the water, capital requirement to the construction conveying water lines, construction and operation of desalination plant and balanced water resources management in their own watershed by the way of constructing a separate storm water line and sewage lines for Chennai metro. The storm water line can convey the water to the existing storage reservoir for Chennai Metro water supply.

**Thursday, December 6, 2018 | Waterborne Pathogens and Disease**

### **The Role of Algae in the Removal and Inactivation of Pathogenic Indicator Organisms in Wastewater Stabilization Pond Systems**

Lei Liu Queen's University Canada	Geof Hall Queen's University Canada	Pascale Champagne Queen's University Canada
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Wastewater stabilization ponds (WSPs) are an economical alternative to conventional wastewater treatment technologies. They are commonly favored by small and rural communities. Due to long hydraulic retention time required by the treatment in these systems, algal activity is often expected during summer season. This study investigated the effects of algal growth on the removal and inactivation of pathogenic indicator organisms in WSP systems. Two predominant algae species (Mougeotia sp. and Hydrodicty sp.) that were found in Amherstview WSP were able to increase both pH and DO. The highest inactivation rates of both E. coli and total coliforms (TC) were observed at pH 10.5

compared to other pH (4, 8, 8.5, 9.5) investigated in the bench-scale experiments. Both high (20mg/L) and low DO (1 mg/L) levels can facilitate the removal and inactivation of both E. coli and TC. Enterococci were significantly reduced at both intermediate (8.6 mg/L) and high (20 mg/L) DO concentrations. Therefore, the presence of algae can potentially promote the removal of E. coli, TC and Enterococci. Much higher inactivation of E. coli, TC and Enterococci at a higher temperature (20°C) than at a lower temperature (4°C) indicates temperature is one the most important removal factor. Two potential/additional indicator organisms (Enterococci and Clostridium perfringens (C. perfringens)) exhibited different inactivation trends than the traditional indicators (E. coli and TC) under the same pH and DO conditions. C. perfringens were tolerant to all the tested pH, DO and temperature conditions. Their resistance to environmental stresses may pose potential health risk. Hence, both Enterococci and C. perfringens could be potentially used as indicator organisms to predict the overall level of pathogens in treated wastewater.

**Thursday, December 6, 2018 | Modeling and GIS II**

**Understanding hydrological processes in the Coello basin with a distributed hydrological model**

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Hydrological behavior of a watershed is an important input for the development of water resources management plans. For that purpose, numerical models are widely used to estimate the behavior of a watershed under certain rainfall conditions. For the Coello basin, the distributed Tracer-Aided Catchment model (TACD) was adapted to describe the current behavior of the basin, given its size and spatial variability. The model parameters were successfully calibrated to minimize the error between observed and estimated flow data. The distributed model represents accurately the watershed processes and can be used as an input for further development such as hydrological sectorization, uncertainty analysis and flood/water shortage prevention.

**Friday, December 7, 2018 | Modeling**

**Use of the preference curves of the macroinvertebrate Chironomidae, basic food of the species Eremophilus Mutisii, in order to evaluate the application of the IFIM methodology in the calculation of the environmental parameters of the Sisga River in the de**

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The development of projects that involve the use of the water resource in Colombia or in the world, requires studies to maintain a minimum level of water that guarantees the adequate development of the species of the rivers. In Colombia, the use of the IFIM methodology in flat rivers has been implemented, which is based on a quantitative relationship between the physical and hydraulic parameters of the habitat and the series of flows, but due to the great biodiversity, it is not possible to

generalize the use of this methodology for the country, without carrying out the study in mountain rivers. The present work, seeks to apply the IFIM methodology through modeling using the PHABSIM software, to determine optimal ecological flows in a section of the Sisga River which corresponds to 3.2 km from the discharge of the reservoir that bears its name until the mouth in the Bogotá river, and that by its characteristics can be classified as a mountain river. First of all, the collection of information necessary to carry out the modeling in PHABSIM was carried out. The hydrological and topobathymetric information was provided by the Autonomous Regional Corporation of Cundinamarca, CAR, while the information of suitability curve of the macroinvertebrate Chironomidae, being this the main feeding source of the fish *Eremophilus mutisii* (captain of the savanna), was obtained from the Work "Habitat Suitability Curves for Benthic Macroinvertebrates: a Tool for the Estimation of Environmental Flows" by Cardona, (2012), since Colombia has not developed field work for the collection of biological information on fish species. With the necessary information obtained and taking into account that PHABSIM has low processing capacity, 10 different models were carried out, which represent the 10 sections in which the river had to be divided. Finally, it is concluded that the use of the IFIM methodology is of great importance in mountain rivers, since with the help of the PHABSIM program, and taking into account physical and habitat parameters, reliable results can be obtained for decision making.

**Wednesday, December 5, 2018 | Water Resources**

**VARIATION OF THE WATER QUALITY OF THE CIENAGA DE LA VIRGEN IN CARTAGENA-COLOMBIA DUE TO THE IMPLEMENTATION OF THE SUBMARINE OUTFALL**

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The Cienaga de la Virgen, is an ecosystem with ecological, hydraulic and environmental importance in the city of Cartagena de Indias. This water body received for more than 60 years, 70% of wastewater from the city, causing the deterioration of the ecosystem. The objective of this research was to analyze the spatio-temporal variation of water quality of the Cienaga de la Virgen from 1999 to May 2018, (the outfall started their operation in 2000 and 2013 respectively). The water quality of the estuary was analyzed in terms of Water Quality Index – WQI (IDEAM, 2011), taking into account parameters such as Dissolved Oxygen, Fecal Coliforms, Biochemical Oxygen Demand, and others, from samples taken in 26 points of the water body. The results show that before the outfall, the WQI of swamp was Medium with average values of 65 and 57, in the north and south zones, respectively, and after its implementation it remained in the Medium category but with an average values of 67 in the northern zone and 66 in the southern zone, indicating an improvement in the southern zone, where the majority of discharges of wastewater occur. Moreover, it was found that the concentrations of thermotolerant coliforms also decreased after the implementation. The events of non-compliance of the Colombian norm related to the use of water in the primary contact category also decreased (from 68% before the outfall to 35% after the outfall). These results indicate that the outfall, has high degree of importance for the recovery of the ecosystem. However, its recovery would be faster if the informal discharges of wastewater currently present, were eliminated.

**Thursday, December 6, 2018 | Water Supply Infrastructure**

**WATER DISTRIBUTION NETWORKS IN FAST GROWING LATIN AMERICAN CITIES**

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It is well known that population growth in Latin-American cities has been one of the main causes of malfunction and operational costs overruns in the Water Distribution Networks (WDN), as it is a phenomena that has been driven by an accelerated migration and increase of urbanization. As population varies with time, building occupancy changes and uncertainty about the hydraulic performances of the WDNs arises. The main objective of this paper is to understand how the geometry and topology of the networks are being affected as population density increases in Latin-American cities. Therefore, the methodology proposed was applied on four real networks with different geometric shapes located in Colombia. First, the initial conditions related to population, system flows and geometry of each WDS were analyzed, and subsequently each design of the WDN were carried out under five different scenarios of increases in population densities, by using the Optimal Power Use of Surface (OPUS) methodology. Afterwards, the networks' hydraulics and performances were verified by analyzing pressure surfaces and pipe diameters, and by calculating rating, reliability and energy efficiency indexes. Additional analyses were proposed such as location of the geometric centroids of each design, changes in water age and chlorine initial concentration in the tank, variations of cost per cubic meter of transported water and the fractality of the WDN. Main results showed that increases in population density did not necessarily lead to significant variations of the studied geometric parameters, the reliability and energy efficiency indexes remained almost constant, the required chlorine initial concentration in the tank increased and the age of the water decreased, the costs per cubic meter of transported water also dropped, and that fractality was not affected.

**Friday, December 7, 2018 | Water Supply and Sanitation II**

**WATER QUALITY IN THE BASINS OF RIVERS TORCA, SALITRE, AND FUCHA FOR REGIONAL WATER ASSESSMENT (RWA)**

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This article shows the results of the study performed for Regional Water Assessment (RWA) by the Water and Sewage Company of Bogota (EAB in Spanish) in the basins of rivers Torca, Salitre, and Fucha, wherein monitoring points were selected to estimate the values of Water Quality Index (WQI) and Water Quality Potential Alteration Index (IACAL in Spanish). The results are compared with current regulations for quality objectives at the national and district level, finding that water quality in urban basins, such as Torca, Salitre, and Fucha, has a high IACAL due to the elevated number of DBO5 and COD in population and industrial factors. Estimating the water quality indices of RWA led to state the current state of water quality in the river basins.