STATUS OF MEDRC R&D PROJECTS

OCTOBER 2009

STATUS OF MEDRC R&D PROJECTS

COMPLETED PROJECTS

97-AS-001	Novel material selection to improve corrosion resistance
97-AS-002	Automation and operation optimization to reduce water costs
97-AS-004a	Development of new technologies for the reduction of fouling and improvement of performance in SWRO systems
97-AS-004b	Identification of critical flux and cross flow conditions for control of bacterial and organic fouling of seawater reverse osmosis membranes
97-AS-004d	Study of the formation and inhibition of silica scales in RO desalting
97-AS-005a	VARI-RO^{tm} solar powered desalting study
97-AS-005b	Seawater greenhouse development for Oman: Thermodynamic modeling and economic analysis
97-AS-006a	Matching renewable energy with small unit desalination plants: Literature review and analysis of the state of the art of renewable energy and small unit desalination systems
97-AS-006b	Matching renewable energy with small unit desalination plants: Development of a pc-based decision support system
97-AS-007	Investigation on the use of evaporation ponds for brine disposal in inland desalination plants
97-AS-008a	Hybrid desalination systems: effective integration of membrane/thermal desalination and power technology
97-AS-008b	Hybrid desalination systems
97-BS-013	A novel method to permanently improve the rejection of RO desalination modules to significantly lower the cost of desalination
97-BS-015	Beach well intakes for small seawater reverse osmosis plants
97-BS-016	Hybrid fossil/solar heated multi-effect-still

97-BS-018	Zero-waste design development and performance evaluation for small home-use RO units
98-AS-024a	Small solar MED desalination plant
98-AS-024b	Small thermal water desalination systems using solar energy or waste heat
98-AS-032a	Assessment of the innovative freezing-melting process for desalination of sea water
98-Bs-032b	A comprehensive study of solar desalination with humidification/ dehumidification cycle
98-BS-033	PV powered desalination: matching technology options with market demands
98-BS-034	Critical assessment of fouling indices
98-BS-036	Data bank of seawater compositions
00-AS-001	Study of the interactive effects of inorganic and biological fouling in RO desalination units (Phase-A)
00-AS-006	The release of CO_2 in Multiple-Effect Distillers
00-AS-010	Spirulina culture using reject brine water from desalination plants
00-AS-014	Development of a logistic model for the design of autonomous desalination systems with renewable energy sources
00-AS-019	Design and development of a small packaged reverse osmosis system driven by a hybrid power supply system
00-AS-020	Enhanced evaporation for treatment of desalination brines
00-BS-005	Computational fluid dynamics (CFD) studies for performance enhancement of spiral modules by modifying fluid flow behavior
00-BS-017	A study of the state of the art, commercial potential, and prospects for advancement of desalination by membrane distillation
02-AS-001	Development of a novel approach to the prediction of nano-

	filtration membranes performance using advanced atomic force microscopy
03-AS-001	Review of colloidal fouling in spiral wound modules
03-AS-002	Combined macromolecular adsorption and coagulation for improving pre-treatment processes in desalination plants
03-AS-003	Greenhouse – State of the art review and performance evaluation of Dehumidifier
03-AS-004	Evaluation of the performance of reverse osmosis plants in Oman
03-AS-005	System analysis of renewable energy conversion integrated with desalination processes
03-AS-006	Improvement of techniques for assessing RO membrane colloidal fouling
03-AS-007	A study of a hybrid fuel cell / desalination systems
04-AS-002	Theoretical and experimental studies of flow through narrow channels with insert towards membrane module performance optimization
04-AS-004	Study of the adsorption-membrane filtration (AMF) hybrid process for removal of boron from seawater
04-AS-005	Comparison of nano-filtration and reverse osmosis processes for treatment of brackish water feeds
04-AS-006	Design of novel membranes for desalination by direct contact membrane distillation
05-AS-001	Systematic application of exergo-economic methods for the analysis and optimization of desalination processes
06-AS-001	Critical performance analysis of a reverse osmosis plant – Case study
98-AS-026	Assessment of the composition of desalination plant disposal Brines
04-AS-001	Development of web based computer package for simulation of thermal and membrane desalination processes

05-AS-002	An integrated membrane operation in desalination of sea and brackish water
05-AS-006	Development of novel methods for the control and inhibition of scaling in thermal seawater desalination plants
06-AS-003	Novel Seawater Pre-treatment Processes by Sorption onto Chemically Modified Bentonite Coupled with Ultra-filtration Operation in RO Plants
07-AS-004	Development of particulate/colloidal fouling indicators in SWRO: Further development of MFI-UF concept

Final reports of all the completed projects are available as downloadable files under the title “Final reports”

ONGOING PROJECTS

02-AS-002	Basic experimental studies of the CO_2 release in the carbonate system in seawater distillation
04-AS-003	Development and analysis of the Diffusion Driven Desalination (DDD) process
05-AS-003	Experimental and theoretical studies on integration of new PCM-based components in solar desalination
05-AS-004	Privatization of Water Desalination in Oman
05-AS-005	Preparation of thin film composite RO membranes with reduced fouling for seawater desalination
05-AS-007	Application of molecular modelling to understand crystallization fouling and the interactive effects
05-AS-008	Study of the interactive effects of inorganic and biological fouling in reverse osmosis desalination units (Phase B)
06-AS-002	Development of Polymer Nano-fiber, Micro-fiber and Hollow-fiber Membranes for Desalination by Membrane Distillation
06-AS-004	Minimize the Use of Chemicals in Sea Water Reverse Osmosis: Impact on Scaling & Concentrate Disposal

07-AS-001	Computational fluid dynamic simulation of MSF condensers: Non-condensable gas effects and design organization
07-AS-003	Environmental planning, prediction & management of brine discharge from desalination plants
07-AS-005	Optimization of the membrane sub-layer for development of RO membranes with improved fouling resistance
08-AS-001	Boron pre-treatment for seawater and brackish water desalination
08-AS-002	An investigation of total composition of sea water in Oman
08-AS-003	New desalination process for enhanced recovery from brackish water: Smart system utilizing Ultrasonic Reflectometry (UR) and Flow Reversal (FR) - Phase I
08-AS-004	Toward better calcite scaling understanding in SWRO
08-AS-005	Application of solar energy in RO pre-treatment process – Phase I
08-AS-006	Development of a solar still desalination system with enhanced productivity
08-AS-007	Performance evaluation and optimization of the Barka MSF desalination plant
08-AS-009	Reliability modeling and analysis of a desalination plant

NEW PROJECTS AWARDED

09-AS-002	Boron content reduction from permeate waters of Hij RO plant
09-AS-003	Desalination of brackish water by photovoltaic in West Bank, Palestine

ONGOING PROJECTS

BASIC EXPERIMENTAL STUDIES OF THE CO_2 RELEASE IN THE CARBONATE SYSTEM IN SEAWATER DISTILLATION

02-AS-002

Principal Investigator

Dr. Heike Glade, Matin-Luther-Universitaet Halle-Wittenberg, Germany

Research Partners

Dr. Hazim Mohamed Qiblawey, Jordan University of Science & Technology

Objectives

The main objectives of the project are to acquire an in-depth understanding of the reaction kinetics and the mass transfer phenomena controlling the release of CO_2 in desalination distillers and to verify and improve the CO_2 release model developed earlier by PI for MED distiller using the experimental results obtained from a stirred vessel test ring and falling film experimental set-up. The main work packages of the proposed project are:

- Detailed design and set up of the stirred vessel test rig and falling film experimental setup including the measuring instrumentation.
- Carrying out various experiments to study the effects of influencing parameters on CO_2 release and the carbonate system in the test rig such as operating temperatures and pressures, composition of the test solution, pH and ionic strength of the test solution, fluid dynamics, simultaneous precipitation of $CaCO_3$ and $Mg(OH)_2$.
- Conduct experiments with falling film apparatus to determine the physical mass transfer coefficient depending on the fluid dynamics in the falling film apparatus, the absorption of pure CO_2 in distilled water.
- Evaluation of the measurement results by calculating the CO_2 release and the ion concentrations in the carbonate system by applying the theory of mass transfer with chemical reaction to the various experiments and comparing the experimental results with the calculation results and with the results of previous experimental work.
- Consolidation and improvement of the model for the predictive simulation of CO_2 release in ME distillers developed in the earlier project and examining if the approach applied to the simulation of CO_2 release in ME distillers is consistent with the experimental results and then suggest improvements to the model.
- Comprehensive literature survey on the experimental work proposed.

Status

Submitted draft final report.

Development and Analysis of the Diffusion Driven Desalination (DDD) Process

04-AS-003

Principal Investigator

Prof. James F. Klausner, Department of Mechanical and Aerospace Engineering, University of Florida, USA

Research Partners

Mr. Fadi Alnaimat, PhD scholar, Jordan

Objectives

1. Experimentally measure the fresh water production rate and associated energy consumption required to pump water and air through the facility. Measurements will be made over a wide range of operating conditions in order to find an optimum condition where fresh water production is maximized with low energy consumption.

2. Develop a computational modeling tool that reliably simulates the thermal and mass transfer processes within a DDD facility. Such a tool has already been developed for the diffusion tower and the development of a modeling tool for the direct contact heat exchanger is required. The successful completion of this objective will allow the performance of a specified design to be predicted as well as provide design recommendations for a specific application.

3. Use the computational model to assess the required sizes for the diffusion tower, direct contact condenser, and associated secondary heat exchangers, pumps, and blowers applied to a commercial scale DDD plant.

Tasks:

1. A detailed literature survey of direct contact heat exchangers and associated heat and mass transfer transport properties will be conducted.

2. A direct contact condenser will be fabricated based on design considerations recommendations from the literature, and will be installed in series with the diffusion tower to complete the fabrication of the bench scale DDD experimental facility.

3. A detailed computational model that simulates the heat and mass transfer processes within the direct contact condenser will be developed. This model will be combined with an existing model that simulates the heat and mass

transfer processes within the diffusion tower. The combined model will simulate the entire desalination process and will be very useful as a design tool and a predictive analysis tool.

4. Extensive measurements of the heat and mass transfer coefficient within the condenser will be obtained. These will be used to calibrate a computer simulation for the condenser operation, and integrated with the diffusion tower simulation to provide a detailed simulation of the entire DDD process.

5. The fresh water production rate and pumping energy consumption through the DDD facility will be measured over a wide parameter space and compared with those predicted from the computer simulation.

6. Using the experimental results and aid of the computer simulation, the required size of the components within the DDD facility will be estimated.

7. The outcome of the experiments and results from the computer simulation will be used to make design recommendations for commercial scale facilities and will be useful in designing the pilot scale plant to be fabricated with FPL Corporation.

Status

A PhD scholar was fixed recently in place of MSc scholar. Second progress report is submitted.

EXPERIMENTAL AND THEORETICAL STUDIES ON INTEGRATION OF NEW PCM-BASED COMPONENTS IN SOLAR DESALINATION

05-AS-003

Principal Investigators / Supervisors

Prof. Abdalla Hanafi, Cairo University, Cairo, Egypt

Dr.-Ing. Markus Spinnler, Lehrstuhl für Thermodynamik Technische Universität München, Germany

Prof. Wolfgang Polifke, Lehrstuhl für Thermodynamik Technische, Universitat München, Germany

Ph.D. Scholar

Mr. Abdel Hakim M. Hassabou, Cairo University, Cairo, Egypt

Research objectives

Examine the technical and economical feasibility of a PCM based humid air distillation system. The benefits of PCM storage in solar air distillation units shall be worked out and documented clearly.

Applying porous components, an optimum between porosity, pore width and pressure loss has to be found in theoretical as well as experimental investigations. In a second step, characteristics of various PCM materials have to be compiled and an optimal solution has to be integrated into the process. Regarding the general plant setup, flow characteristics between evaporator and condenser as well as the dynamic thermal charging/discharging behavior of the PCM cans have to be studied carefully. An energetic simulation of the whole plant with periphery has to be performed in order to figure out suitable plant configurations.

Based on these studies, a test plant shall be built up and provide data for validating a simulation model. Given suitable meteorological data for continuously varying climate conditions, the detailed design and performance of the desalination plant can be optimized for every location and environment.

Tasks:

1) Theoretical studies on PCM materials including a compilation of switching temperatures, long-term stability in about 70.000 cycles, crystallization and melting behavior.

2) Elicitation of suitable encapsulating technologies, mainly welding of plastic cans. Evaluation of costs, mass manufacturing potentials and long-term stability.
3) Study of a preliminary evaporator and condenser design and assessment of the main influencing parameters. Based on these parameters, a detailed plan of the further experimental program and theoretical studies can be worked out and boundary conditions for both experimental plant and numerical simulation can be fixed.
4) Realization of different test series on non-PCM cubical and spherical filling material evaluating the flow characteristics using the existing evaporator test rig.
5) Adequate modification of the existing desalination test rig, add-on of suitable PCM condenser testing possibilities. Assessment of design possibility for realizing a discontinuous PCM wheel. Performance of systematical test series yielding characteristic maps of both evaporator and condenser behavior as a function of Reynolds-number, brine mass flow, brine temperature. Assessment of suitable operation strategies.
6) Enhancement of an existing energetic model describing the plant configuration based on the dynamic simulation platform “TRNSYS”. Therefore, characteristic maps measured in 5) serve as a crucial boundary condition. Assessment of different plant configurations and operation strategies with given meteorological data (Egypt, India, Spain, others).
7) Development of a thermodynamic model and use of computational fluid dynamic modeling (FLUENT) to have a good comprehension of the physical phenomena in the desalination module. With the thermodynamic model, heat and mass transfer coefficients and transient phase change phenomena in the porous bed can be determined.
8) Topics 6) and 7) shall be iterated, until detailed predictions of an optimal design and performance of the plant can be made for every suitable location and environment throughout the world. Numerical results can be validated with experimental data, and can therefore yield high accuracy.
9) Accompanying the numerical studies, the already existing test rig shall be enlarged and adapted stepwise, until a close-to-production prototype of the system is available in the laboratories of Technische Universität München. Future field tests should be made in Egypt, but due to the tight working schedule should not be part of the present studies.

Status

PhD Scholar is not working full time. Final thesis will be submitted by end of July 2010.

PRIVATIZATION OF WATER DESALINATION IN OMAN

05-AS-004

Graduate student

Mr. Ahmed Al Busaidi, Oman Power and Water Procurement Company, Oman

Objectives

To study the privatization of desalination projects in Oman with emphasis on its strategy, planning and regulations, and to provide over view of Oman's experience in privatization of such projects through one of the existing/newly privatized projects of a capacity of not less than 10 MGD Plant.

In this study the conceptualization and argumentation for the privatization of desalination projects will be briefly reviewed, then the move towards privatization in Oman will be addressed, and the main issues for this development will be identified. This shall include the Oman experience in implementation of such Independent Water Desalination Projects (IWP).

Tasks

The following are the main tasks of the project.

1. Description of research methodology
2. Literature survey
3. Survey and review of desalination projects in Oman with special emphasis on investment costs, operating costs and unit water costs including government subsidies
4. Review of privatization concepts of desalination projects and privatization polices and regulation in Oman
5. Development of planning, management and tendering procedures / methodologies for privatization of desalination projects
6. Case study: Experience of execution and monitoring of a privatized desalination project in Oman.
7. Economics and criteria for the tariff/costs calculation of desalinated water produced from such private project.

Status

Course work is completed and dissertation will be submitted by end of October 2009.

PREPARATION OF THIN FILM COMPOSITE RO MEMBRANES WITH REDUCED FOULING FOR SEAWATER DESALINATION

05-AS-005

Principal Investigators / Supervisors

Prof. Takeshi Matsuura, University of Ottawa, Canada

Dr. Hassan Arafat, An-Najah National University, Palestine

Scholarship recipient

Mr. Bilal Abu-Tarboosh, Palestinian

Objectives

To study systematically the effect of surface charge, hydrophobicity/philicity and surface roughness on the TFC membrane fouling, aimed at the design of a novel polyamide TFC membrane for seawater desalination with reduced fouling.

Tasks

1. To prepare TFC polyamide reverse osmosis membranes for seawater desalination based on the conventional interfacial polycondensation of diamine and polyfunctional acid chloride monomer on a porous support membrane.
2. To change the surface charge density, hydrophobicity/philicity and surface roughness systematically by adding an organic solvent or a surfactant or an electrolyte into the aqueous diamine solution. An attempt will also be made to add a surface modifying macromolecule (SMM) into the organic phase.
3. To characterize the membrane surface by streaming potential measurement, contact angle measurement, atomic force microscope (AFM), X-ray photoelectron microscope (XPS) and scanning electron microscope (SEM).
4. To conduct reverse osmosis experiments with aqueous 3.5 % sodium chloride solution with potential foulants. The rate of flux reduction is measured in this experiment.
5. To correlate the rate of flux reduction with the surface properties by regression analysis and optimize the conditions of membrane preparation to achieve a membrane of the least fouling.

Status

PhD Scholar left the university with MSc degree but project is continuing with new research assistant.

APPLICATION OF MOLECULAR MODELING TO UNDERSTAND CRYSTALLIZATION FOULING AND THE INTERACTIVE EFFECTS

05-AS-007

Principal Investigator

Dr. Roya Sheikholeslami
AAA Water Energy Technologies Pty Ltd, Australia

Participants

Dr. Alexander Goldberg Accelrys K.K., Japan/USA

Ph.D. Scholarship recipients

Mr. Farnaz Sotoodeh, Iranian National

Objectives

In this project a study of the crystallization fouling will be carried out based on Molecular Modelling methods. This will include crystal morphology analysis under different operating conditions, studying the interactive effects on Gibbs free energy and thermodynamic solubility constants and crystal growth and strength, and the effect of the presence of other species on the crystal habit (coprecipitation). Experimental work also will be done in order to compare, and validate the results that will be obtained from the computations. Ultimately, it is hoped that once this project is completed and at later stages, the results and output from these molecular modelling simulations and investigations would be coupled with kinetic data and fed to a CFD software for coupling with hydrodynamic effects. Therefore, this possibility will be assessed to establish the future directions.

Tasks

1. Comprehensive literature review: This will include the review of the basics of molecular modelling, ab initio quantum mechanics (QM) based on Density Functional Theory (DFT) and Molecular Dynamics (MD).
2. Software and module assessments: The specifics of the software modules and their applicability for the inorganic salts will be assessed. Not much simulation techniques are available for inorganic salts.
3. Energy minimization analysis: Energy minimization techniques will be assessed and analyzed.
4. Calibration of software and modules: The software and modules will be calibrated by comparison with previous experimental work. Experimental data are available for simple salts such as NaCl. Also, simple inorganic salts such as NaCl could be modelled relatively easier than more complicated ones and as such will be used for calibration and preliminary assessments.

5. Thermodynamic approach: Development of thermodynamic approach involves the lattice energy determination by using ab initio quantum mechanics (QM) based on Density Functional Theory (DFT) method. The obtained lattice energy is incorporated with the thermodynamic relationships to determine the formation enthalpy of the crystal by implementing the Born-Haber thermodynamic cycle and then by determination of Gibbs Free energies and hence the solubility products. In addition, molecular dynamics (MD) simulation will be carried out.
6. Heat of formation analysis: It is performed at different temperatures, pressures and feed concentrations. Heat of formation of any given salt is related to the heat of formation of its constituents and also the entropy of products and reactants. The relationships will be developed for the salts in concern and the thermodynamic relationships will be developed based on the thermodynamic principles.
7. Gibbs free energy evaluations: Gibbs free energy of the reaction will be determined based on those of products and reactants. That would provide a means to theoretically calculate the solubility product.
8. Ksp evaluation: The method of theoretical calculation of Ksp will be validated and the results compared with the available experimental data. Also the effect of temperature and possibly salinity will be theoretically investigated and compared with available experimental data.
9. Experimental analysis for the same scaling salts and under same conditions: Experimental wok will be conducted to fill the gap in the availability of data and for the purposes of comparison of the theoretically calculated values and those obtained experimentally.
10. Comparison and validation: The thermodynamic technique developed and used for theoretical determination of Ksp will be compared with the experimental results.
11. Assess linkage between the outputs from the software with CFD package: Gibbs free energy determination can be used to determine Ksp and it will be endeavored to also develop sub-modules in CFD package that can access the theoretically calculated Ksp at a local conditions of temperature and pressure with the process stream.
12. Simulations and the experimental work: Continuation of simulation and experimental work and further comparisons of the results.

Status

Conducted extensive literature review of crystallization of composite fouling and calculated different thermodynamic parameters.

STUDY OF THE INTERACTIVE EFFECTS OF INORGANIC AND BIOLOGICAL FOULING IN REVERSE OSMOSIS DESALINATION UNITS (PHASE B)

05-AS-008

Principal Investigator

Dr. Roya Sheikholeslami
AAA Water Energy Technologies Pty Ltd, Australia

Partner

Mr. Salem Qasem, Jordanian

Objectives

The objective of this project is to study the interactive effects in composite fouling by developing a theoretical approach and model that takes into account the interactive effects and conduct experiments to assess and validate the theoretical model predictions.

Tasks

Task 1: Experimental work on biological fouling and individual fouling types
This task mostly encompasses the experimental work on individual inorganic and biological fouling. In these experiments the effect of salinity, nutrient and bacterial count on biological growth will be investigated with simulated waters. Psuedomonas fluorescens will be used for the experimental investigations. The effect of operating conditions such as concentration and salinity on inorganic foulant formation will also be investigated. The structure of the foulant formed will be assessed.

Task 2: Experimental Work on Composite Fouling
Initially selected runs will be carried out to investigate the individual fouling processes to obtain a base comparison lines. For the inorganic fouling, salt concentrations will be in the range of those usually encountered in RO desalination. Two different salts ($CaSO_4$, $CaCO_3$) will be tested, as they are predominant scaling salts in process equipment. Distilled water will be used for preparation of the feed and the unit will be sterilized to alleviate or minimize the possibility of bacterial growth in the system (aseptic technique).

Simulated feed water will be used to determine the effect of biological fouling in composite fouling under given conditions. Psuedomonas fluorescens that it is prevalent in industrial water systems will be used as the model micro-organism.

Glucose will be used as a source of carbon (nutrient). Again the system will be sterilized (aseptic technique) and distilled water will be used for preparation of the feed solution. After the information on the inorganic fouling and biological fouling in isolation is obtained, tests will be performed using simulated model feed waters, containing both inorganic salts and micro-organisms, to determine the simultaneous effects.

The above experiments will provide some indication of the synergistic effects in composite fouling. At this stage, the focal point is to determine the effect of biological fouling on inorganic fouling. However, if the above results indicate that there is significant particulate fouling present, then additional experiments are required to determine the relative effects biological fouling on particulate and crystallization fouling on by repeating some of the experiments with a filter on the line. Also, the effect of humic acids on inorganic fouling will be investigated as humic acids are sometimes included as inhibitors.

Task 3: Develop a theoretical model which could take into account the interactive effects

Theoretical model will be developed which would be able to incorporate some of the interactive effects. The model will be modified, if required, to take into account the effect of simultaneous fouling processes.

Task 4: Assessment of composite fouling model

In this task model predictions are compared with experimental data. First, the experimental data will be used to substantiate the applicability of the model to individual fouling. Further experimental results on composite fouling will assess the applicability of the model to composite fouling.

Task 5: Complementary experiments to refine the model

In this task complementary experiments will be carried out to assess the composite fouling structure. Refinement and suggestions will be made for improvement of the model and extension of this theoretical approach.

Status

Draft final report is submitted.

DEVELOPMENT OF POLYMER NANO-FIBER, MICRO-FIBER AND HOLLOW-FIBER MEMBRANES FOR DESALINATION BY MEMBRANE DISTILLATION

06-AS-002

Principal Investigator
Dr. Mohamed Khayet, University Complutense of Madrid, Spain

Participants
Dr. Hassan Arafat, An-Najah National University, Palestine

Ph.D. Scholar
Mr. Essalhi Mohamed, Morocco

Objectives

To prepare nano-fiber, micro-fiber and hollow-fiber membranes for Membrane Distillation (MD) desalination using hydrophobic homopolymers and copolymers

Tasks:

Task 1: Literature survey that includes

- Brief description of both commercial and laboratory made membranes for MD as well as different MD configurations
- Summary of different methods for porous hydrophobic membrane preparation
- Summary of the different involved parameters in dry/jet wet spinning method and their effects on hollow fiber membrane morphology and structure
- Summary of already prepared nano-structured polymer webs by electrospinning method and effects of different involving process parameters on the structure of nano- and micro-fibers as well as on the nano-structured membrane
- Summary of MD for desalination and other applications

Task 2: Membrane preparation that includes

- Preparation of hollow-fiber membranes for MD by dry/jet wet spinning method using PVDF hydrophobic polymer
- Preparation of nano-fiber and micro-fiber membranes by electrospinning method using hydrophobic homopolymers and copolymers
- Preparation of nano-structured based electrospun nano-tubes
- Determination of appropriate conditions for electrospinning the above fibrous membranes.

Task 3: Membrane characterization that includes

- Determination of geometrical, physical, mechanical, thermal and chemical properties of the fiber membranes
- Measurement of water contact angle of nano-structured membranes
- Measurement of liquid entry pressure (*LEP*) of water and salt aqueous solutions of hollow-fiber membranes and nano-structured membranes
- Measurement of mean pore size and pore size distribution of hollow-fiber membranes and nano-structured membranes
- Measurement of void volume of hollow fiber and nano-structured membranes
- measurement of thermal conductivity of nano-structured membranes

Task 4: Design and module preparation that includes

- Shell-and-tube and plate-and-frame membrane modules
- Packing of dry/jet wet spinning hollow-fiber (capillary) membranes prepared above in shell-and-tube modules
- Packing of electrospun nano- and micro-fibrous (tubular) membranes prepared above in plate-and-frame modules.

Task 5: MD desalination experiments that include:

- Seawater and aqueous sodium chloride feed solutions
- Various membranes prepared above and two commercial polyvinylidene fluoride (PVDF) and/or polytetrafluoroethylene (PTFE) membranes for comparison
- Effect of membrane parameters (web structure, pore size, void volume, roughness and thickness)
- Effect of MD operational conditions: temperatures and flow rates.

All MD experiments will include the measurement of the permeation flux and the salt concentration in feed and permeate. Comparison of desalination performance by the membranes prepared in this project and the commercially available membranes will be made.

Task 6: Model development that includes

Application of available theoretical MD models to electrospun fibrous (tubular) membranes in order to predict their MD performance under various operating conditions and MD configurations (DCMD and AGMD)

Status

PhD student was fixed recently. Second progress report is submitted.

MINIMIZE THE USE OF CHEMICALS IN SEA WATER REVERSE OSMOSIS: IMPACT ON SCALING & CONCENTRATE DISPOSAL

06-AS-004

Principal Investigator
Dr. Maria K. Kennedy, UNESCO-IHE Institute of water education, The Netherlands

Participants
Dr. Jan C. Schippers, Professor emeritus, The Netherlands
Prof. Gary Amy, UNESCO-IHE Institute of water education, The Netherlands

Ph.D. Scholar
Mr. Tarek K.Waly, Cairo, Egypt

Objectives

The objective of the study is to minimize/eliminate the use of chemicals for scale prevention in Sea Water Reverse Osmosis.

- Determine the maximum safe (i.e., limits of) recovery in the absence of acid and/or an anti-scalant in SWRO systems
- Determine the minimum dose of anti-scalant and/or acid required to prevent scaling above the safe conversion in SWRO systems
- Determine the impact of using NF-RO sequence for unsafe conversion
- Technical and commercial comparison between different systems

Tasks

Task 1: General literature review on the subject of the study will be carried out

Task 2: Critical review of methods used for the calculation of the scaling potential and kinetics of CaSO4 and CaCO3 will be carried out. Improvements will be proposed and/or new methods will be developed and verified with experimental results obtained with laboratory and pilot scale experiments.

Task 3: Laboratory scale experiments
Laboratory scale experiments will be performed at the UNESCO-IHE laboratory using the bench scale RO unit and other experimental facilities to estimate the scaling potential of artificially prepared (supersaturated) concentrates that simulate typical SWRO plant recoveries (20-60%). Induction times and growth rates of calcium carbonate and calcium sulphate will be measured in the supersaturated concentrates and the maximum safe recovery in the absence of antiscalant/acid will be elucidated. The laboratory experiments and modeling will focus on

- Determination of critical recovery

- Bulk crystallization measurements
- Induction time measurements
- Determination of solubility ratio
- Determination of the effect of anti-scalant dose on unsafe conversion
- Determine the effect of acid doses using unsafe recoveries and its effect on induction time
- Determine the benefits of NF-RO sequence in increasing the threshold scalinglimits

Task 4: Pilot scale experiments
To verify the experimentally determined safe conversion estimated for artificially prepared concentrate in laboratory scale experiments, pilot plant trials employing natural seawater will be performed using the maximum safe conversion estimated in laboratory scale experiments. The relation between induction time and recoveries again will be tested in order to confirm laboratory scale results. Compositions of the raw and treated feed water and of the reject brine will be determined using inductively coupled plasma (ICP) spectrometry and ion chromatography (IC) while analytical visual methods using environmental scanning electron microscopy (environmental SEM) will be utilized to confirm the scaling mechanism and components. The pilot scale experiments will focus on

- Determination of critical recovery
- Determination of the effect of anti-scalant dose for unsafe conversion
- Determination of the effect of acid doses using unsafe recoveries and its effect on induction time

Task 5: Technical and cost comparison between different systems Technical and operational comparison between SWRO system utilizing minimum chemical doses and that using NF as pre-treatment will be addressed. The comparison will cover the following.

- The ease of system operation and maintenance
- The difference in design and equipments
- The power consumption
- The difference in instrumentations and control

Cost comparison between SWRO system utilizing minimum chemical doses and that uses NF as pre-treatment will be addressed and will depend on the following.

- The change in capital cost
- The change in the operational and maintenance cost
- The change in power consumption

Status

Second progress report is submitted.

COMPUTATIONAL FLUID DYNAMICS SIMULATION OF MSF CONDENSERS: NON-CONDENSABLE GAS EFFECTS AND DESIGN OPTIMIZATION

07-AS-001

Principal Investigator

Prof. Yousef Zurigat, Mechanical Engineering Department, American university of Sharjah, Sharjah

Participants

Dr.-Ing. Heike Glade, University of Bremen, Germany

Objectives

Conduct a comprehensive CFD study of the flow, heat and mass transfer characteristics of MSF condensers. Specifically, the characteristics of condensation with non-condensable gas in real MSF condensers will be investigated to provide design improvements that lead to performance enhancements via reducing the adverse effects due to the presence of non-condensables.

TASKS

Phase-I: A Preliminary Study of CFD Modeling of MSF Desalination Condensers

Due to the complexity of mathematical modeling of condensation in condensers used in real MSF desalination plants Phase I is designed to give MEDRC the basis upon which to decide on funding Phase II of the proposed work. Thus, Phase-I represent a fact-finding mission to mathematical modeling of MSF condensers.

Task 1

A review of the literature and manufacturers' information on the design of real MSF condensers and identification of the major design parameters affecting their performance will be carried out. Physical models of the most widely used MSF condensers will be clearly presented to assess in the Tasks 2 and 3.

A review of the field experience data on various tube failures due to tube corrosion problems on the vapor side of MSF condenser. This should aid in investigating possible design improvements to prevent or reduce corrosion problems in MSF condensers

Task 2

A thorough literature review on the CFD modeling of condensation in condensers similar, or nearly similar to MSF condensers will be carried out. The simplifying assumptions used, the boundary layer treatments, the liquid-gas two-phase and multi-component two-phase flow modeling approaches and the auxiliary relations governing the heat and mass transfer will be identified and assessed in view of the physical model outlined in Phase I.

Task 3

Specifying the requirements on the CFD model and providing realistic simplifying assumptions that enable the software providers to gauge their software capabilities against.

Task 4

Review of CFD commercial software capability in modeling condensation in MSF condensers under real-world conditions under the simplifying assumptions in Task 3 above. Contact with commercial CFD software providers will be carried out at this stage which culminates in an assessment of the modeling capabilities of the selected software. Moreover, the cost required for the best suited CFD software can be specified as an input for phase II.

Task 5

Identify a set or sets of experimental data for validation of the models being intensively developed and implemented in Phase II. This is to ensure the success of model validation process, a priori.

Status

First progress report submitted.

ENVIRONMENTAL PLANNING, PREDICTION AND MANAGEMENT OF BRINE DISCHARGES FROM DESALINATION PLANTS

07-AS-003

Principal Investigator

Dr.-Ing. Tobias Bleninger & Prof. G.H. Jirka, Institut für Hydromechanik (IfH), Universität Karlsruhe, Germany

Participants

Prof. Anton Purnama & Prof. Hamdi H. Al-Barwani, Sultan Qaboos University, Sultanate of Oman

Prof. Robert L. Doneker, MixZon Inc. and Department of Civil and Environmental Engineering, Portland State University, Oregon, USA

Ms. Sabine Lattemann, Prof. Dr. Thomas Höpner, H.Brunken-Winkler, ARSU - Regional Planning and Environmental Research Group, Oldenburg, Germany

Objectives

Sea water desalination plants discharge a concentrated brine effluent into coastal waters. Modern, large capacity plants require submerged discharges that ensure a high dilution in order to minimize harmful impacts on the marine environment. Existing design practice is limited to poor modeling concepts and a very heterogeneous or weak regulatory base. Stakeholder opinions vary from “negligible localized impacts” up to major objections leading to significant project modifications and unnecessary delays.

The Objective this project is to develop a modeling framework for the environmental-hydraulic design of the outfall system for desalination plants based on the following:

1. Identification of environmental impacts, regulatory frameworks and public concerns regarding brine effluent discharges with emphasis on MENA (Middle East, North African) and Mediterranean countries.
2. Elaboration of easily applicable design nomograms including the density dependence on salinity and temperature as basis for the first screening process within the assessment of brine effluents after discharge into the receiving coastal waters.
3. Development of hydrodynamic model interfaces for predicting brine effluent concentrations of key parameters in the marine environment by coupling a near-field mixing model for outfall design optimization with a far-field transport model for optimized outfall site.

4. Model application and validation for typical case studies for the compilation of design recommendations with parallel improvement of design oriented input/output features.
5. Management and realization of capacity building on environmental planning, prediction and management of brine discharges from desalination plants.

TASKS

Task 1: Identification of environmental issues and regulatory / planning needs
A thorough survey of typical effluent characteristics from desalination plants, environmental impacts and effects on the marine ecosystem caused by brine discharges, existing designs and regulations on effluent discharges in MENA and Mediterranean countries and available planning tools and synchronization of experimental data for model validation will be performed

Task 2: Nomograms and engineering screening equations
Nomograms consisting of a density calculator based on the typical characteristics of brine effluents and coastal waters in the considered project regions will be developed. The density calculator will be used to elaborate nomograms to define the density variation and estimates for general plume characteristics depending on the discharge and receiving water parameters. Simple screening equations on initial effluent dilution will be adopted based on similar approaches for wastewater discharges and conservative simplifications.

Comment [BI1]: Eventually delete that part, if more space is needed

Task 3: Development of model coupling interface
For the prediction of the brine effluent concentrations in the marine environment an interface for coupling near-field mixing models with far-field transport models will be developed. The model development will expand on an existing modeling approach for wastewater discharges by applying the new interface for the coupling of the near-field model CORMIX with the research based SQU transport model and the commercially used Delft3D (Delft Hydraulics) model.

Task 4: Optimal design and final assessment of the brine discharge system
With the help of the developed software tools, the optimal approach to design and assess brine discharges will be determined by the application of optimization algorithms, sensitivity analysis and case studies:

Task 5: Capacity building: training, workshops and beta-testing
A capacity building process is planned to improve the final products and as an important step for the product transfer to the user community.

Status

Third progress report is submitted.

OPTIMIZATION OF THE MEMBRANE SUB-LAYER FOR DEVELOPMENT OF RO MEMBRANES WITH IMPROVED FOULING RESISTANCE

07-AS-005

Principal Investigator

Prof. B. Van der Bruggen, Department of Chemical Engineering, Leuven, Belgium

Participants

Dr. L. Braeken, Department of Chemical Engineering, Leuven, Belgium

KHLimburg, Department Industrial Sciences and Technology, University Campus Diepenbeek, Belgium

M.Sc. Scholar

Mr. Ali Rashed, Libya

Objectives

To improve the stability of operation of reverse osmosis membranes by optimizing the properties of the membrane's sub-layer. This includes the membrane's overall mass transfer resistance (and therefore, its water permeability), and the occurrence of fouling.

TASKS

Task 1: Sub-layer optimization

Asymmetric polyethersulfone sub-layer membranes in the low ultrafiltration – high nanofiltration range will be synthesized for reverse osmosis membranes (molecular weight cut-off 800-1,000) by using the DIPS technique. The properties of the sub-layer will be changed by changing the synthesis parameters (polymer concentration, solvent type, choice of non-solvent, air humidity, temperature, additives). Initially, monolayers on a non-woven support will be used; subsequently, multilayered structures also will be used.

The water flux, pore size and pore size distribution will be used as the optimization parameters for the sub-layers. Fluxes with pure water will be measured for the sub-layer. This should eventually lead to the highest flux and the highest hydrophilicity for the sub-layer; an iterative procedure with back coupling of the pore size and pore size distribution to membrane will be used.

Task 2: Addition of a top layer by in-situ polymerization

A conventional approach will be used to apply in-situ polymerization on the support layers. Well known procedures will be used to this purpose, as described in the literature. Comparison of top layers is not considered. However, it will be necessary to select appropriate conditions during synthesis so that a representative reference is obtained.

Task 3: Assessment of membrane performance

Assessment of membrane performance includes (1) evaluation of the physico-chemical properties of the membrane and its ideal conditions, i.e., determination of the pure water flux and salt rejection using standard filtration conditions, and (2) evaluation of membrane fouling.

The membrane performance will be evaluated experimentally by carrying out filtration tests with the membranes synthesized in task 2, relative to commercial membranes. These experiments will be carried out in a cross-flow filtration unit using flat sheet membranes with a diameter of 0.09 m.

For the evaluation of membrane fouling, synthetic solutions mimicking seawater in terms of ionic composition will be applied. The focus, however, will be on organic fouling; the synthetic matrix will be used as a reference condition only. To this matrix, organic foulants will be added; in contrast to the study of fouling of the sublayers, a series of small organic molecules will be used here; a selection of compounds with molecular weight close to 150 but with a large variation in hydrophobicity will be used. Filtration of “seawater” with addition of small concentrations of one of these compounds will allow to compare the different membranes, relative to commercial membranes.

Status

MSc Scholar joined the university in October 2009.

BORON PRE-TREATMENT FOR SEAWATER AND BRACKISH WATER DESALINATION

08-AS-001

Principal Investigator

Dr. Mushtaque Ahmed, Sultan Qaboos University, Sultanate of Oman

Participants

Mr. Rashid Hamed Al-Belushi, Mr. Mohammed Al-Hassan Mansour and Dr.

Mohammed Nurul Abser, Sultan Qaboos University, Sultanate of Oman

Dr. Hari Vuthaluru and Dr. A. Sathasivan, Curtin University, Australia

M.Sc. Scholar

M.Sc. student from Oman will be involved in this project as a research assistant. A senior undergraduate student from the MENA region currently studying at Curtin University will also participate in the project

Objectives

The proposed research work is targeted at arriving at pre-treatment options and increase membrane efficiency for removal of boron from feed water resources (such as sea water and brackish water). The main objectives for the proposed program are:

- To review the existing approaches for the removal of boron as a possible pre-treatment option for sea water/brackish water desalination.
- Evaluate the feasibility of using coal/fly-ash or cations to remove boron under seawater/brackish water desalination conditions.
- Investigate feasibility of pre-treatment for Boron removal using aluminum oxide.
- Investigate commercially available Boron selective membrane efficiency for brackish water.

Tasks

- A through literature review will be carried out to evaluate various pre-treatment options.
- Selection of two pre-treatment technologies (most probably it would be the use of coal/fly ash or cations) to remove boron under seawater desalination conditions.

- Parametric study to evaluate retention time, pH, and temperature effect under seawater conditions for each of these processes.
- Conduct experiments using FILMTEC NF90-2540 polyamide thin film composite spiral wound membrane under variable conditions (e.g. single pass, second pass, pH control, etc.)
- Column experiments using aluminum oxide as a pre-treatment agent.

Status

Submitted draft final report.

AN INVESTIGATION OF TOTAL COMPOSITION OF SEA WATER IN OMAN

08-AS-002

Principal Investigator

Dr. Feroz Shaik, Caledonian College of Engineering, Sultanate of Oman

Participants

Dr. Nitin Bhaurao Raut and Ms. Sushma, Caledonian College of Engineering, Sultanate of Oman

Objectives

- To collect seawater samples at ten locations in Oman over a period of one year at two different time intervals winter and summer and analyze these samples for complete composition.
- To tabulate the total composition data for the ten locations and submit the report to MEDRC.

Tasks

1. Collect samples of seawater from ten locations in Oman during the Winter and the Summer.
2. Carry out a total composition analysis including the following summarized parameters (total 64 parameters)
   - Hydro-meteorological Information
   - General
   - Particulates
   - Alkalinity & Hardness
   - Nutrients
   - Major Ions
   - Other Inorganics
   - Organic Matter
   - Metals
3. Tabulate the total composition data analyzed for the samples collected at the ten different locations in Oman and briefly describe the methods used for analysis over a period of one year.

Status

First progress report submitted.

NEW DESALINATION PROCESS FOR ENHANCED RECOVERY FROM BRACKISH WATER: SMART SYSTEM UTILIZING ULTRASONIC REFLECTOMETRY (UR) AND FLOW REVERSAL (FR) - PHASE I

08-AS-003

Principal Investigator

Dr. Alan R. Greenberg, University of Colorado at Boulder, USA

Participants

Prof. William B. Krantz, University of Colorado at Boulder, USA

Dr. Jack Gilron, Ben Gurion University, Israel

Dr. Mousa S. Mohsen, The Hashemite University, Jordan

Dr. Kholoud Y. Masahl, The Hashemite University, Jordan

Mr. Ratib Al Adwan, Water Authority of Jordan, Jordan

Mr. Menahem Priel, Mekorot, Israel

Dr. Michael Peterson, University of Maine, USA

Objectives

The overall goal of the project is to combine a novel membrane separation process, flow reversal, with unique detection methodology, ultrasonic reflectometry, to create a successful and practical high-recovery brackish water desalination unit.

Tasks

Task 1: Adaptation and optimization of Flow Reversal to Tapered-Flow RO Desalination through bench scale experiments using synthetic brackish water feeds

Task 2: Adaptation of Ultrasonic Sensors for Control of Flow Reversal through bench scale experiments using synthetic brackish water feeds

Task 3: Development of bench scale combined unit of Tapered Flow RO with Flow Reversal and Ultrasonic Sensors for control

Task 4: Testing of Tapered Flow with Flow Reversal and Ultrasonic Sensors bench scale unit with Real Brackish Water for performance studies and collection of data for the design of pilot scale unit

Task 5: Training of the project partners in operation of the developed Flow Reversal Tapered-Flow RO Desalination bench scale unit and Ultrasonic Sensors for Control and the unit combining these two systems.

Status

First progress report submitted.

TOWARD BETTER CALCITE SCALING UNDERSTANDING IN SWRO

08-AS-004

Principal Investigator

Dr. Maria Kennedy, UNESCO-IHE Institute for Water Education, The Netherlands

M.Sc. Scholar

Mr. Saleh Ali Abd El Hamid Mohamed Saleh, Egypt

Objectives

The main goal of this study is to eliminate the use of chemicals for $CaCO_3$ scaling prevention in SWRO systems through induction time.

Tasks

Experiments will be performed to estimate the scaling potential of artificially prepared (supersaturated) concentrates that simulate typical SWRO plant recoveries (10-50%). Induction times and growth rates of calcium carbonate will be measured in the supersaturated concentrates and the maximum safe recovery in the absence of antiscalants/acid will be elucidated. The induction time will be measured using ICP at various thermodynamic conditions e.g. temperature, flow conditions and ionic interference. Measurements of the induction time for $CaCO_3$ will involve the use of a high sensitivity pH meter to monitor real time changes in pH concentration. The tests will be done on synthetic seawater with ionic constitute resembles that of SWRO concentrate of recoveries range from 10 to 50% with 10% step.

Status

MSc scholar completed course work and started dissertation work.

APPLICATION OF SOLAR ENERGY IN RO PRE-TREATMENT PROCESS – PHASE I

08-AS-005

Principal Investigator

Dr. Feroz Shaik, Caledonian College of Engineering, Oman

Participants

Dr. Nitin Bhaurao Raut, Caledonian College of Engineering, Oman

Dr. Anupam Srivastav, Caledonian College of Engineering, Oman

Objective

To investigate the application of photo catalytic oxidation using solar energy in Reverse Osmosis pre-treatment process

Tasks (Phase I)

1. Extensive literature review on photo catalytic applications especially in desalination process.
2. To conduct feasibility studies for application of photo catalytic mechanisms in RO pre-treatment process.
3. Visit to a major research center where photo catalytic research is under progress especially in the area of desalination.

Status

Draft final report submitted.

DEVELOPMENT OF A SOLAR STILL DESALINATION SYSTEM WITH ENHANCED PRODUCTIVITY

08-AS-006

Principal Investigator

Prof. George Ayoub, American University of Beirut, Lebanon

PhD. Scholar

Ms. Lilian Malaeb, Lebanon

Objective

The objective of this project is to increase the productivity of solar still desalination system while maintaining their simplicity, relatively low cost, and ease of operation and maintenance.

Tasks

1. Setting up the solar still system: Build the experimental still using different materials for the proposed modifications. All the systems are to be constructed taking into account the optimal design parameters as found in the literature.
2. Selecting the best materials for the proposed modification: Compare the performance of the constructed stills in terms of both quantity and quality the distilled water produced.
3. Determining the optimal design characteristics: For the best performing material, further experimental work is required to determine the optimal geometrical and operational parameters relevant to the proposed design
4. Developing a simulation model for the proposed still: The objective is to obtain a descriptive behavior of the proposed solar still by correlating productivity with relevant climatic and operating conditions.
5. Model calibration and validation: The developed model is calibrated based on records of collected data that include technical, operating and climatic conditions
6. Analysis of results

Status

First progress report submitted.

PERFORMANCE EVALUATION AND OPTIMIZATION OF THE BARKA MSF DESALINATION PLANT

08-AS-007

Principal Investigator

Dr. Sabah A. Abdul-Wahab Al-Sulaiman, Sultan Qaboos University, Oman

Partners

Eng. Salim Al-Hatmi, Barka Power and Desalination Plant, Oman
Eng. Mohammed Al-Weshahi, Shinas College of Technology, Oman

Objective

The main objective of the project is to study the performance of the Barka MSF desalination plant and optimize its operating conditions at various loads using a steady state mathematical model.

Tasks

1. Conduct literature survey for collecting better correlations for physical & thermodynamic properties and heat and mass transfer rates in MSF plants.
2. Develop mathematical models that describe the physical phenomena occurring in the MSF process based on the basic principles of chemistry and physics.
3. Identifying the methods to solve the developed model for simulating and optimizing MSF plant operations.
4. Collect the dimensional parameters of Barka MSF desalination plant, its design conditions, performance test conditions during commissioning and current operating conditions
5. Check the developed model with the design data of the Barka MSF plant and evaluate the design data with the performance runs after commissioning the plant.
6. Evaluate performance of the Barka MSF plant with the present operating data.
7. Identify bottlenecks and optimize the Barka MSF plant operations for various loads and evaluate the economic benefits.

Status

Revised draft final report submitted.

Reliability modeling and analysis of a desalination plant

08-AS-009

Principal Investigator

Dr S. M. Rizwan
Caledonian College of Engineering, Oman

Partners

Dr K P Ramachandran, Caledonian College of Engineering, Oman

Dr Gulshan Taneja, Maharishi Dayanand University, Rohtak, India

Eng. Ali Mohammed Al-Balushi, Al Ghubrah Power & Desalination Company SAOC, Oman

Mr A G Mathew, Caledonian College of Engineering ,Oman

Objectives

Develop reliability models on failure and repair of Al Ghubra desalination plant, Muscat Oman and analyze using the mathematical techniques for obtaining important reliability indices.

Tasks

- Review the related literature on the project subject.
- Collection of real maintenance data for Al Ghubra desalination plant.
- Develop and investigate some Reliability models based on real maintenance data for system with finite servers and various types of repair policies.
- Suggest some extended modeling strategies for a good comparison with the existing ones.
- An extensive reliability analysis of the desalination plant / system which in turn is helpful in increasing the uptime of the plant / system.
- Predicting the breakdown and repair possibilities
- Improve the effectiveness of the plant / system.
- An extensive failure analysis of the plant / system.
- Obtaining the important reliability indices numerically.
- An extensive graphical analysis to interpret the results.

Status

First progress report submitted.

NEW PROJECTS AWARDED

Boron content reduction from permeate waters of Hij RO plant

09-AS-002

Principal Investigator

Dr. Maria K. Kennedy, UNESCO-IHE Institute of water education, The Netherlands

Participants

Dr. Jan C. Schippers, Professor emeritus, The Netherlands

MSc. Scholar

Mr. Suleiman Sqalem Khamis Al-Seifi, Oman

Objectives

Boron content in the permeate of Hij RO content is presently high in the range of 1.7 mg/L due to change in the Boron content of the feed water. But the permissible content of Boron in potable water as per Oman standards is 0.5 mg/L. The present study thus concentrate on the reduction of Boron content from the product water of this plant by studying the alternatives like changing the operating conditions of the plant, replacing with the present membranes with appropriate high Boron rejection membranes and also studying the alternative designs.

Tasks

1. Study the plant design, design operating conditions, commissioning data and present operating strategies.
2. Develop strategies for reducing Boron content in the permeate by studying the operating conditions and their boundaries
3. Implementation of the developed operating strategies in the plant and study the technical and economic feasibilities of the new operating strategies.
4. Based on the above study decide whether any other alternatives like replacing the membranes with new high Boron rejection membranes, introducing second pass, introduce other processes like ion exchange to remove Boron from the permeate is required. Evaluate the feasibility, technically and economically the selected alternate.

Desalination of brackish water by photovoltaic in West Bank, Palestine

09-AS-003

Principal Investigator

Prof. Marwan Haddad, Environmental Engineering, An Najah National University, Palestinian Authority

Participants

Dr. Numan Mizyed, Water Management, An Najah National University, Palestinian Authority

Professor Dr. Marwan Mahmoud, Alternative Energy, An Najah National University, Palestinian Authority

Objectives

The overall goal of this project is to provide detailed regional research whilst enhancing the production of potable drinking water in the rural areas of Jeftlik and Zbeidat (Jordan Valley) by desalination of available brackish water through solar energy.

Tasks

The following are the main tasks of this project

- Execution of a field survey for brackish water wells that can be used to provide residents of rural areas with drinking water.
- Categorization of these wells according to salinity, water discharge and the water needs in the well sites. According to such categorization, appropriate sites for the erecting of the PV desalination system will be selected.
- Design of the desalination system and specification of its components.
- Purchase of the system components
- Preparation of the well site and implementation of all civil works necessary for installation of the system.
- Installation, inspection and commissioning of the system.
- Measurements of system parameters and evaluation of results.
- Implementation of techno-economic feasibility study for the system with special consideration given to its social and environmental impacts.
- Workshop on the project findings and results.