amsic 3 The 3rd African Membrane Society International Congress
Dakar, SENEGAL - November 2-5, 2021

The 3rd African Membrane Society International Congress (AMSIC-3) 2021

hosted by

……..

Dakar, Senegal
On
2 – 5 November 2021

Membrane and Filtration Technologies for Sustainable Development

MOT DU DIRECTEUR DE L'ECOLE SUPERIEURE POLYTECHNIQUE

L'Ecole Supérieure Polytechnique de l'Université Cheikh Anta DIOP est heureuse de coorganiser du 02 au 05 novembre 2021 le troisième congrès ordinaire de l'Association Africaine des membranes (AMSIC). Ce choix porté sur notre institution tire sa pertinence du fait que le Laboratoire d'Electrochimie et des Procédés Membranaires (LEPM) de l'Ecole Supérieure Polytechnique (ESP) est l'un des premiers laboratoires de recherche au Sénégal à travailler sur les techniques membranaires. A cet égard, l'ESP est particulièrement honorée de participer pleinement à l'organisation dudit congrès dont l'objectif principal est de mettre en exergue la contribution de la recherche scientifique et technologique sur les membranes au développement durable et à l'évolution des bonnes pratiques à travers le monde.

En effet, ce congrès offre l'occasion aux participants de découvrir les innovations en matière de technologie et de filtration membranaires. En outre, il sera le lieu idéal pour le lancement de formations académiques et professionnalisantes sur les techniques membranaires.

Compte tenu de la pertinence des thématiques qui y seront abordées, j'invite les enseignants, les chercheurs, les doctorants, les étudiants et les acteurs économiques concernés à prendre part à cet important événement qui devrait marquer le renouveau de l'enseignement et de la recherche sur les technologies membranaires qui constituent des solutions d'avenir dans divers domaines tels que l'eau, la santé, l'énergie...

Au nom du recteur de l'UCAD et en mon nom propre, je souhaite la bienvenue au Sénégal, terre de la « teranga », aux participants venant de l'étranger.

PRESIDENT MESSAGE - THE AFRICAN MEMBRANE SOCIETY, AMSIC

This 3rd congress of the African Membrane Society, AMSIC-3, will hold a special place in our memories for several reasons. In spite of an unforgiving COVID-19 pandemic, AMSIC-3 organizers made the challenging decision to schedule an in-person meeting. Indeed, the types of activities we envisioned could only make sense by prioritizing physical attendance, and because building personal connections is critical to effectively promote technological advances on the Continent. To this extent, we are fully indebted to those who have accepted to join us in Africa, and to the many who were not able to travel but have supported us throughout this long journey.

. AMSIC and its partners are convinced that Africa higher education schools should put more emphasis on seeking to develop technical competencies not only for university students, but they can also reach out to the youth with secondary-level education. Hence, we are ready to kick-off a two-day hands-on filtration workshop where a dozen graduate students will learn about membrane desalination technologies - at the Ecole Supérieure Polytechnique/UCAD, October 31st and November 1st. Our objective is to make these training tools available to the youth, to the local business, and to ultimately help strengthen the local industrial eco-system by leveraging membrane processes.

AMSIC venues include a commercial exhibition, an activity that is slowly growing. This year, AMSIC EXPO'21 will feature cutting-edge membrane/renewable energy companies from Europe, as well the main water and sanitation companies from Senegal including ONAS, SONES, SEN'EAU and CASAMANCAISE des EAUX. The organizers seek to build long term relationships with these institutions in order to advance the sustainable development of membrane and filtration sciences in Senegal and elsewhere in Africa. A couple of workshop sessions will be held during AMSIC-3 to encourage synergistic interactions among the various stakeholders by identifying means to secure a steady pipeline of trainees and by funding technician development programs supporting the needs of local companies.

We are thankful to the European Membrane Society -represented by its president professor Anthony Szymczyk – for awarding several prizes to our brightest young scientists and for its enduring support to our network. We also recognize the World Association of Membrane Societies for its close interaction with our network to consolidate teaching strategies in membrane sciences all across Africa.

Despite the SARS-CoV2 pandemic, some forty (40) international participants coming from more than fifteen (15) countries across Africa, Europe and the US have kindly accepted to physically attend AMSIC-3. We are thankful for their efforts and are committed to maintaining safe working practices.

As president of the African Membrane Society, it has been an honor to serve, since 2014, many collaborators and friends that are so dedicated to advance the field of membrane and filtration sciences in Africa and elsewhere across the globe.

We started with thirty (30) members and today two hundred (200) delegates are enjoying AMSIC services, including 25 African nations and other countries in Europe, North America and Asia. As my term will end soon (not my involvement with AMSIC), I would like to convey my deepest feelings of gratitude to AMSIC Board of Directors and congress Chairpersons who have made this journey possible.

It is said that the reward is in the journey, a statement which I wholeheartedly support. We are just scratching the surface of what our network needs to accomplish to effectively promote membrane and filtration sciences in Africa, and AMSIC-3 in Dakar is certainly a step in the right direction. To our visitors, I wish that you will enjoy your stay in Senegal and its unmatched TERRANGA – i.e. reflecting its willingness and capacity to host and honor its guests.

Abdoulaye Doucouré

On behalf of the African Membrane Society

MOT DU PRESIDENT DU COMITE D'ORGANISATION

C'est avec un plaisir immense que le comité d'organisation se fait l'honneur de vous accueillir à la 3ième Conférence Internationale de la Société Africaine des Membranes qui se tiendra du 02 au 05 novembre 2021 au Musée des Civilisations Noires à Dakar au Sénégal.

La Société Africaine des Membranes présente dans 25 pays d'Afrique et la diaspora, s'active autour de sujets d'application stratégique tels que Le dessalement de l'eau de mer, la défluoration des eaux saumâtres, le recyclage des eaux usées en milieu urbain, la potabilisation de l'eau en milieu rurale, l'usage de filtres biomédicales dans les hôpitaux, les mines et la qualité de l'air.

Ce sont là autant de thèmes qui seront abordés par la communauté scientifique lors de cette conférence internationale.

Un comité scientifique se chargera de sélectionner les travaux à publier dans « Journal of Membrane Science and Research ». Egalement, les partenaires industriels nationaux et internationaux qui prendront part à cet événement à travers l'exposition de Kits et d'unités de démonstration feront l'effort de proposer des solutions adaptées aux besoins des populations.

En marge de cette Conférence sur les membranes et les technologies de filtration pour un développement durable, une session de formation de techniciens venant de l'Afrique de l'Ouest est organisée en partenariat avec l'Institut Européen des Membranes de Montpellier. Cette formation porte sur les techniques de montage, de démontage et d'exploitation d'une unité de dessalement.

Le Sénégal consent actuellement d'importants investissements dans le domaine de l'eau et de l'assainissement dont le plus ambitieux est l'usine de dessalement de l'eau de mer en construction à Dakar. L'organisation du 9ième forum mondial de l'eau en 2022 à Dakar, illustre bien ce tournant stratégique amorcé par l'Etat du Sénégal.

En relation avec l'Ecole Supérieure Polytechnique de Dakar et l'Université Assane Seck de Ziguinchor, la Société africaine des membranes espère votre vive participation à ces échanges scientifiques de haut niveau.

Le comité d'organisation se félicite de la participation effective de Monsieur Abdoulaye SENE, Secrétaire Exécutif du 9ième forum mondial de l'eau et de l'invité d'honneur le Professeur Enrico DRIOLI pionnier dans l'ingénierie des membranes pour le dessalement, auteur 800 articles scientifiques, 25 ouvrages sur la filtration membranaire, 22 brevets et fondateur de « ITM » (Institute for Membrane Technology).

Chers participants, le comité d'organisation vous souhaite un excellent séjour au pays de la Teranga.

Professeur Courfia Diawara

AMSIC-3 HONORARY GUEST

We are celebrating Professor **Enrico DRIOLI** for his unmatched accomplishments in the field of membrane science and engineering.

Enrico gave a two-hour online lecture to AMSIC delegate on June 8th, 2021. He will be our Special Keynote Speaker for our first congress in Western Africa.

1 Institute on Membrane Technology (ITM-CNR), National Research Council, c/o The University of Calabria, Cubo 17C, Via Pietro Bucci, 87036 Rende CS, Italy
2 University of Calabria - Department of Environmental and Chemical Engineering, Rende, Italy
3 Hanyang University, WCU Energy Engineering Department, Seoul 133-791 S. Korea
4 Center of Excellence in Desalination Technology, King Abdulaziz University, Jeddah Saudi Arabia

Professor Enrico DRIOLI's pioneering work in the field of membrane engineering and membrane-based desalination, distillation and energy recovery system has contributed to streamline the adoption of membrane processes by the academic and industrial communities. Enrico has authored over 800 scientific papers, 22 patents and 24 books in the field of membrane and filtration sciences. He is also the founding director of the Institute on Membrane Technology of CNR, Italy, and former Dean of the School of Engineering of the University of Calabria (Italy). Enrico is the first president of the European Membrane Society that was founded in 1982

Prof ENRICO DRIOLI's *Research Interests*

1. Science and Engineering of membrane operation
2. Membrane Science and Engineering
3. Process Intensification
4. Integrated Membrane Processes
5. Regenerative Medicine

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Objective of the Conference

AMSIC-3 congress is the premier international venue on the African continent that will simultaneously address key advances in membrane, filtration and sustainable energy technologies. It will be held in Dakar, capital city of Senegal, from November 2 to 5, 2021.

The rich venue will include a technical conference, a commercial exhibition, some panel sessions and several tutorials.

AMSIC and its partners will also share their plan to help training skilled technicians across the African continent. The Western Africa subregion will roll out its Apprenticeship Training Programs for high-school-level Technicians focusing on manufacturing competencies relevant to local industries involved in membrane and filtration systems, water, HVAC ventilation, mineral extraction, and waste management technologies.

AMSIC-3 organizers strive to encourage scientific and technological innovation that will facilitate access to clean water, improved sanitation, better air quality and improved human health in Africa and other regions of the world. The fast-growing demographics and change of ecological landscape facing Africa are bringing to the forefront issues of youth employment and erratic urban center development.

Contributors will have an opportunity to share their knowledge and to comment on implementing membrane, filtration and sustainable energy technologies in the following areas:

- Sustainable water production via membrane and filtration technologies
- Clean air, environmental protection and sustainable filtration strategies
- Wastewater reuse, recycling via membrane & filtration treatment
- Industrials applications for membranes (bioseparation, treatment of chemical, textile and mining compounds)
- Synergistic use of filtration and renewable energies
- Novel membranes and fiberwebs - Sustainable fabrication methods
- Novel characterization/analytical techniques and instrumentation
- Modeling and theoretical tools in filtration and membrane science

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CALL FOR PAPERS

Special issue by *Journal on Membrane Science and* Research:
Membranes for Development and Sustainable Future

The African Membrane Society has created the ***Africa JMSR Editorial Committee, AJEC,*** which is responsible for collecting and screening articles that are deemed to be published in this special issue. The four AMSIC members engaged in AJEC are:

			
Dr Nozipho GUMBI South Africa	**Ms Lina Rim FRADA Algeria**	**Dr Mohamad DIEME Sénégal**	**Mr Misgina TSEHAYE Ethiopia**

- **Dr Nozipho GUMBI**, lecturer at University of South Africa, South Africa
  She manages contributions from authors located in Southern Africa.
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- **Ms Lina Rim FRADA**, PhD student at USTHB, Algeria
  She manages contributions from authors located in Northern Africa.
  Email: fradalina04@gmail.com

- **Dr Mohamad DIEME**, lecturer at University of Ziguinchor, Sénégal
  He manages contributions from authors located in Western Africa.
  Email: mohadieme@gmail.com

- **Mr Misgina Tilahun TSEHAYE**, PhD student, LEPMI, Univ. of Grenoble Alpes, France. He manages contributions from authors located in Eastern Africa.
  Email: misginabcen@gmail.com

The committee encourages researchers in Africa to send their title by the first week of March and email their articles to the addresses above in May. The deadline for paper submission to JMSR is September 30th, 2021.
AJEC is working closely with JMSR Guest Editors to select high quality contributions for this special edition and encourages authors to present their findings during AMSIC-3 venue in Sénégal.

Note from JMSR Guest Editors on this special edition:
Membranes for Development and Sustainable Future
Dear Colleagues,

We are coordinating a special issue covering the superior role of membranes and membrane processes in different aspects of people's life, in the ***Journal of Membrane Science and Research***, in which Professor Bart Van der Bruggen (Belgium), Dr. Asim Khan (Pakistan) and Dr. Abdoulaye Doucouré (USA) are the Guest Editors.
The main theme of this special issue is "Membranes for Development and Sustainable Future". This special issue will be oriented to cover the recent progresses and prospects of membrane technologies for development and sustainable future in a wide range of applications, most preferably in developing countries. This special issue covers both original research papers and critical/comprehensive review papers on all aspects of membrane technology, but biological membranes.
Given your invaluable experience in the field and professional leadership in *Membrane Science and Research*, we would like to cordially invite you to submit a manuscript to this special issue through the webpage of the journal: (http://www.msrjournal.com. **it is important that authors choose the "SI: Membr. for Develop.&Sustain." when reaching the selection for "*Article Type*" in the submission process.** We would be very happy if you could consider accepting this invitation and email us **by March 31st,** with a proposed title to express your interest.
You are welcome to forward this invitation to your colleagues who may be interested. The deadline for manuscript submission is September 30th **2021**. The submitted manuscripts will be fast peer-reviewed. The accepted papers will be then published online very fast with an assigned DOI number. To ensure that all manuscripts are correctly identified for inclusion into the special issue, it is important that you select "**SI: Membr. for Develop.&Sustain**" when you reach the "*Article Type*" step in the submission process.
With Best Regards,

Bart Van der Bruggen
Asim Khan
Abdoulaye Doucouré
Guest Editors

SPONSORS ACKNOWLEDGEMENT

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INFORMATION & COMMUNICATION

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FORMATION PRATIQUE SUR LES TECHNOLOGIES MEMBRANAIRES

Jour 1, Dimanche 31 Octobre

Durée 5 heures, de 9.00 à 12.00 et de 14.00 à 16.00

A. Introduction aux procédés membranaires (1h00) (IEM)

Objectifs : Comprendre la filtration membranaire

- Les procédés membranaires : La membrane, le carter et le pilote de filtration

B Construire un pilote membranaire (2h00) (Patrice Montels)

Objectifs : Montrer les outils permettant de concevoir/réaliser/améliorer les pilotes de filtration

- Choix des matériaux
- Réalisation d'une cuve
- Réalisation d'un chassis
- Circuit haute pression : Tuyau, Raccord, étanchéité et sécurité
- Instrumentations et capteurs

C Travaux pratiques de filtration (2h00) (Geoffroy Lesage/Marc Heran)

Objectifs : Comprendre le fonctionnement d'un procédé membranaire

- Mise en route du pilote (Pompe haute pression et risques associés)
- Montée en pression (Mise en place de la membrane dans son carter et réaliser son étanchéité)
- Paramètres opératoires (Influence de la pression et écoulement tangentiel)
- Mesures débit, qualité eau,

- Interprétation et caractérisation (Besoin conductimètre et chronomètre)
- Comment installer une station pilote de traitement d'eau ?

Jour 2, Lundi 1 Novembre

Durée 5 heures, de 10.00 à 12.00 et de 14.00 à 16.00

A. Configuration et spécificité des membranes de NF et d'OI (2h00) (IEM)

Objectifs : Comprendre la filtration membranaire

- Spécificités des membranes de nanofiltration et d'osmose inverse
- Surface membranaire mise en jeu et configuration des modules spiralés
- Calcul de la perméabilité membranaire
- Impact de la pression osmotique et de la valence des ions
- Impact des paramètres procédés : Pression, température sur les performances
  - Quantité et qualité d'eau produite
  - Bilan en sels
  - Taux de conversion (Y) en fonction de la pression appliquée.
  - Taux de rejet
- Energies mises en jeu
- Pertes de charge longitudinale et transmembranaire

B. Maintenance des procédés membranaires (2h00) (Patrice Montels/Geoffroy Lesage)

Objectifs : Assurer la maintenance d'un pilote de filtration

- Arrêt et (re)mise en route de l'unité membranaire :
  - Maintenance de la pompe
  - Régénération chimique (Lavage des membranes)
  - Hivernage des membranes (Bisulfite)
- Approvisionnement des pièces détachées :

HANDS-ON TRAINING PROGRAM ON MEMBRANE TECHNOLOGIES

DAY 1, Sunday October 31, 2021
Duration 5h, from 9.00 à 12.00 and from 14.00 to 16.00

A) Introduction to membrane processes – (1:00 – IEM)
Objectives: Understanding membrane filtration
Membrane processes: Membrane, filter housing and filtration manifold

B) Building a membrane filtration pilot (2h00) /IEM Technical Manager
Objectives: Showing tools designed to build/assemble / upgrade filtration pilotes

- Choice of materials
- Building a reservoir
- Designing a manifold
- High pressure equipment: hoses, fittings/adaptors, sealing and safety
- Instrumentation and sensors

C Filtration laboratory classes (2h00) (Geoffroy Lesage/Marc Heran)
Objectives: Understanding the principles and operations of membrane processes

- Turning on the pilote (high pressure pump and potential risks)
- Ramping up in pressure - Membrane in its housing and checking the sealing conditions
- Operating parameters (Effect of pressure and tangential flow)
- Flow rate measurement and water quality
- Interpretation and capacitation (tools : conductimeter and stop watch)
- How to install a water treatment pilot station?

DAY 2, Monday November 1, 2021

5 hours, from 10.00 to 12.00 and 14.00 to 16.00

A) Configuration and NF et d'OI (2h00) (IEM)

Objectifs : Understanding membrane filtration

- Specifics of nanofiltration and Reverse Osmosis
- Membrane area in use and configuration of spiral wound module
- Calculating membrane permeability coefficient
- Impact of osmotic pressure and et ionic valence
- Impact of process parameters: Pressure, temperature on filtration performance
  - Quantity and quality of produced water
  - Salts balance
  - Conversion rate (y) as a function of applied pressure
  - Rejection rate
- Energy consumption
- Pressure drop in frontal and cross flow direction

B) Maintenance and trouble shooting of membrane processes (2h00) (Patrice Montels/Geoffroy Lesage)

Objectives : Maintenance of a filtration pilote

- Stop and (re) start of a membrane equipment:
  - Pump maintenance
  - Chemical regeneration (Membrane flushing/washing)
  - Membrane storage and use of preservatives (Bisulfite)
- Sourcing equipment parts:

Plenary sessions in yellow /Keynotes in green / Oral presentations

	SUNDAY OCTOBER 31 (HANDS-ON TECHNICIAN WORSHOP at ESP-UCAD) / REGISTRATION AT THE MUSEUM		
	MONDAY NOVEMBER 1 (HANDS-ON TECHNICIAN WORKSHOP / MEMBRANE COURSE WITH at ESP-UCAD) / REGISTRATION AT THE MUSEUM		
09:00 - 12:30 14:00 - 16:00	**HANDS-ON TRAINING AT ESP-UCAD (IEM. MONTPELLIER - SENEGAL UNIV. & AMSIC)**		
16:30 - 18:30	**INTRODUCTION TO WORLD ASSOCIATION OF MEMBRANE SOCIETIES (MEMBRANE EDUCATION GROUP)**		
	DAY 1 - TUESDAY NOVEMBER 2		
	8:30 - 9:15	AMSIC-3 DELEGATES ARRIVAL	
		HIS EXCELLENCY DR Cheikh Oumar ANNE, SENEGALESE MINISTER OF HIGHER EDUCATION, RESEARCH & INNOVATION	
	9:20- 10:20	Dakar officials (ESP-UCAD, etc) and EM, AMSIC, ONAS, SMMD	
	10:25 - 10:55	**COFFEE BREAK & GROUP PICTURE**	
	ROOM 1	**PLENARY 1 (Inaugural presentation - Chair: A. DOUCOURE)**	
SPEAKER	11:00-12:15 PM	**Cheikh Mbacke DIOP (France-Senegal)**	
SESSION CHAIR VENUE			
	12:20- 14:00	**LUNCH**	
	ROOM 1	**PLENARY 2 (Chair - M HERAN)**	
SPEAKER	14:10 -15:10	**Mihail BARBOIU (France)**	
SESSION CHAIR			
SPEAKER	15:15 - 16:00	**Keynote -A. Y. GEBREYOHANNES (Room 1)**	
		ROOM 1 (chair : A. SZYMCZYK)	ROOM 2 (chair : Sidy BA)
SPEAKER	16:10 -16:30	**Walid Ghamri, Patrick Loulergue, Irena Petrinic, Claus Hélix-Nielsen, Maxime Pontié, Noureddine Nasrallah, Kamel Daoud and Anthony Szymczyk ;** Impact of sodium hypochlorite on biomimetic aquaporin forward osmosis membranes	**Raja Ben Amar;** Ajer Aloulou: New Kaolin based microfiltration membrane supported on natural sand for the removal of oil and heavy metals from electroplating wastewater
	16:35- 16:45	**COFFEE BREAK**	**COFFEE BREAK**
SPEAKER	16:50 - 17:10	**Gaetan Blandin, Federico Ferrari, Quim Comas, Ignasi Rodriguez-Roda, Geoffroy Lesage, Marc Heran and Xavier Martinez** ; Opportunities and challenges to implement forward osmosis to combine nutrients concentration and water recycling	**Abdoulaye Tamba; Mady Cisse**: Membrane-based technologies as a promising tool for purifying and concentrating betacyanins
SPEAKER	17:15 - 17:35	**Mohamad Dieme, Amadou Dieye, Mouhamadou Diallo, Saidou N Diop, Courfia K. Diawara**: Renewable energy-powered membrane process for the removal of excess fluoride ions and safe drinking water supply in rural areas.	**El Hadji Dieye;** Synthesis of new polyanilines doped with ionic liquids for the elimination of heavy metals by electrodialysis technique
	19:30 - 20:50		END OF SESSION **DINNER**

Room 1
200 SEATS
Room 2
50 SEATS
Room 3
50 SEATS

Plenary sessions in yellow /Keynotes in green / Oral presentations

		DAY 2 - WEDNESDAY NOVEMBER 3	
	ROOM 1	PLENARY 3 (Chair: A. DOUCOURE)	
SPEAKER	08:30- 09:25	**Andrea SCHAEFER (Germany)**	
SESSION CHAIR		ROOM 1 (chair A. DOUCOURE)	
SPEAKER		**WORKSHOP: SPONSORING TECHNICAL TRANING PROGRAMS SUPPORTED BY AFRICA CAMPUSES (AMSIC)**	
SESSION CHAIR	9:30 - 9:55	**Keynote - H. SUTY (Room 1)**	
SPEAKER			
SPEAKER	10:00 - 10:40	Technician programs led by Africa campuses	
SPEAKER			
SPEAKER	10:45 - 10:55	COFFEE BREAK	
SPEAKER	11:00- 12:25	Technician programs led by Africa campuses	
	12:30 - 13:45	**LUNCH**	
SPEAKER			
	ROOM 1	PLENARY 4 (Chair : C. DIAWARA)	
SPEAKER	14:00 -14:55	**Abdoulaye SENE (Senegal)**	
SESSION CHAIR			
	15:00 - 15:30	**Keynote ALAMI-YOUNSSI**	**Keynote - M. HERAN**
SPEAKER		ROOM 1 (chair : R. BEN AMAR)	ROOM 2 (chair : Sidy BA)
	15:35 - 15:55	**Youssef-Amine Boussouga, Akhil Gopalakrishnan and Andrea Iris Schäfer ;** Arsenic (III, V) removal from water via nanofiltration: role of water chemistry variation and organic matter	**Soumana Gagara, Mustafa El Fatih and Ismael Abdelhamid** ; Wastewater management improvement in the UNAMID headquarter in central Darfur, Zalinger, Sudan
SPEAKER		**Amina Ramdani, Mohamed Ayman Kammoun, Sana Gassara, Saidou Nourou Diop, Courfia Diawara, Safia Taleb, John Palmeri and Andre Deratani** ; Fluoride transport in nanofiltration membranes : experimental and modeling investigation	**Jin Taira;** From the islands as anthropocene laboratories to the contextualization in the African continent.
	16:00 - 16:20		
SPEAKER	16:25 - 16:35	COFFEE BREAK	COFFEE BREAK
	16:40- 17:00	**Mehran Aliaskari and Andrea Iris Schäfer ;** Electrodialysis (ED) for nitrate, arsenic (V) and fluoride removal from brackish ground water	**Richard C. Ehiri, Emmanuel Nwaeze and Peter A. Ebokaiwe** ; Factor interactions, modeling and optimization of biodiesel production from waste cooking oil
SPEAKER		**Imen Khouni, Ghofrane Louhichi, Ahmed Ghrabi and Philippe Moulin** ; Highly efficient vegetable oil refinery wasterwater treatment using hybrid coagulation/floculation–membrane filtration process: a pilot study	**Adama Tolofoudye**; Environmental imapct of acid mine drainage in Western Africa in the context of a growing footprint from the extractive industries
	17:05 - 17:25		
	17:30- 17:50	**Arona Dolo**, Adama Tolofoudye, Abdoulaye Doucoure and Raja Ben Amar; Treatment of wastewater streams from tanneries using ulectrocoagulation technology	**Ameen Babatunde Abdulrahman ;** Physicochemical analysis of leachate from municipal solid wastes landfills in Ilorin metropolis Kwara State Nigeria
	17:50 - 18:05		**Ameen Babatunde Abdulrahman** ; Generation, composition and some physicochemical characteristics of municiapl solid waste (MSW) in Ilorin - Nigeria
	18:00 -19:00		END OF SESSION
	19:30 - 20:55		**DINNER**
	21:00 - 22:30	PROFESSIONAL SOCIETIES AMSIC, IWA, WAMS. etc	

Room 1
200 SEATS
Room 2
50 SEATS
Room 3
50 SEATS

Plenary sessions in yellow /Keynotes in green / Oral presentations

DAY 3 - THURSDAY NOVEMBER 4

		ROOM 1	ROOM 2	ROOM 3
	ROOM 1	PLENARY 5 (Chair: M BARBOIU)		
SPEAKER	08:30 -09:30 AM	Anthony SZYMCZYK (France)		
SESSION CHAIR				
SPEAKER	09:30 - 10:15	Keynote - E. DRIOLI	Keynote - E. DRIOLI (Room 1)	Keynote - E. DRIOLI (Room 1)
	10:15 - 10:30	COFFEE BREAK	COFFEE BREAK	COFFEE BREAK
	10:35 - 10:55	Keynote - C. DIAWARA	Keynote - C. DIAWARA (Room 1)	Keynote C. DIAWARA (Room 1)
		ROOM 1 (chair A.Y. GEBREYOHANNES)	ROOM 2 (chair: M. DIEME)	ROOM 3 (chair: M. CISSE)
	11:00 - 11:20	**Youssef-Amine Boussouga, Bryce S. Richards and Andrea Iris Schäfer** ; Resilience of small-scall solar powered membrane filtration systems for fluoride removal from brasckish water	**Sara Ouali, Patrick Loulergue, Pierre-François Biard, Noureddine Nasrallah, Rachida Maachi and Anthony Szymczyk** ; Comparative study on the resistance of NF membranes exposed to ozone	**Membrane, Desalination, Sanitation, Hygience : Opportunities & Challenges in Africa**
STUDENTS IN RED	11:25 - 11:45	**Yang-Hui Cai and Andrea Schäfer** ; Scaling and osmotic backwash cleaning in a batteryless photovoltaic-powered nanofiltration/reverse osmosis system	**Abdoul Wahab Nouhoum Moussa :** Beverage industry wastewater treatment by anaerobic membrane bioreactor in a Sahalian climate	**Javier Acerte (CANARY ISLANDS)** : Background in PV-RO desalination – ICT experience in implementing the DE-SOL system
	11:50 - 12:10	**Bryce S. Richards** ; Photovoltaic powered membrane filtration systems for brackish water treatment in Africa: energy storage considerations	**Qazi Sohaib, Geoffroy Lesage, Jean-Pierre Mericq and Marc Heran** ; Biogas recovery from anaerobic membrane biorector effluent using membrane contactor	**SEN'EAU/SUEZ company** : Key water development programs in Senegal
	12:15 - 12:35	**Ameen Babatunde Abdulrahman** ; Generation, composition and some physicochemical characteristics of municiapl solid waste (MSW) in Ilorin - Nigeria		**ONAS company Abdoulaye Mallo GUEYE** - Management of Senegal Industrial Waste Water **SONES company** - **Ada Ndao**, Ousmane Coulibaly: First Reverse Osmosis desalination plant in SENEGAL
	12:30 - 13:50	LUNCH		
	ROOM 1			
SPEAKER	14:00 -14:30 PM			
SESSION CHAIR				
EVENT	15:00 - 15:25	SITE-SEEING EVENTS: National Sanitation Office of Senegal (ONAS) / National Office of Senegalese Water (SONES)		
	15:30- 15:55			
	16:00 - 16:25			
	16:20 - 16:30			
	16:35 - 16:50			
	16:55 - 17:10			
	17:30			
	19:30 - 20:55	DINNER GALA (Enrico DRIOLI, Italy - HONORARY GUEST)		
	21:00 - 22:30	POSTER SESSION		

Plenary sessions in yellow /Keynotes in green / Oral presentations

DAY 4 - FRIDAY NOVEMBER 5

	ROOM 1	**SELECTION OF BEST PRESENTATIONS (JURY COMMITTEE ONLY)**
SPEAKER	8:30- 9:00	
		PLENARY 6 (chair -M. CISSE)
SPEAKER	09:10 - 10:00	**Raja Ben AMAR (Tunisia)**
SESSION CHAIR		
	10:05- 10:35 AM	**Keynote - A. DOUCOURE (Room 1)**
	10:40 - 10:55	**COFFEE BREAK & GROUP PICTURE**
	11:00 - 11:15	**Closing -1**
	11:15- 11:30	**Closing -2**
	11:30 - 12:00	**Closing -3** **AWARDS and AMSIC-4 announcements**
	12:15 - 14:00	**LUNCH**
	TECHNICAL SITES	**SITE TOURS (campus visits; touristic venues, lerisure, etc.)**
	17:30	PROFESSIONAL SOCIETIES (IWA, AMSIC, Others)
	19:30 - 21:00	**DINNER**

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PLENARY

LES ENJEUX DU 9ÈME FORUM MONDIAL DE L'EAU POUR SÉCURISER L'EAU POUR LA PAIX ET LE DÉVELOPPEMENT

Abdoulaye SENE

Executive Secretary of the 9th World Water Forum
Former Member of the National Assembly (2007-2012)
President of the Commission for Development and Land Use.
Former Chairman of the Board of Directors of SOGEM/OMVS (2013-2017)
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Le Sénégal et le Conseil mondial de l'eau organiseront le Forum à Dakar du 21 au 26 février 2022, sous le thème « La sécurité de l'eau pour la paix et le développement ».L'ambition du Sénégal et du Conseil Mondial de l'Eau est d'organiser un Forum efficace, aux niveaux social, politique et économique; un Forum qui sera un catalyseur d'action pour accélérer l'accès universel à l'eau et à l'assainissement ; un Forum connecté et lié aux agendas et engagements mondiaux liés aux ODD, à l'Accord de Sendai, à l'Accord de Paris sur le climat, à l'Agenda 2063 de l'Afrique, etc.

Le processus préparatoire du Forum « Dakar 2022 » intervient dans un contexte particulier avec la propagation du coronavirus Covid-19. L'eau est vitale pour la santé et donc pour la vie. Ce qui se passe actuellement avec le Covid-19 l'illustre et le confirme parfaitement. Sans eau en quantité et qualité suffisantes, il sera impossible de faire face à cette menace mondiale majeure.

Le 9ème Forum Mondial de l'Eau sera global, mais aussi contextualisé, ancré sur les principaux enjeux de l'eau du monde, mettant au cœur les préoccupations des citoyens dans leur diversité régionale. Il abordera les quatre priorités suivantes : (1) Sécurité de l'eau et de l'assainissement ; (2) Coopération ; (3) L'eau pour le développement rural ; (4) Outils et moyens (y compris finance, gouvernance, innovations et connaissances).

Le Forum est aussi l'occasion de trouver des réponses à la répartition inégale des ressources en eau ; la sécheresse et le changement climatique et le faible accès à l'eau potable et à l'assainissement dans de nombreuses zones rurales et périurbaines. Ces aspects représentent des obstacles à la réalisation de la sécurité de l'eau en Afrique. Par conséquent, nous devons travailler ensemble pour veiller à ce que ces questions soient prises en compte dans le processus préparatoire.

En effet, la pandémie de COVID-19 indique l'urgence de mettre la question de l'eau au cœur de l'agenda politique mondial et de mobiliser la communauté internationale dans toute sa diversité, et à tous les niveaux.

En présentant les enjeux politiques du Forum, cet article montrera comment le Forum prend en compte les dimensions de la politique nationale de l'eau, si l'on sait que la question de la qualité de l'eau est un enjeu majeur pour assurer l'accès universel à l'eau à l'horizon 2030

Le 9ème Forum Mondial de l'Eau offre une opportunité unique de partager des innovations réussies telles que la gouvernance et la coopération transfrontalière dans les bassins fluviaux tels que ceux du Sénégal et de la Gambie, mais aussi d'apprendre des expériences afin de construire des politiques publiques robustes et efficaces pour une gestion durable de l'eau afin de promouvoir la paix pour un développement social et économique durable au profit des populations.

The *African Membrane Society* (AMSIC) is headquartered at the *Ecole Nationale d'Ingénieurs Abderhamane B. Touré* (ENI-ABT) located at 410 avenue Vollenhoven, BP 242, Bamako – Mali Links: ENI-ABT at https://www.eni-abt.ml/ and AMSIC at http://www.sam-ptf.com/

DEVELOPMENT OF MESOPOROUS COMPOSITE CERAMIC MEMBRANES FROM LOW COST MATERIALS: APPLICATION TO WATER TREATMENT

Professeure RAJA BEN AMAR

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One of the challenges for development of inorganic membranes are to produce low-cost membranes from natural materials such as clay, Sand, Zeolite and apatite which are in abundance, need lower firing temperature than pure metal oxide and subsequently, low energy consumption. In this presentation, particular attention is paid to the development and application of new low cost porous ceramic membranes made particularly from natural materials and also from nanocomposites of clay for nanocomposite UF membrane preparation. In this case, the mesoporous active layer is deposited on tubular microporous supports via several techniques such as dip-coating or layer - by- layer.

The efficiency of the prepared membranes is evaluated by the application to the treatment of different types of wastewater coming from different sectors, for water desalination and remediation of industrial effluents.

CHALLENGES TOWARDS PRACTICAL APPLICATION OF ANAEROBIC MEMBRANE BIOREACTOR FOR MUNICIPAL WASTEWATER TREATMENT

Professor XIA HUANG

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https://www.tsinghua.edu.cn/enven/info/1052/2012.htm, xhuang@tsinghua.edu.cn

Anaerobic membrane bioreactor (AnMBR) is a proming green technology in municipal wastewater treatment since it can effectively convert organcis in wastewater to biogas and provide high-quality effluent.

However, stable operation at ambient temperature, cost effective fouling control stratagies, dissolved methane recovery, integration with additional functions such as nitrogen removal and phsophorus recovery are still challenges towards practical application of AnMBR.

This presentation will sumarize the current status of AnMBR technology for municipal wastewater treatment. The key bottlenecks and future challenges will be also addressed

NANO-MEMBRANE HYPERBRANCHED POLYMER INTEGRATED SYSTEMS FOR WATER REMEDIATION

Senior Lecturer SORAYA M. MALINGA

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https://scholar.google.co.za/citations?user=JvBx_kEAAAAJ&hl=en,
https://www.scopus.com/authid/detail.uri?authorId=57191952259, smalinga@uj.ac.za

Water scarcity has become a major constraint globally. This situation has been further aggravated by the introduction of harmful foreign substances into most natural water systems. Among these highly toxic pollutants, bisphenol A (BPA), Organic dyes, polychlorinated biphenyls and pesticides.

In this presentation, photocatlytic membranes, biocatalytic membranes and catalytic membranes are presented as a solution to eradicate these pollutants from water.

DECENTRALIZED RENEWABLE ENERGY POWERED MEMBRANE FILTRATION SYSTEMS: IMPLEMENTATION POTENTIAL AND CHALLENGES IN AFRICA

Professor ANDREA IRIS SCHÄFER

Director of the Institute for Advanced Membrane Technology (IAMT) at the Karlsruhe Institute of Technology (KIT).
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Membrane processes such as nanofiltration and reverse osmosis directly coupled with renewable energy such as photovoltaics present enormous opportunities in Africa. This enables the utilization of brackish water, naturally or anthropogenically contaminated water to be utilized to enhance drinking water – and provide water that is fit for purpose for irrigation, animal feeding and washing. Mirobiological contamination through typically unintended wastewater reuse or open defecation in rutal area is retained using a dual barrier concept.

Advanced technology to achieve high quality drinking water is feasible, while high infrastructure implementation and maintenance costs for conventional centralized system scan be saved. High water quality, high system resilience, and environmental sustainability speak for the technology.

Technical sustainability remains a challenge with operation & maintenance through qualified personnel, water distribution and monitoring and local business plans remain resolvable challenges. The talk will give an overview of experience based on research in Tanzania and invite collaboration for both research and implementation.

1. *Boussouga, Y.-A. ; Richards, B.S. ; Schäfer, A.I. ; (2020) Renewable energy powered membrane technology: System resilience under solar irradiance fluctuations during the treatment of fluoride-rich natural waters by different nanofiltration/reverse osmosis membranes, Journal of Membrane Science, 617, 1 January 2021, 118452. doi.org/10.1016/j.memsci.2020.118452*
2. *Schäfer, A.I. ; Shen, J. ; Richards, B.S. (2018) Renewable energy powered membrane technology: Removal of natural organic matter and fluoride in Tanzanian communities, npj Nature Clean Water, 24, 1-10. Doi.org/10.1038/s41545-018-0026-6*
3. *Schäfer, A.I. ; Hughes, G. ; Richards, B.S. (2014) Renewable Energy Powered Membrane Technology: A Leapfrog Approach to Rural Water Supply Technologies in Developing Countries? Renewable and Sustainable Energy Reviews, 40, 542–556. doi.org/10.1016/j.rser.2014.07.164*

ARTIFICIAL WATER CHANNELS- TOWARD BIOMIMETIC MEMBRANES FOR DESALINATION

Researcher MIHAIL BARBOIU

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This lecture discusses the incipient development of the first artificial water channels systems. We include only systems that integrate synthetic elements in their water selective translocation unit. Therefore, we exclude peptide channels because their sequences derive from the proteins in natural channels.

We review many of the natural systems involved in water and related proton transport processes. We describe how these systems can fit within our primary goal of maintaining natural function within bio-assisted artificial systems. In the last part, we present several inspiring breakthroughs from the last decade in the field of biomimetic artificial water channels. All these examples demonstrate how the novel interactive water-channels can parallel biomolecular systems.

At the same time these simpler artificial water channels offer a means of understanding water structures useful to understanding many biological scenarios. Moreover they can be used for the preparation of highly selective membranes for desalination.

STATE OF THE ART OF SCIENTIFIC RESEARCH IN AFRICA

Researcher CHEIKH M'BACKE DIOP

Association KHEPERA,

After sharing an overview of the history of sciences and techniques in Africa, challenges specific to research and development on the Continent will be addressed in consideration of today's globall context.

ELECTROKINETIC CHARACTERIZATION OF MEMBRANES: PAST, PRESENT AND FUTURE

Professor ANTHONY SZYMCZYK

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The zeta potential of membranes can be inferred from electrokinetic methods such as streaming potential and streaming current. Since these techniques permit to consider the compensation of the surface charge by the ions within the electrical double layer on the liquid side of the interface, they are particularly useful when investigating problems of practical relevance. Assessing the zeta potential of membranes is particularly attractive to provide insight into the charge formation process of membrane surfaces but also to investigate surface functionalization, fouling, ageing... From the experimental point of view, the easiest way to perform the electrokinetic characterization of membranes is to implement transversal (i.e. through-pore) measurements. However, the multilayer structure of many membranes makes the determination of the skin layer properties quite tricky. In order to overcome this issue, tangential measurements (streaming potential or streaming current) based on the application of a pressure gradient along the membrane skin layer have been developed and have become the most widely used method for determining the zeta potential of membranes.

However, complications have been pointed out when such tangential electrokinetic measurements are applied to membranes for which a part of the experimental signal is likely to pass through the membrane matrix (and not only on the external surface of the skin layer) [1]. This parasitic contribution to the experimental signal, referred to as electrokinetic leakage [2], has been largely overlooked in the literature although it may lead to a relatively inaccurate determination of the zeta potential or even to misleading conclusions about the surface properties of membranes. However, relevant information on the membrane matrix can extracted from electrokinetic leakage since the membrane is crossed by this parasitic phenomenon. Thus, we will show that electrokinetic leakage can be used as a probe for investigating various phenomena occurring inside the membrane matrix, paying special attention to fouling and ageing issues.

1. A. Szymczyk, Y. Ibrahim Dirir, M. Picot, I. Nicolas, F. Barrière, J. Membr. Sci. 429 (2013) 44-51.
2. C. Rouquié, S. Liu, M. Rabiller-Baudry, A. Riaublanc, M. Frappart, E. Couallier, A. Szymczyk, J. Membr. Sci. 599 (2020) 117707.

Keynote

DECENTRALIZED MEMBRANE TECHNOLOGY OPTIONS FOR SAFE WATER PROVISION IN DEVELOPING ECONOMIES – A REVIEW OF CURRENT TECHNOLOGIES

Professor LINGAM PILLAY

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Many developing economies face a major challenge in terms of meeting the SDG of safe water provision to their citizens. Membrane technology can play a major part in redressing this issue. However, on viewing current membrane water treatment systems in so-called ' first world economies', decision makers in developing economies often conclude that ' membrane technology is too expensive or too complex for us'.

This presentation aims to disrupt that viewpoint, and indeed demonstrate that decentralised membrane technology systems, designed specifically for the realities of developing ecocomies, can be significantly more attractive than conventional water treatment processes.

The presentation will address :

(1) The Philisophy of decentralised systems, and how this is highly applicable to developing economies ;

(2) a critical review of current decentralised membrane water treatment systems available internationally ; and (3) identification of research and design bottlenecks that need to be addressed. The presentation should hopefully be of interest to water practitioners, decision makers and water scientists and enginers.

AIR FILTER STANDARDS AND WHAT YOU NEED TO KNOW

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Abstract
Built environments are being added at a rapid pace around the world, both for residential and commercial use. While there is more familiarity with air conditioning, there is growing interest in the air quality of the indoor air. The required air quality is usually achieved by means of air filters. The performance of these filters is established by filter test standards. There are ISO standards as well as numerous national standards that it is confusing even for experts in the field. This paper will provide an overview of these standards, from their basis to classification schemes, as well as provide guidance on their intended application. After all the first step in acquiring the right product is to understand what product will verifiably do

ROLE OF MEMBRANE SCIENCE AND TECHNOLOGY IN ACTUALIZING UN SUSTAINABLE DEVELOPMENT GOALS

Professor M. DARAMOLA

Dept head Michael Daramola
University of Pretoria, South Africa

Within the framework of the UN Sustainable Development Goals (SDGs), responsible resource production and consumption in a way that preserves ecological footprint coupled with challenge to meet the needs of the growing population while minimising the pressure on the planet will be the great challenge of engineers and scientists.

Thus, development and application of energy-efficient and economically viable membrane materials and processess will facilitate development of circular economy (CE), that is regarded as a resource optimisation concept that stimulates conservation of materials, energy and other resources by reducing, reusing and recycling, thereby accelerating the realization of the SDGs, in particular goal 6

Recently, research efforts have been directed at eliminating or minimising the negative ecological footprints of unsustainable industrial activities by treating, reducing, reusing and recycling waste materials (solid/liquid/gas) via membrane science and technology. Presence of energy-efficient membrane processes could be instrumental to beneficiating and creating value-added commodities from these waste products. These efforts are integral to the circular economy concepts. Therefore, this lecture will highlight some thought-provoking research activities in this area.

MEMBRANE TECHNOLOGIES: STATE OF THE ART AND AREAS OF FUTURE INNOVATION

Val FRENKEL

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The most recent climate challenges, global warming, water level rise, droughts, natural disasters affected many parts of the world and all these challenges affected water supplies.
Membrane technologies offered one of the most desired solutions when facing recent challenges. Membrane technologies infiltrated into every corner of water and wastewater treatment such as municipal and industrial water, advanced wastewater treatment and reuse, sea and brackish water desalination. The major reasons are the unique features that membrane technologies can provide for the treatment solving the water shortage which is in close association with a global climate change. This trend accelerated the growing rate of membrane market currently and the expected growth in the coming years.
While membranes became the "new norm", there is still room for improvements: reduce the energy and reduce the fouling. Significant progress has been done, and new concepts are "knocking the doors".

OPPORTUNITIES AND CHALLENGES TO IMPLEMENT FORWARD OSMOSIS TO COMBINE NUTRIENTS CONCENTRATION AND WATER RECYCLING

G. BLANDIN[1], F. FERRARI[2], J. COMAS [2,3] , I. RODRIGUEZ-RODA[2,3] , G. LESAGE[4], M. HÉRAN[4], X. MARTINEZ[1]*

1 Eurecat, Centre Tecnològic de Catalunya, Water, Air and Soil Unit, Manresa, Spain.
2 Catalan Institute for Water Research (ICRA), Girona, Spain
3 Laboratory of Chemical and Environmental Engineering (LEQUIA), University of Girona, Girona, Spain
4 Institut Européen des Membranes, UMR5635, Montpellier, France.

Forward osmosis (FO) and its unique feature (high rejection, no hydraulic pressure, low fouling propensity) opens the door for the treatment of complex streams with the double interests of concentrating feed water components while allowing permeation of high purity water. Such functionalities are of high interest for wastewater (WW) treatment in the context of circular economy, pushing towards concentration of nutrients and water recycling. This work presents 5 years of investigations where FO was evaluated in various schemes such as osmotic membrane bioreactor, as pre/post treatment of anaerobic digestion, concentration of greywater combined with fertigation and microalgae concentration. WW concentration rate up to 30 times was successfully achieved with high rejections of all tested compounds including small organics (VFA, trace organic contaminants (TROCs)…) confirming FO as a promising concentration technology and a strong barrier to pollutants. However, key challenges such as salinity increase in the feed, selectivity to nutrients and salts, degradation of organics during the concentration step, fouling and clogging needs to be addressed through specific process design and appropriate operation.

Keywords: Forward osmosis; nutrients recovery; water reuse

RESEARCH WITH A PURPOSE

Senior Lecturer Dr HEIDI RICHARDS

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Globally water resources are under threat due to the impact of factors such as climate change, pollution and increased population and industrialisation, to name a few. This presents a multitude of complex, interconnected problems that cannot be solved through the efforts of one discipline alone. In order to address these problems as scientists, it is important to be able to identify projects where we can make the most impact and where we can make a difference for those in need of these interventions, whether its industry or the community.

In this presentation, current research projects based on polymer membrane systems, that are geared toward addressing immediate challenges and show promise for future application in industry and communities, will be shared. These projects include technical innovations, as well as international projects with key collaborators. The role and importance of capacity building within these projects will also be touched on and some success stories shared.

LIMITING THE INTERACTIONS BETWEEN NANO/MICROPLASTICS AND WATER FILTRATION MEMBRANES USING PLASMA SURFACE TREATMENT

Prof/Dr LUDOVIC DUMEE

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The contamination of worldwide waters and ecosystems by plastic litter has turned plastic pollution into a serious environmental problem. Among all plastic pieces, microplastic fragments and fibers constitute a real threat for aquatic species and human health. Although a growing number of studies have investigated the environmental impact of nano/microplastics, knowledge on the occurrence and behavior of nanoplastics (NPs) and nanofibres (NFs) in water is limited. Common analytical methods are not appropriate to detect and analyze NPs and NFs due to their shape and nanometer size. The main concern relies on the fate of NPs and NFs through water treatment plants since processes used to treat water can be impacted by the presence of these nano-sized fragments and fibres, such as ultrafiltration membranes. Membrane can suffer from fouling due to the adsorption of species on their surface which decreases their filtration performance, however, the fouling mechanism of NPs and NFs remains unclear. Investigating the fouling of NPs and NFs on filtration membranes is therefore necessary to develop a solution preventing fouling from occurring and keep membrane performance to a high level.

The present work aims at studying the fouling of poly(ethylene) fragments and textile poly(ester) fibres on commercial ultrafiltration membranes. The membrane surface was subsequently enhanced by plasma polymerization to induce the repulsion of fragments and fibres from the membrane surface. Fouling mechanism was followed by measuring permeate water flux and turbidity measurements were combined to optical imaging to quantify the amount of fibres in water. Nanoparticle Tracking Analysis was used to quantity the amount of fragments in water. Membrane surface properties such as roughness and hydrophilic were assessed before and after filtration to understand the impact of NPs and NFs on the structural and chemical properties of the membrane. Results suggest that the plasma layer reduced the fouling of NPs and NFs by decreasing the amount of NPs and NFs adsorbed on the membrane which kept permeate water flux decline to a low value.

VALORIZATION OF NATURAL MATERIAL IN DEVELOPMENT OF NEW CERAMIC MEMBRANES. APPLICATION TO ENVIRONMENT PROCESS

Professsor Saad ALAMI YOUNSSI

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In recent years, various removal methods have been developed for the treatment of pollutants containing in wastewater such as chemical precipitation, membrane filtration, adsorption, dialysis/electrodialysis…

Among this methods, we choose to work with ceramic microfiltration and ultrafiltration membranes made from natural material: phosphate, clays... due to its abundance in Morocco.

The filtration test of salts solutions performed with different ultrafiltration ceramic membranes show that salt rejection depend on the charge of the ions, pH, salt nature and concentration. The rejection mechanism depends on the relative ratio of the coulombic, dielectric and hydration interaction between the material and the ionic species.

We will focus in this presentation on the elaboration and characterization of microfiltration and ultrafiltration ceramic membranes and their application to remove salts and textile dyes in water.

HYDROPHILIC ADDITIVE IMMOBILIZATION ON POLYSULFONE MEMBRANE USING RADICAL INITIATED CROSS-LINKING

A/Prof. Céline Pochat-Bohatier

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Poly(vinyl pyrrolidone) (PVP) immobilization by radically-initiated crosslinking using potassium persulfate (KPS) was studied in view of obtaining polysulfone (PSU) membranes with long-lasting surface hydrophilicity. Reducing the hydrophobicity of polymeric materials allows the preparation of membranes with improved flux and fouling resistance.

PSU membranes with PVP as hydrophilic additive were prepared by non-solvent induced phase separation (NIPS) process. A method based on ATR-FTIR technique was developed to discriminate cross-linked PVP from unreacted PVP in the membrane. The crosslinking progress was investigated as a function of temperature, KPS concentration and reaction time.

The effect of the degree of PVP crosslinking on the structure and properties of the prepared membranes was examined by studying mechanical properties, morphology by SEM, surface hydrophilicity by contact angle measurements and water permeability of the prepared membranes

ASSESSMENT OF ATMOSPHERIC EMISSIONS FROM DEOILING PROCESS AND TREATMENT OF REJECT WATER

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The deoiling process is an essential treatment in the petroleum industry. The rejected wastewater resulting from the crude oil and gas production goes through a pretreatment in the sedimentation basin, before complete evacuation towards the sewers. The elimination of pollutants mainly oil and metals, from oily water are always accompanied by atmospheric emissions. However, the characterization before treatment shows that reject water is charged with oxidable matters with high chemical oxygen demand COD.

The total suspended solids TSS are also too high, so the effluent is classified as very turbid. An acidic pH and high concentrations of Ca2+ and Mg2+ give a very significant hardness. Sulfates, nitrates, and nitrites are existing in high concentrations. Most contaminants present in the reject water are not easily biodegradable.

This work aims to evaluate the air emissions in the deoiling station and treat a rejected water. The simulation results obtained for air emissions are too low, which meets national and international standards. A series of treatments for the reject water is carried out to reduce the suspended matters and eliminate the traces from dissolved hydrocarbons, such as coagulation-flocculation, adsorption on the activated carbon, catalytic reduction on activated carbon, and filtration on the sand.

The characterization of wastewater after treatment using the catalytic reduction on activated carbon gives the best results. The effectiveness is 98.88% for traces of hydrocarbons, 97% for COD, 100% for turbidity, and 94.67% for TSS. The efficiency treatment of the effluent by a series of processes (coagulation-flocculation-adsorption-ultrafiltration) is evaluated by the reduction rates of pollution, which reach more than 99% for turbidity and suspended matters.

MEMBRANE TECHNOLOGY HAS A ROLE TO PLAY FOR A MORE SUSTAINABLE WATER MANAGEMENT

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Scientists, engineers, companies, governments are all looking at a more sustainable development. Water sector is strongly concerned: is it possible to provide the growing amounts of water needed for domestic consumption, for agriculture, for industry? Is it possible to treat the increasing amounts of domestic wastewater and industrial effluents at the high level of quality required?

We need a better management of water and we need simultaneously new sources of fresh water. Seawater is presently the first source but domestic wastewater and industrial effluents are more and more considered as a potential source of water through recycling and reuse.

Several examples show the feasibility of this approach that requires an optimization for complying with the simultaneous need of sustainability. For desalination, membrane technology (RO) is definitely the best solution but there is room for improving the sustainability of the process.

For drinking water production, membrane technology appears more and more as the best available technology due to its performance concerning microorganisms and micro pollutants removal.

For domestic wastewater and industrial effluents, Membrane Bioreactor is today a mature technology in rapid expansion. The treated effluent is ready for reuse following an additional step of treatment depending upon the kind of application. Several industrial sectors are presently involved in this process of "Zero Liquid Discharge" or "dry plants"

"MEMBRANE TECHNOLOGIES FOR INDUSTRIAL EFFLUENTS VALORIZATION : WATER TREATMENT TO REUSE AND ADDED-VALUE RESOURCES RECOVERY"

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The agri food industry uses substantial amount of water to achieve the production process, especially for the maintenance of hygiene and cleanliness conditions. With this, is generating considerable amount of wastewater requiring treatment to meet the discharge standards before discarded! On the other hand, with the shortage of water resources and charging for water use, minimizing water consumption in agri food industries is of paramount importance to maintain its market competitiveness. In this sense, there has been increasing interest in the reuse of treated wastewater, in order to decrease the good water consumption by processes that do not require such high quality feature.

At present, membrane separation processes are arising commercially as industrial solutions and highlighted as novel, eco-friendly and low-cost technologies for water treatment to reuse that can meet the demand of various industrial processes and for resource recovery and valorization following circular economy frameworks.

Thus, resources such as oil, protein, lactose, fat, energy, or other added-value products/resources can be recovered from wastewater by any kind of membrane technology (microfiltration, ultrafiltration, nanofiltration, reverse osmosis, membrane distillation, forward osmosis, etc.) or using a combination of two or more membrane technologies in an integration process. Then, this recovered product or products could be valorized and used in the same treatment process, in another process of the same industry or in another industrial field closing a circular economy loop.

PERFORMANCE OF GAS SEPARATION HOLLOW FIBER MEMBRANE MODULES FABRICATED FROM FIBER TOWS

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Commercial hollow fiber membrane manufacturing processes commonly use hollow fiber spinning to produce multiple fibers from one spinneret head. These fibers move together through the manufacturing process and are collected on a spool at the end of the process. This group of fibers is referred to as a fiber tow.

Modules are fabricated from fiber tows by wrapping or weaving tows to form a cylindrical bundle. Tubsesheets are formed at one or both ends of the bundle to create a module that is placed in a case for use in a separation process.

The use of fiber tows introduces two length scales in the fiber bundle: 1) the nominal spacing between fibers in the tow and 2) the nominal spacing between tows. The existence of two length scales for shell-side axial flow channels exacerbates the residence time distribution that exists in the shell-side flow which can be detrimental to performance.

The changes in residence time distribution associated with bundles of fiber tows is evaluated for a range of intra and inter-tow fiber packings. The effect increases as the packing fraction difference increases.

The effect of the residence distribution on module performance is evaluated for operating conditions anticipated for carbon dioxide capture applications from fossil-fuel fired power plants. Broadening the residence time distribution is detrimental to performance, especially as the stage cut increases.

ORAL PAPER

TREATMENT OF WASTEWATER STREAMS FROM TANNERIES USING ELECTROCOAGULATION OR FLOCCULATION COUPLED WITH PRESSURE-DRIVEN MEMBRANE TECHNOLOGY

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Abstract
This research work investigates whether wastewater streams originating from tanneries in Mali can be effectively processed by coupling electrocoagulation (or flocculation) systems with pressure-driven membrane technologies. Earlier studies conducted on this topic in Africa will be reviewed and used as a reference [1,2]. To date in Bamako, 30,000 litters of wastewater are discharged each year into the Niger river with limited pre-treatment. Unfortunately, such practice has severely altered the river eco-system which is also threatened by drought.
Three consecutive steps will be pursued to conduct this research work including

- Diagnosis of the existing pre-treatment process.
- Pilot laboratory treatment of raw wastewater effluents by electrocoagulation or flocculation precipitation and coupling with UF membrane technology.
- Optimization of the process efficacy by adjustment of operational variables (wastewater quality, process settings, and environmental factors).

Fatty substances will be withdrawn from wastewater using an air bubbling technique prior the electrocoagulation (or flocculation) treatment step. Other essential pollutants that are expected to be removed, or recovered, include heavy metals (chromium, arsenic), minerals and caustic agents. Membrane technologies will also be assessed given their ability to eliminate most forms of micropollutants.
Outcome of this research work should help assess the technological efficacy, physical robustness, cost-effectiveness and ease of scaling-up of the recommended process(es).

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A NOVEL RGO@TIO2 NANOFIBROUS PHOTOCATALYTIC MEMBRANE FOR FILTRATION- ENHANCED HIGHLY EFFICIENT DEGRADATION: IMPLICATION FOR IMPROVING PHOTOCATALYTIC EFFICIENCY

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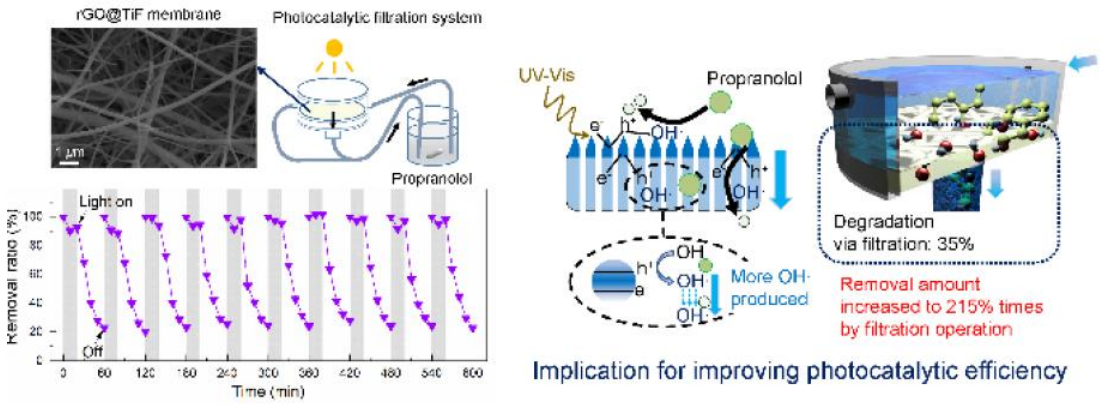
Abstract
Many parts of the world still lack access to safe drinking water and wastewater treatment, which is more prevalent in developing countries and sparsely populated regions. Expensive infrastructure costs (electricity grid, pipe network and sewage treatment plant, etc.) and operation costs are the main challenges, while population growth and excessive consumption also require the urban water system to switch to a sustainable direction. Besides, conventional wastewater treatment processes cannot effectively remove emerging organic micropollutants which are causing a serious impact on human health and ecosystem balance. Photocatalysis and membrane filtration are both promising technologies to solve the above problems, especially suitable for the decentralized small-scale water treatment system, but both of them have some inherent defects. Correspondingly, combining membrane filtration process with photocatalysis can achieve the in-situ solar-powered degradation of pollutants during the separation process, which can not only break through the trade-off limitation and fouling problem but also solve the photocatalyst recovery trouble and enhance the mass transfer. So, the novel membranes with high photocatalytic activity and strong stability are urgently required. It is also necessary to reveal the influencing mechanism of operational conditions on photocatalytic membrane process, thereby providing implication for design and operation in practical applications.
This study proposed a novel electrospun rGO@TiO2 nanofibrous (rGO@TiF) membrane fabricated with a successive electrospinning–calcination method. The rGO@TiF membrane possesses a typical interconnected nanofibrous morphology with numerous pores in the microfiltration level. On the basis of systematic optimization, the optimum rGO/TiO2 loading ratio and calcination temperature were determined to be 2% and 450 ℃, respectively. The optimized rGO-2@TiF_450 membrane achieved an up to 100% removal of propranolol (PR, 2 mg L−1) within 60 min. Besides, the prepared membrane is sufficiently strong and can satisfy the mechanical requirements of the filtration process.
A series of degradation experiments in four types of carefully designed operational modes, including the surface-flow (SF, Fig.1a), flow-through (FT, Fig.1b), cross-flow (CF, Fig.1c), and static modes (Fig.1d), were conducted to reveal the enhancing mechanism of filtration on photocatalytic degradation efficiency. Consequently, the overall degradation efficiency in different modes follows an order of FT>CF>SF (Fig. 2a), which demonstrates that the gradual increase of the proportion of filtration flow gives rise to an increase of degradation efficiency. The calculated degradation efficiency with the filtration-enhanced operation is up to 2.15 times as much as that without filtration
(Fig. 2b). Undoubtedly, the filtration process significantly improves the photocatalytic degradation efficiency. But the proportion of the improved degradation in membrane interior due to filtration was determined to be ~35% on the basis of the calculations in the CF-mode tests.

In the FT mode, more OH· was potentially generated from hole due to filtration that drove the reaction to the right. Also, more propranolol molecules, oxygen and hydroxide ions could be migrated to the vicinities of the electron–hole pairs, where the quenching of electrons and holes could potentially inhibit their recombination. This speculation was preliminary verified through measuring the OH· amounts using 4- chlorobenzoic acid (pCBA, a commonly used capture agent for OH·). Results showed that a higher filtration flux led to a higher removal amount of pCBA, indicating more OH·generated during the test. Overall, the filtration-induced improvement could be probably attributed to the enhanced mass transfer of the reactants and inhibited electron–hole recombination that resulted in more practically active oxidative radicals (Fig. 1e). Accordingly, in addition to the development of new catalyst materials, the accompanied specific and innovative operational conditions should also be carefully considered.

Additionally, the degradation performance of the rGO@TiF membrane (76.1% propranolol removed within 40 min) is highly stable (Fig. 2c), without obvious deterioration over 10 degradation cycles ($P<0.05$, Kruskal-Wallis, Fig. 2d). The analysed degradation results of HPLC/MS/MS verified the rapid content decrease of PR in the effluent, and also demonstrated that the intermediate products of PR degradation were removed quickly from the solution. As compared with previous studies, the apparent kinetic constant k (indicating removal rate) for PR was 2–10 times higher than the values reported in other studies. In summary, the prepared rGO@TiF membrane exhibits better photocatalytic degradation performance and higher stability, suggesting promising sustainable applications in decentralized small scale water treatment driven by solar energy.

Keywords: Photocatalytic membrane; decentralized small scale units; sustainable wastewater treatment; advanced oxidation; organic micropollutants

Graphical abstract:



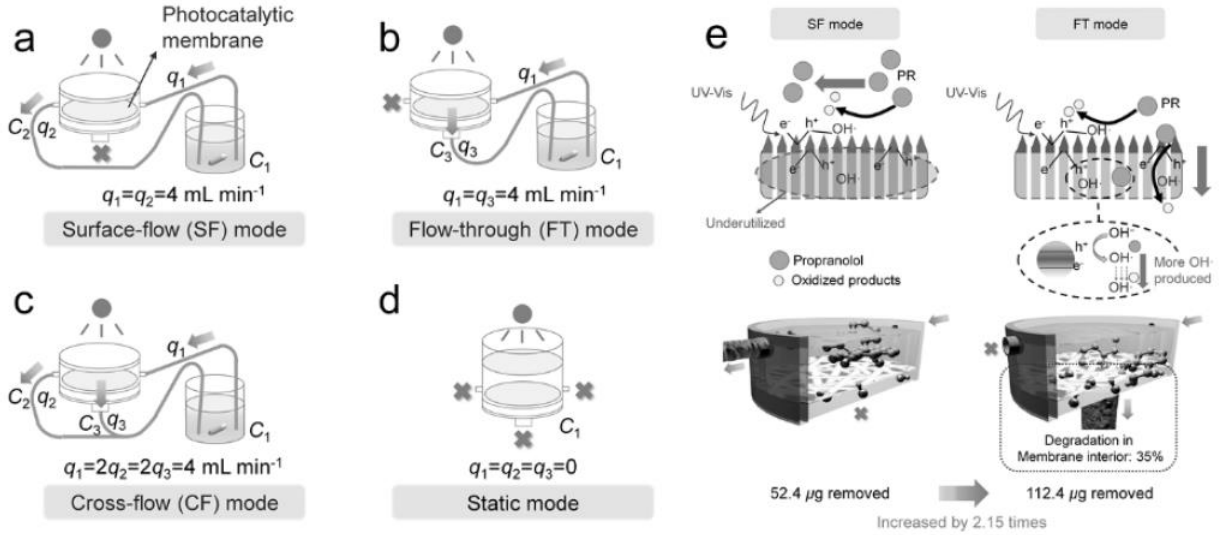


Fig. 1. Schematic illustration of the four operational modes of the photocatalytic filtration system: (a) surface-flow (SF) mode; (b) flow-through (FT) mode; (c) cross-flow (CF) mode, and (d) static mode. And (e) schematic illustration of a hypothesized principle behind the enhancement of photocatalytic degradation due to filtration.

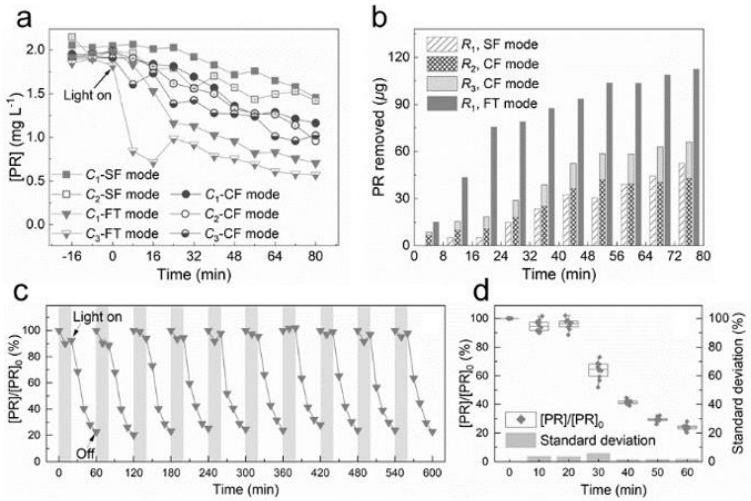


Fig. 2. (a) Declines of the PR concentrations at the inlet (C1), side outlet (C2), and the outlet beneath the membrane (C3) along with time in different operational modes. (b) Amounts of removed PR (μg) in different operational modes at different times. The R1 is the total removed amount of the whole system, and the R2 and R3 are the removed amounts on the membrane surface and in the membrane interior during filtration, respectively. In the CF mode, R2 plus R3 equals R1. (c) Stability tests of the filtration-enhanced photocatalytic degradation performance of the rGO@TiF membrane: PR degradation curves over a ten-cycle test and (d) boxplots with a descriptive analysis of the corresponding data obtained in the ten-cycle test.

STUDY OF COUPLING A MINIMAL WATER FOOTPRINT MED PROCESS WITH SOLAR THERMAL ENERGY

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Abstract
Many arid regions in the world face a potable water shortage. The Algerian desert is one of them, even if it has the second largest underground water reservoir in the world. This later is abrackish water with a high fluctuation in the salinity level from one well to another, and this ofwater is the only one for all the living. That way this aquifer must be treated carefully and in the most sustainable way to preserve it.
Regarding the salinity fluctuation and the high level of solar energy available in this region, a solar thermal system coupled with a standard MED and a modified MED system are compared.The modification on MED desalination system consists on the change of the last water condenser of the unit for a hybrid condenser (water and air condenser in order to reduce the water footprint of the process.
This modification allows a minimal water footprint by reducing from 4 to 18 the cooling waterratio, and reject only from 4% to 10% of brine from all the process according to the salinity level, but in another hand a significant increase of the heat exchangers size of each effect is noted for a low temperature MED system, this difference in the size of the unit could be almosteliminated by elevating the operating temperature of the MED process to 100 °c.
At the end a comparison of the size of the solar system, which power the modified MED and the standard MED is done.

Keywords: MED process, sustainable Desalination, solar energy, Brackish water, waterfootprint.

OPPORTUNITIES AND CHALLENGES TO IMPLEMENT FORWARD OSMOSIS TO COMBINE NUTRIENTS CONCENTRATION AND WATER RECYCLING

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Abstract

Forward osmosis (FO) and its unique feature (high rejection, no hydraulic pressure, low fouling propensity) opens the door for the treatment of complex streams with the double interests of concentrating feed water components while allowing permeation of high purity water. Such functionalities are of high interest for wastewater (WW) treatment in the context of circular economy, pushing towards concentration of nutrients and water recycling.

This work presents 5 years of investigations where FO was evaluated in various schemes such as osmotic membrane bioreactor, as pre/post treatment of anaerobic digestion, concentration of greywater combined with fertigation and microalgae concentration. WW concentration rate up to 30 times was successfully achieved with high rejections of all tested compounds including small organics (VFA, trace organic contaminants (TROCs)…) confirming FO as a promising concentration technology and a strong barrier to pollutants. However, key challenges such as salinity increase in the feed, selectivity to nutrients and salts, degradation of organics during the concentration step, fouling and clogging needs to be addressed through specific process design and appropriate operation.

Keywords: Forward osmosis; nutrients recovery; water reuse

TECHNICAL DESIGN AND OPTIMISATION OF UPSCALED POLYMER INCLUSION BASED PASSIVE SAMPLERS FOR VALUE RECOVERY OF METALS FROM MINE WASTEWATER

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Abstract
An upscaled passive sampler for determining the time weighted average total metal ions (Cu(II), Cd(II), Co(II), Ni(II) and Fe(II)) concentration (CTWA) in mine polluted water, which incorporated a polymer inclusion membrane (PIM) as a semi-permeable barrier separating the aqueous source solution from the receiving solution (1 M HNO3), was developed. The PIM was composed of 40 wt% di-2-(ethylhexyl) phosphoric acid (D2EHPA) as a carrier and 60 wt% poly (vinyl chloride) (PVC) as a base polymer. The implementation of the designed PIM in a special device that contained 1000 mL of the stripping solution, allowed preconcentration of metal ions from a 10000 mL water sample, thus facilitating its detection with ICP-OES. The effect of environmental variables such as the water matrix and pH were also studied using synthetic waters. The passive sampler was calibrated under laboratory conditions using synthetic water and exhibited a linear response of metal ions CTWA for over a month. This highlights that the PIMs are a promising tool for in situ monitoring of metal ions in mine wastewater.

Key words: Passive sampling, Polymer inclusion membranes (PIMs), Preconcentration, Mine wastewater, Di-2-(ethylhexyl) phosphoric acid (D2EHPA).

FLUORIDE TRANSPORT IN NANOFILTRATION MEMBRANES: EXPERIMENTAL AND MODELLING INVESTIGATION

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Abstract

Fluoride ions (F^-) are considered by the World Health Organization (WHO) as a priority parameter to be monitored for drinking water. Actually, a concentration lower than
1.5 ppm is beneficial because it prevents dental caries, while higher concentrations are detrimental because they can cause serious diseases, such as dental and skeletal fluorosis. Groundwater with high F^- content (> 1.5 ppm) is distributed in many places around the world, such as, for instance, in Africa (Senegal, southern Algeria and Tunisia, East Africa) and in Asia (India and China). Membrane technologies provide a solution to reduce and adjust the F^- concentration in drinking water. Among these, nanofiltration (NF) has been recognized as one of the most cost-effective processes for F^- removal provided that the salinity of the water to be treated is not too high. In particular, NF has the advantage of being more productive than reverse osmosis at the same operating pressure [1]. Commercially available NF membranes for desalination can be roughly classified into two categories regarding the rejection of monovalent anions (Cl^-) [2]: those with low to medium rejection (< 50%) and those with high rejection (> 80%). Unexpectedly, the former leads to high F^- rejection. This unique feature is at the origin of the NF application for F^- removal. However, the associated transport mechanism is still poorly understood. This presentation will summarize experimental NF data at the lab and pilot scale of single halide salt rejection and of complex matrices from South Algerian groundwaters, as well as their modelling using Nanoflux® software [3]. The objectives of this work were to (i) clarify our understanding of halide ion transport across NF membranes and (ii) predict NF performance in the case of complex ion mixtures. Ion rejection in NF results from a combination of effects, mainly steric exclusion and electrical interaction. Based on the ionic radius, the rejection of the monovalent halide anions should be as follows: I^- (0.216 nm) > Br^- (0.198) > Cl^- (0.181) > F^- (0.136), whereas the experimental

rejections of single sodium salts show the opposite order, similar to that of the Hofmeister series. The most immediate explanation would be to consider the hydrated radius [4]. Except for F^-, the values do not seem to be different enough to explain the observed rejection data: F^- (0.352 nm) > Cl^- = Br^- = I^- (0.331 nm ± 0.001). Additional interactions are then expected to govern the transport of halide ions across NF membrane pores, including Born dehydration energy [5], charge surface density and polarizability.

These different mechanisms of ion rejection will be discussed in the framework of the hindered electro-transport model in which are included additional residual interactions [2,3] (other than steric and electrostatic). The previously proposed Born dehydration energy rejection mechanism [5], which depends on the effective dielectric constant of nanoconfined water, will be reassessed in the light of recent measurements in idealized nanoscopic systems [6].

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Keywords:
Membrane defluorination; Nanofiltration; Halide ions transport; Modeling; Performance prediction;

NEW INORGANIC ULTRAFILTRATION MEMBRANE BASED ON HYDROXYAPATITE - KAOLIN COMPOSITE FOR INDUSTRIAL EFFLUENT TREATMENT

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Abstract

Over the last decades, membrane technology has been proposed for treatment of industrial wastewaters usually after a classical physico-chemical process to produce water that can be directly reused in the industry or meeting the increasingly stringent discharge regulations. Porous ceramic membranes exhibit numerous remarkable advantages for this kind of application such as good chemical corrosion resistance, excellent high-temperature and structure stability, high separation efficiency, low energy consumption and easy clean- regeneration [1,2]. Unfortunately, commercial ceramic membranes prepared from alumina, titania, zirconia, and silica are too expensive for a cost-effective application in environmental technology which requires high permeation flux and low cost to treat large volumes of polluted wastewaters. Attempts to find new porous ceramic materials at low price and needing low thermal treatment temperatures have become a very active research field and numerous papers have published in literature. Recently, the development of low-cost ceramic membranes based on natural materials such as apatite powder, natural raw clay, graphite, phosphates, dolomite, kaolin and waste materials such as fly ash, appeared as a promising solution for treating wastewaters with low-cost materials. In this context, the main goal of our work is to propose a simple way to prepare ultrafiltration (UF) ceramic membrane using the direct deposition of a single layer of hydroxyapatite onto the surface of a porous clay support without intermediate layer. The fabrication of the composite membrane comprises the following sequential steps: preparation of the clay support and of the hydroxyapatite suspension, and the subsequent coating of an active mono-layer onto the support. This procedure was expected to decrease the membrane resistance and thus to enhance the UF process performances. In a first stage, tubular porous ceramic membranes were prepared by extrusion of a plastic paste prepared from clay powder (Kaolin) mixed with organic additives and water. The obtained membrane exhibited high properties in terms of mechanical resistance, porosity and chemical stability [1-4]. The so-designed tubular ceramic tube served as solid support for the preparation of defect-free UF layer via slip-casting, using hydroxyapatite particles suspension in the second stage. The formulation of the slip solution was optimized using a rheological study. The obtained membranes display an asymmetric structure as showed by SEM pictures. It was also observed that an excellent adhesion between the kaolin support and the hydroxyapatite filtration layer took place. The thickness of this surface layer can be adjusted by polymeric additive content in the slip suspension and by the duration of the deposition time from 3 to 30 µm. Water permeability and colour rejection determined from filtration of an industrial textile effluent were demonstrated to be dependent on the UF layer thickness. The best performances was observed for a membrane having a surface filtration layer thickness of 9 µm with a permeability of 112 l/h.m2.bar and a decrease of turbidity to less than 1 NTU and of chemical oxygen demand (COD) with a retention rate of about 90% and an almost complete color removal.

The *African Membrane Society* (AMSIC) is headquartered at the *Ecole Nationale d'Ingénieurs Abderhamane B. Touré* (ENI-ABT) located at 410 avenue Vollenhoven, BP 242, Bamako – Mali Links: ENI-ABT at https://www.eni-abt.ml/ and AMSIC at http://www.sam-ptf.com/

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Keywords: Inorganic ultrafiltration membrane, kaolin, hydroxyapatite, textile effluent treatment

ENHANCED PERFORMANCE OF A PILOT-SCALE BIOGAS SPARGED ANAEROBIC MEMBRANE BIOREACTOR COMBINED WITH GRANULAR ACTIVATED CARBON FOR REAL MUNICIPAL WASTEWATER TREATMENT

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Abstract
A novel biogas sparged anaerobic membrane bioreactor (AnMBR), which consisted of expanded bed anaerobic bioreactor combined with granular activated carbon (GAC) as carriers for microbial growth and membrane tank with biogas sparged, was developed for the treatment of real municipal wastewater at ambient temperature seasonally fluctuating from 35 to 5 °C. Two types of membrane modules, polymeric and ceramic membranes, were submerged in the membrane tank for comparing their performance. The novel biogas sparged AnMBR showed sound organic removal over 86% and permeate COD was found less than 50 mg/L at all times regardless of the operation at extremely low temperature of 5-10 °C. Methane yield was found over 0.24 L CH4 (STP)/g COD removed at mesophilic temperature, which was higher than the reported values by most conventional pilot AnMBRs. Even at extreme temperature of 5-15 °C which was scarcely investigated previously, 0.21 L CH4 (STP)/g COD removed of methane yield was obtained in this study. The enhanced methane yield was attributed to the fact that GAC addition enhanced methane production by increasing the biomass and enriching methanogens Metanephric and Methanobacterium and exoelectrogenic Geobacter attached on GAC. In terms of membrane fouling behaviour, TMP was maintained below 20 kPa at mesophilic temperature. More notable membrane fouling was observed at psychrophilic temperature, which was mainly resulted from the accumulation of proteinaceous soluble microbial products (SMP) and extracellular polymeric substances (EPS) in the mixed liquor, increased concentration of colloidal matter between 500 kDa and 1.2 μm, and relatively high abundance of Firmicutes and Bacteroidetes. External cake and gel layer resistance was found responsible for over 67% of the total fouling for both membranes. The polymeric membrane had a higher total fouling resistance as compared with the ceramic membrane. The internal foulants on polymeric membrane contained more organics while those formed on ceramic membrane were predominantly associated with inorganic components. These results suggested that this novel biogas sparged AnMBR is technically feasible for the treatment of municipal wastewater even at extremely low temperature due to the combined merits of biofilm process and membrane separation. Further study should focus on the selection of GAC types and dosage, and the discovery of effective biogas sparging regimes such as alternating high and low intensity gas sparging, intermittent high intensity gas sparging or Pseudo dead-end gas sparging in relation to membrane fouling and energy efficient operation, particularly at psychrophilic temperature.

Keywords: Granular activated carbon; Anaerobic membrane bioreactor; Municipal wastewater; Ambient temperature; Membrane fouling

COST-BENEFIT ANALYSIS AND TECHNICAL EFFICIENCY EVALUATION OF FULL-SCALE MEMBRANE BIOREACTORS FOR WASTEWATER TREATMENT

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Abstract
As membrane bioreactor (MBR) technology for wastewater treatment has developed and controversy with other technologies has always existed, knowing the whole cost, net profit and cost efficiency of MBR applications is important, both economically and environmentally.
In this work, considering that the wastewater treatment is similar to the production process of treated water and sludge, we build a cost-benefit analysis framework and apply a data envelope analysis (DEA) methodology based on the non-radial direction distance function (NDDF) to calculate the net profit and cost efficiency of MBRs() for sampling of 35 wastewater treatment plants (WWTPs) located in China. We further analyse the internal and external factors affecting the profit and efficiency of MBRs by nonparametric test and the panel econometric model. The results show that the net profits of MBR are all positive, indicating the technical and economic feasibility. The average cost efficiency of MBR is 0.77, and the average energy efficiency is 0.66. Compared with the WWTPs' efficiency value of 0.3 reported in the literature, the efficiency of MBR is generally at a higher level. We also find that geographic location, effluent standards and the regional economic development level can significantly affect MBRs' wastewater treatment performance, while the position of MBR (underground or overground) and the type of wastewater treated (municipal wastewater or industrial wastewater) are not determining factors.

Keywords : Full-scale membrane bioreactors, Cost benefit analysis, Net profit, Cost efficiency

A COMPREHENSIVE STUDY ON THE SPECTROSCOPIC SENSING OF EXTRACELLULAR POLYMERIC SUBSTANCE IN A LONG-TERM ANAEROBIC MEMBRANE BIOREACTOR

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Abstract

Anaerobic membrane bioreactor (AnMBR) is a promising technology to simultaneously eliminate pollutant and recycle energy from wastewater. However, membrane fouling still hinders its large-scale application in wastewater treatment. In an AnMBR, sludge adsorbs and degrades pollutants, and is also the source of membrane foulant. The composition and structural properties of extracellular polymeric substance (EPS) in sludge can affect the metabolism of microorganisms and the formation of membrane fouling, thus affecting the efficiency and stability of biological treatment systems. EPS can be divided into tightly-bound EPS (TB-EPS), loosely-bound EPS (LB-EPS) and soluble EPS (S-EPS) according to the distance to microbial cells. Each layer of EPS differs greatly in structural composition and function. Therefore, investigating the properties of EPS is significant for the stable operation of AnMBR and the control of membrane fouling.

Several conventional methods have been widely used to characterize EPS, including catalytic oxidation-nondispersive infrared detection of total organic carbon (TOC), high-temperature digestion-titration/colorimetric determination of chemical oxygen demand (COD), phenol-sulfuric assay for polysaccharides measurement, modified Lowry method for proteins and humics quantification, etc. These methods are time-consuming and laborious, thus unavailable for on-line monitoring of EPS.

UV-vis absorption spectrum and excitation-emission matrix (EEM) fluorescence spectrum can be applied to quickly and sensitively monitor dissolved organic matter (DOM) in sludge. UV-vis spectrum can be used to reflect the unsaturated aliphatic chain and aromatic substances in EPS. EEM spectrum can reflect numerous information about DOM, including chemical composition, biodegradability, humification, hydrophobicity, molecular weight, and potential of disinfection by-products, etc. In recent years, UV-vis spectrum and EEM spectrum have been used to characterize EPS in many AnMBR studies. However, these studies mainly focus on using absorbance peaks, fluorescence peaks, fluorescence regional integration (FRI) and parallel factor analysis (PARAFAC) to indicate chemical compositions. Previous studies generally believed that the fluorescence intensity of EEM was mainly contributed by protein-like, humic-like and soluble microbial byproduct-like substances, while polysaccharide contained few fluorescent functional groups. However, the organic substances in EPS are cross-linked in a complex structure. Polysaccharide may bind with some organic groups (such as methyl, acetyl, amino, phosphoric acid and sulfhydryl) and some molecular fragments (such as uronic acid and peptide chain). In addition, polysaccharide interacts with protein-like groups and humic acid-like fragments through hydrogen bonds, electrostatic forces, and biochemical reactions. Therefore, we can ignore the effect of polysaccharide to the EEM spectrum. At present, the contribution of organic substances to EEM spectrum has yet to be established in a quantitative analysis model.

This study aims to explore the relationship between the spectral properties and the composition of organic matter in each EPS layer. We extracted S-EPS, LB-EPS, and TB-EPS in AnMBR that was running for a long period (151 days). The polysaccharide, protein and humic acid concentrations of EPS were determined using traditional chemical methods. UV-vis and EEM spectrum were measured. The specific regions of various types of EPS in the EEM spectrum were analysed by fluorescence quotient method.

The relationship between EEM and polysaccharide, protein and humic acid concentration was established by multiple linear regression analysis. The variance partitioning method was used to analyse the contribution of polysaccharide, protein and humic acid to EEM spectrum. In addition, the structure characteristics of EPS were explored through Fourier transform infrared spectroscopy (FTIR), X-ray photoelectron spectroscopy (XPS) and high-performance liquid chromatography mass spectrometry (HPLC-MS).
We found that the composition of organic matter and spectral differed among each layer of EPS. Polysaccharide, protein and humic substances exhibit different fluorescence characteristics in different layer of EPS, indicating various structures. In TB-EPS, polysaccharide, protein and humic mixed together in a chaotic state. In LB-EPS, the EEM spectrum was characterized by humic, protein and a hybrid of them. While in S-EPS, the heterozygous state gradually differentiates, and the EEM spectrum was mainly characterized by polysaccharides. From TB-EPS → LB-EPS → S-EPS, the interaction between those organic matters became weaken. This may provide useful information for the understanding of EPS structure and regulation in AnMBR.

Keywords: anaerobic membrane bioreactor (AnMBR), extracellular polymeric substance (EPS), UV-vis spectrum, Excitation-emission matrix (EEM),statistical analysis

HIGHLY EFFICIENT VEGETABLE OIL REFINERY WASTEWATER TREATMENT USING HYBRID COAGULATION/FLOCCULATION– MEMBRANE FILTRATION PROCESS: A PILOT STUDY

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Abstract
Membrane filtration process involving ultrafiltration (UF) have increased rapidly for the past decade in industrial wastewater treatment field and would potentially replace the conventional treatment. Despite all the advantages of this process, some aspects should be considered, which can compromise its efficiency. Among the drawbacks of this process is the decline in permeate flux due to the concentration polarization, cake formation, solute adsorption, as well as fouling. To overcome these problems in UF applications, conjunctive use of coagulation and membranes is becoming more attractive for water treatment because the coagulation is an opportunity to remove particles present in water before it reaches the membrane. Therefore, this study aims to investigate the efficiency of hybrid treatment process using Coagulation/Flocculation (CF), Cross Flow Ultrafiltration (UF) and/or Dead-End Filtration (DEF) on the treatment of synthetic (SVORW) and real (RVORW) vegetable oil refinery wastewater. Experimental runs with SVORW were used to identify the most appropriate conditions to perform with RVORW treatment. CF experiments were conducted using the well-known Jar-Test protocol. The bench- scale experiments were carried out using a tubular ceramic membrane of UF with a molecular weight cut off (MWCO) of 150 kDa under cross-flow filtration (CFF) mode in turbulent flow regime and a trans-membrane pressure (TMP) of 1.2 bars. DEF experiments were carried out using different pore size of flat membrane as preliminary work to find the most adequate membrane pore size. The permeability of membrane was investigated as function of volumetric concentration factor in order to achieve a cost-effective process. The comparative performance evaluation of direct (CF, UF and DEF) and hybrid (CF/UF,UF/DEF and CF/UF/DEF) processes showed that the hybrid process using UF as a secondary step after CF under optimal conditions (2.4 g□ L-1 of aluminium sulfate, 60 mg□ L-1 of CHT flocculant under an initial wastewater pH of 9.23) allows to achieve the best treated oily wastewater quality compared to direct CF and UF used separately while turbidity, COD and TOC removals reached 100%, 98% and 97%, respectively. However, the CF pre-treatment was useless from the standpoint in reducing membrane fouling and did not improve the membrane permeability (135 L□ h-1□ m-2□ bar-1) compared to that achieved with direct UF (150 L□ h-1□ m-2□ bar-1) in agreement with some publications. For both cases (direct UF and hybrid CF/UF), the membrane permeability was in agreement with an industrial application. DEF as post treatment (hybrid CF/UF/DEF process) did not improve the final quality of the treated VORW water. These findings strongly suggest that the hybrid CF/UF process is the promising option to realize water resource recovery and pollution removal even though it does not offer the advantage for vegetable oil recovery and valorisation. The results can be useful for the development and performance optimization of industrial installation to treat and reuse vegetable oil refinery wastewater using a hybrid CF/UF process as feasible, safer and more environmentally friendly alternative to other available treatment options

Keywords: Vegetable Oil Refinery Wastewater, Coagulation/Flocculation, Membrane Filtration, Hybrid process, COD and Turbidity Removals

ELECTRICALLY ENHANCED ULTRAFILTRATION FOR ADVANCED WASTEWATER PURIFICATION

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Abstract
The crises of water scarcity and energy shortage evoked a desire for compact and energy-efficient water treatment technologies. The present study established a novel integrated capacitive-deionization (CDI)–enhanced ultrafiltration (CUF) system, which achieved a simultaneous removal of organic matter and inorganic salts from wastewater. The organic matter was removed through size exclusion (by the ultrafiltration component) and/or electro-catalytic oxidation, while the inorganic salts were retained via electrosorption by the CDI component. Systematic experiments were conducted to investigate the CUF behavior. Consequently, the CUF process achieved an enhanced antifouling performance in both the ultrafiltration and CDI aspects. Besides, the organic matter facilitated the removal of Ca2+- and Mg2+-based ion pairs probably via complexation interaction, but hindered the electrosorption of Na+- and K+-based ion pairs due to site competition. During the desalination, the CUF system could achieve an up to 100% removal of foulants through electro-catalytic oxidation, suggesting promising applications in various areas.

Keywords: ultrafiltration; hybrid system; antifouling

SIMULATION OF THE MEMBRANE FILTRATION PROCESS FOR INDUSTRIAL WASTEWATER

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Abstract
The textile and petroleum industries are classified among the largest industries consuming water, which generate large quantities of wastewater discharged into the environment with inefficient treatments.
The main objective of our work is to propose a process simulation approach for the treatment of industrial wastewater depending on the nature of the load. The two industrial effluents textile and petroleum are treated by membrane filtration process to obtain purified water. These effluents are complex mixtures, concentrated in pollutants harmful to the environment, such as dyes, hydrocarbons, heavy metals, mineral salts, which are very high compared to the discharge standards required by the regulations. The simulation required an Excel interface to create the membrane that include the mathematical equations of the proposed model, as well as the data intrinsic to the membrane. The modelling of filtration on an inorganic mineral membrane containing silica gel as a material grafted to its walls consists of translating the mass transfer between the filler and the membrane to obtain a permeate and a retentate.
The process has given remarkable efficiency in reducing mineral salts and heavy metals such as chromium and manganese. This purified water meets national and international standards. It can be recycled and even reused in irrigation.

Keywords | Simulation; Textile; Petroleum; Membrane.

FINGERPRINTING ORGANIC MATTER IN MBRS: WHAT CAN WE LEARN FROM EXCITATION-EMISSION MATRIX (EEM) FLUORESCENCE SPECTROSCOPY?

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Abstract:
Dissolved organic matter (DOM) plays substantial roles in membrane bioreactors (MBRs). Fluorescence is an important nature of DOM and the fluorescence excitation-emission matrix (EEM) spectroscopy is promising for DOM monitoring during MBR operation. Previous applications of EEM have been mainly limited to the detection of DOM chemical components, such as that by Chen et al. (Environ. Sci. Technol. 2003, 37, 5701-5710) who divided an EEM map into five regions to indicate protein/humus-like substances; whereas few applications of EEM have been extended to the indication of DOM physicochemical properties (such as hydrophobicity and molecular weight (MW)) and behaviors (such as biodegradation and membrane fouling). To this end, our study aims to systematically explore the relationships between EEM spectral fingerprints and DOM properties/behaviors.
DOMs were sampled from various (up to 10) full-scale MBRs treating municipal wastewater, with their total organic carbon (TOC) and polysaccharide/protein/humus contents determined. The DAX-8 resin column was used to characterize the hydrophobic/hydrophilic composition, and sequential ultrafiltration was used to determine the MW distribution. The EEM spectra were analysed using fluorescence regional integration (FRI), parallel factor analysis (PARAFAC), and fluorescence quotient (FQ) techniques. Fluorescence quantum yield, fluorescence lifetime, and fluorophore energetic properties (e.g. Stokes shift and energy state) were further extracted from EEM. A series of EEM spectral properties were found to be indicative of DOM hydrophobic/hydrophilic composition. The FQ verified that hydrophobic acids/bases (HOA/HOB) tended to occur in the wavelength range of Ex < 235-250 nm, or in the region with Stokes shifts > 1-1.2 μm-1. Fluorescence quantum yield, average excitation energy, and average Stokes shift correlated well with k'cr, a measure of the relative degree of hydrophobicity, with the relationships verified by Monte Carlo examination. Statistical screening of the EEM signals found that smaller-MW fractions tended to occur in the lower-wavelength regions while higher-MW fractions the reverse. The average intensity per TOC was significantly related to logMW. The biodegradation, sludge/water-phase distribution, and membrane fouling behaviors were further related to EEM fingerprints via nonparametric statistical analyses, yielding characteristic wavelength regions on the EEM map for indication of these
behaviors. As a result, a renewed division of the EEM map regions based on the function/behavior of DOM, rather than the conventional division based on chemical composition of DOM, was proposed. These may shed light on further application of EEM for DOM monitoring in practical MBR operation.

Keywords: membrane bioreactor (MBR), dissolved organic matter (DOM), fluorescence excitation-emission matrix (EEM), spectroscopic indicator, statistical analysis

WASTEWATER MANAGEMENT IMPROVEMENT IN THE UNAMID HEADQUARTER IN CENTRAL DARFUR, ZALINGEI, SUDAN.

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Abstract

This study, which focuses on conserving water and reducing the level of risk to personnel, local communities and ecosystems from wastewater management practices is part of the implementation of the new United Nations Secretariat's environmental management strategy through the agenda 2030 for Sustainable Development adopted in 2015.It requires all UN agencies and peacekeeping missions to adopt good environmental management practices in order to leave

Keywords: wastewater; UNAMID; waterborne diseases; water treatment; recycled water

COMBINING ELECTROCOAGULATION WITH ULTRA LOW PRESSURE ULTRA FILTRATION FOR ARSENIC REMOVAL

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Abstract
Inorganic as well as organic arsenic compounds are proven toxic substances, which have acute as well as chronic toxicological effects depending on the dose (WHO 2011). The currently valid WHO guideline value for the arsenic concentration in drinking water is 10 µg/L (WHO 2017). According to estimates, over 200 million people worldwide currently rely on arsenic-contaminated drinking water with arsenic concentrations above the WHO guideline level (Murcott 2012). Most affected are people in economically weak regions of the world with barely developed drinking water supply infrastructure (Khan et al. 2014).
Thus, extensive investigations were carried out on the combination of an electrocoagulation (EC) and a subsequent ultra-low-pressure ultrafiltration plants (ULPUF), targeting for arsenic removal. This paper deals with the technical possibilities of the EC-ULPUF combination process.
Electrocoagulation is an electrochemical process based on the mechanism of electrolytic dissolution of aluminium or iron electrodes of an electrocoagulation cell (EC cell) by the ap-plication of an external electrical voltage (Amrose 2008). This results in an in-situ generation of precipitant; the dissolved arsenic adsorbs to the electrochemically generated metal hydroxide and can then be removed from the water by filtration.

Keywords : arsenic removal, drinking water, electrocoagulation membrane filtration, ultra-low-pressure ultrafiltration, water backpack PAUL

EFFECT OF SILICA SODALITE LOADING ON PERFORMANCE EVALUATION OF SOD/PSF MEMBRANES DURING TREATMENT OF PHENOL-CONTAINING WASTEWATER

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Abstract
Discharging phenolic compounds without proper treatment poses a serious health hazard to animals, humans and aquatic life. Therefore, there is need for a cheap and reliable treatment method that could be used to safely remove hazardous contaminants such as phenols to a permissible level. In this study, silica sodalite (SSOD) was synthesized through topotactic conversion and different silica sodalite loadings were infused into polymer matrix (polysulfone (PSF)) for application in phenol-containing water treatment. The composite membranes were synthesized via phase inversion. Physicochemical characteristics of the nanopartciles and membranes were checked via Scanning Electron Microscope (SEM), Brunauer Emmett–Teller (BET) and Fourier Transform Infrared (FTIR) for surface morphology, textural properties and surface chemistry, respectively. Thermogravimetry analysis (TGA), Nanotensile test, Atomic Force Microscopy (AFM) and contact angle measurement were used to check the thermal stability, mechanical properties, surface roughness and hydrophilicity of the membranes, respectively. SEM results showed that the surface of pure polysulfone is highly porous with large visible pores. However, the pores decreased with increasing SSOD loading (5 wt. % to 10 wt. %). In addition, incorporation of nanoparticles decreased the contact angles from 83.81° for pure polysulfone membranes to 80.94° and 76.68° for 5 wt. % SSOD and 10wt. % SSOD nanoparticles loading, respectively in polysulfone matrix, resulting in hydrophilic enhancement. Performance evaluation of the synthesized membranes for treatment of phenol-containing water was carried out using a dead-end filtration cell at varied feed pressure with a synthetic phenol-containing wastewater prepared by dissolving 20 mg of phenol in 1L of deionized water. Pure water flux for all the membranes was higher than phenol-containing water flux. Permeation flux of phenol-containing water increased from 0.05 to
0.95 Lm-2h-1 with increasing nanoparticles loading of 5 wt. % and 10 wt.%, respectively, when compared with permeation flux of 0.025 Lm-2h-1 for pure polysulfone membrane (0 % SOD/PSF). Pure PSF showed the highest phenol rejection of 95 55 % at 4 bars, compared to the composite membranes having 61.35 % and 64.75 % phenol rejection for 5 wt. % SSOD loading and 10wt. % SSOD loading, respectively. In this study, a novel Psf-infused SSOD membrane was successfully fabricated for treatment of synthetic phenol-containing water to alleviate the challenges associated with it.

Keywords: Polysulfone; Phenol-containing water; Membranes; Water treatment; Silica sodalite

COMPARATIVE STUDY OF SEPARATION PERFORMANCE OF HYDROXY SODALITE INFUSED POLYSUFONE (HSOD/PSF) AND SILICA SODALITE INFUSED POLYSULFONE (SSOD/PSF) MEMBRANES FOR ACID MINE DRAINAGE TREATMENT.

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Abstract
In this study, silica sodalite (SSOD) and hydroxy sodalite (HSOD) nanoparticles were synthesized by topotactic conversion and hydrothermal synthesis, respectively. They were infused into polysulfone (Psf) to prepare SSOD/Psf and HSOD/Psf membranes at different nanoparticles loading (10wt.% and 5wt.%) for comparison in the treatment of acid mine drainage (AMD). The morphology, textural property, crystallinity, surface chemistry and thermal stability of the synthesized nanoparticles were checked using SEM, N2 physisorption at 77 K, XRD, FTIR, and TGA, respectively. Morphology, degree of hydrophilicity and the mechanical strength of the as-prepared membranes were obtained using SEM, contact angle measurement and nano-tensile analyser, respectively, as well. Topotactic conversion of RUB-15 to SSOD was confirmed with the preserved sheet-like shape of the nanoparticles, and the absence of CH3 deformation vibrations at 1488 cm-1. The absence of –OH bond in the 2900- 3600 cm-1 region of the FTIR spectra further confirms formation of SSOD. The SEM images showed a successful infusion of nanoparticles. Loading the membranes with SSOD enhanced the membrane permeability of the membrane from 0.02 g.h-1.cm-2 for Psf to 0.21 g.h-1.cm-2 for 10%SSOD/Psf at 5 bar. A reduction in fouling rate was observed from 93% for Psf membrane to 54% for 10%HSOD/Psf membrane over time. 10%HSOD/Psf membrane had good metal ion rejection with 75%, 66%, 61%, 57%, 52%, and 38% for Mg2+, Fe3+, Mn2+, Ca2+, Al3+and Na2+ , respectively, while Al3+ had the highest rejection (89%) in 10%SSOD/Psf membrane. This study provides a platform for further study on the improvement of SSOD usage in AMD treatment as it shows enhanced permeability with promising rejection.

Keywords: Acid mine drainage; Silica sodalite; Hydroxy sodalite; Membrane, Heavy metals, Topotactic conversion

PHYSICOCHEMICAL ANALYSIS OF LEACHATE FROM MUNICIPAL SOLID WASTES LANDFILLS IN ILORIN METROPOLIS KWARA STATE NIGERIA

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Abstract
Physiochemical assessment of leachate in three different areas of Ilorin metropolis namely Ogundele (OG) Gbagede (GB) and University of Ilorin dumpsites (UI) to representing Dry season sampling in this study using standard methods. The pH of leachate sample from Ilorin dumpsite was ultra- acidic and basic (6.6 – 8.6) with electrical conductivity of 130 - 540 μS/cm. However, pH of leachate samples (6.6 and 8.6) collected from Ilorin metropolis dumpsite were in the partly alkaline and acidic range with electrical conductivity within the threshold. The aforementioned approach were employed at distances of 2m and 5m from the mid-sections of these dumpsites and pH of leachate at a distance of 5m from the three were observed to be in the neutral range. The Physiochemical analysis indicated the hazards of open waste dumping, as leachate in these dumping sites contains Ammonia, calcium carbonate, nitrate, sulphate and other heavy metals, which can percolate and contaminate surface Water and ground water thereby, causing negative effects on public health safety and the environment.

Keywords : Leachate, Open dumpsite, Anions Heavy Metals, Ilorin, Dumpsites

GENERATION, COMPOSITION AND SOME PHYSICOCHEMICAL CHARACTERISTICS OF MUNICIPAL SOLID WASTE (MSW) IN ILORIN – NIGERIA

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Abstract

Municipal Solid Waste (MSW) results from rapid increase in population, massive expansion of the urban areas and changing lifestyle. Increasing population calls for increasing production of goods and services. This in turn results into increasing wastes that are generated and discharged into dumpsites. The aim of this study is to determine the physical and percentage composition of Municipal Solid Waste. Also to determine the physicochemical properties of Decomposed Municipal Waste (DMSW) in the study area. Physical Classification of MSW was conducted at University of Ilorin (UI) and Gbagede (GB) dumpsites using Truck method. Four truckloads of MSW were made to be dumped ate each dumpsite and classification was made at University of Ilorin and Gbagede dumpsites. From the result of physical classification percentage composition of paper and cardboard recorded at Unilorin (19.6%) is associated with the type of material that is mostly used in an academic environment typical of Unilorin while (25.2%) of thermocole recorded at Gbagede dumping site is associated with source of the MSW which are basically industrial waste i.e. Nylon from package water companies, as well as other industries within Ilorin metropolis. In addition, the rate of MSW generated in Ilorin metropolis is calculated as 2.092056203 x 1012 tons/ year.

From the research findings and summations, it was realized that classification of the MSW at both UI and GB were grouped into biodegradable and non-biodegradable waste which further revealed that there is higher concentration of biodegradable matter at UI but at GB non-biodegradable is the highest and the implication is that the MSW at UI could be a good source of energy when subjected to aerobic or anaerobic digestion while the residue obtained after digestion could be used as organic manure. The MSW from Gbagede is a good source of raw materials for recycling industry because of higher percentage of inorganic waste recorded i.e. thermocole (Nylon). Decomposed Municipal Solid Waste physical characterization was made through the collection of DMSW using quadrant-sampling method. The value of iron obtained for both University of Ilorin and Oko -Olowo (3.67 ± 0.01835) and (6.93 ± 0.034633) respectively do not only responsible for the brownish coloration observed in the extracted leachate from the decomposed solid waste but the result of heavy metals recorded at the two sites classified the DMSW as hazardous because the values recorded are above the Federal Ministry of Environment Standard (FMES)

Keywords: Heavy metal, Municipal Solid Waste, Composition, Open dumpsite, Generation

FACTOR INTERACTIONS, MODELING AND OPTIMIZATION OF BIODIESEL PRODUCTION FROM WASTE COOKING OIL

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Abstract
This study investigated factor interactions, modeling and optimization of biodiesel production from waste cooking oil using via H2SO4 catalysed transesterification reaction. Central composite design-response surface methodology (CCD-RSM) was used for monitoring the reaction variables and conditions, namely: reaction time, reaction temperature and H2SO4 catalyst concentration. The CCD-RSM used was 23 (three variables at two levels) with 16 experimental runs. The data obtained were subjected to multivariate regression analysis. From the results, Errors degree of freedom was 9, Root Mean Squared Error was 1.94, F-statistic vs. constant model was 40.8. Furthermore, R-squared value of 0.965, adjusted R-squared value of 0.941 and a p-value < 0.05 were obtained. The model fitted the data correctly and was significant for the transesterification process ($p < 0.05$). On optimization of the model, the results indicate that optimal biodiesel yield of 97.13% occurred at 1.60 h, 54.90 oC, and 2.26 % H2SO4 catalyst concentration. Future research shall center on design of appropriate and robust techniques for separating and purification of the biodiesel product.

Keywords: Catalyst, Waste Cooking Oils, Biodiesel, Transesterification, Modeling

PHOTOVOLTAIC-POWERED MEMBRANE FILTRATION SYSTEMS FOR BRACKISH WATER TREATMENT IN AFRICA: ENERGY STORAGE CONSIDERATIONS

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Abstract
The provision of clean drinking water in remote locations can be challenging – whether physically, technologically, economically or sustainably. This presentation examines the potential for photovoltaic-powered membrane filtration (PV-membrane) systems to treat brackish groundwater. This technology has the advantages of being small-scale with small units producing 1–2m3 of clean drinking water daily when driven by 300 – 500 W of PV panels, while the only existing infrastructure required is a borehole of suitable depth. Such PV-membrane systems are often equipped with a combination of ultrafiltration (UF) – to remove particles, viruses and bacteria – and a nanofiltration (NF) membrane to realise desalination. Extensive PV-membrane field testing experience was gained by the authors in northern Tanzania in 2013-2014, with a particular focus of treating surface- and ground-water with very high fluoride concentrations (see images in Figure 1).

Figure 1. A collage of photographs taken during PV-membrane field-testing in northern Tanzania (2013 – 2014), with a particular focus on fluoride removal.

This paper examines the pros and cons of three different energy storage scenarios. In the first case, no energy storage components are included in the system, resulting in the high-pressure pump of the system being directly connected to the PV modules. The second scenario is where batteries are included, either the more typical lead-acid batteries of the past or the newer lithium-ion batteries made popular via electric vehicles. These permit storage of enough energy such that the system could operate from a period of a few hours up to several days. In the third situation, super-capacitors are employed. These typically possess a more limited energy capacity than a battery and are hence better suited for energy buffering. This means enabling the PV-membrane system to "ride through" many of the larger fluctuations in solar energy throughout the day (e.g. induced by passing clouds) and thus preventing system shut-down events from occurring. While super-capacitors are a less developed technology than batteries, they exhibit a distinct advantage in that they can be charged and discharged up to 1 million times. These energy storage possibilities will be presented along with the considerations for other components (PV panels, pump, etc.) in the hope that such PV-membrane systems could, in the future, realise a lifetime of 20+ years.

Keywords: photovoltaic, solar energy, membrane, water treatment, fluoride removal.

ORGANIC AND INORGANIC PHOTOCATALYTIC COATINGS OF MEMBRANES: PHOTODEGRADATION OF POLLUTANTS TO CREATE CLEAN DRINKING WATER VIA SOLAR ENERGY

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Abstract
The generation of reactive oxygen species via photocatalytic processes that are driven by sunlight are an exciting and sustainable technology for water treatment. However, the efficiency of such photocatalytic processes is poor, with three key challenges remaining [1]:

i maximising the fraction of sunlight that can be utilised;
ii speeding up the slow reaction times; and
iii the potential of scaling-up the technology.

Recent works from the present research team has demonstrated that via coating membranes – both the top/bottom surfaces as well as the inner pores – with a photosensitizer enables enhanced photodegradation rates to be achieved relying on light intensities less than that typically encountered for terrestrial sunlight [2,3,5]. To date, two different approaches have been pursued. Firstly, the coating of ceramic membranes via an ultra-thin film (5 – 10 nm thick) of titanium dioxide (TiO2) have been realised via atomic layer deposition (ALD). Such photocatalytic membranes (PMs) can then be illuminated by ultraviolet (UV) light in order to produce hydroxyl radicals (HO·) that can photodegrade water-borne model pollutants, such as methylene blue [2].
In a second approach, the same pollutants have been photodegraded via visible light absorbing PMs, this time fabricated using organic photosensitizers – in particular palladium(II)meso-tetra(penta-fluorophenyl)-porphin (PdTFPP) – coated onto commercially-available polyvinylidene difluoride (PVDF) membranes that generate singlet oxygen (1O2), which was also demonstrated to photodegrade methylene blue [3]. Furthermore, the authors have developed an analytical method to enable radiolabelled steroid hormones (SH) to be measured down to a limit-of-detection (LOD) of ~2 ng/L) [4]. The combination of the visible-light activated PdTFPP-PVDF membranes – see **Figure 1** (left) – and analytical technique was then demonstrated in a photocatalytic membrane reactor (PMR) [5]. When operated at a water flux of 600 L/m2h, the PMR exhibited significant removal (R = 85 ± 5 %) of SHs at ng/L-concentrations, e.g. **Figure 1** (right) demonstrates this as a function of light intensity for 17ß-estradiol.
In this presentation, both of these approaches will be compared and contrasted, demonstrating that that key challenges i) and ii) above can be addressed via the use of visible-light absorbing organic photosensitizers that achieve a residence time of 0.6 s. Photostability and broader aspects including abundance (relating to the use of a noble metal) will also be discussed.

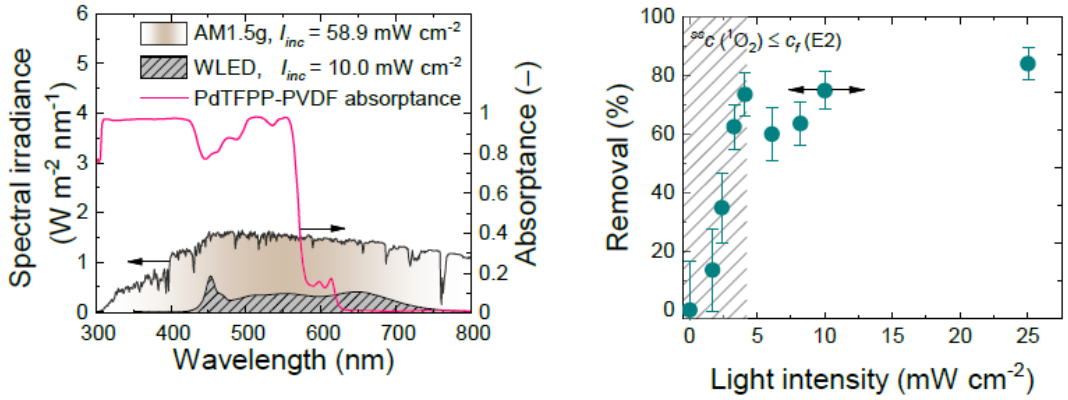

Figure 1. (left) Measured spectral irradiance of the white light emitting diode (WLED) illumination source compared to the standard solar spectrum – referred to as air-mass 1.5 global (AM1.5g) – along with the absorptance of PdTFPP-PVDF membrane. The Iinc values indicate the available light intensity in the 300 − 800 nm wavelength range. (right) Influence of incident light intensity from the WLED on the photocatalytic degradation (expressed as removal) of the SH 17ß-Estradiol at a concentration of 100 ± 10 ng/L (adapted from [5]).

Keywords: photocatalytic membranes, water treatment, photosensitizer, reactive oxygen species, micropollutants.

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USE OF OASIS WASTE IN CERAMIC MEMBRANE MICROFILTRATION TO TREAT OILY WASTEWATER

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Abstract:
This work presents a study of microfiltration of oily wastewater utilizing low-cost ceramic membranes prepared from clay and oasis waste as a pore-forming agent. The prepared membranes were characterized by contact angle, porosity, liquid entry pressure, and permeation experiments. Dead end microfiltration experiments were performed for three oily solutions with oil concentrations of 125, 250, and 500 mg/l. When we vary the mass percentage of oasis waste in ceramic membrane from 12 to 22%, we see a significant increase in open porosity of 34% after sintering at a temperature of 900°C. Besides, a decrease of the liquid entry pressure from 0.8 to 0.4 bar can be remarked. The oil rejection coefficient was up to 95% for all our prepared ceramic membranes. In this case, the permeate oil concentration was less than 10 mg/l, which meets the Tunisian national standard for the discharge of wastewater (NT. 106.002). The obtained results indicate the possibility to treat oily wastewater with a ceramic membrane prepared by a mixture of clay and oasis waste.

Keywords: Ceramic membrane, Characterization, Oasis waste, Oily wastewater

WATER SOURCE QUALITY TESTING IN GEZIRA STATE, SUDAN, USING THE COMPARTMENT BAG TEST

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Abstract
Although poor water quality is recognized as a public health threat, it has been little investigated in Sudan. In this paper, water sources in Gezira State, Greater Wad Medani locality, have been categorized as safe, intermediate safe and high-risk unsafe sources using the compartment bag test (CBT) to detect E. coli, which is an indicator of fecal contamination of water.
The CBT is simple, portable and self-contained, and it can be done in the field environment. A total of 122 samples were collected from different water sources and included rivers, water treatment plant, boreholes/tube wells, hand pumps, public water taps, public water coolers, public elevated water tanks and household elevated water tanks. It was found that 69% (84/122) of investigated water sources were safe to drink. The sources most likely to be contaminated were those close to industrial points and factories or open sources exposed to pollution. The result showed that the highest level of contamination of water sources (high risk and unsafe) was observed in rural area (9.1%) followed by urban (5.7%) and peri-urban (1.6%).
Frequent and routine qualitative analysis of water sources using CBT is recommended to improve human health and hence the country's development.

Keywords: Compartment bag test, Gezira State, Sudan, Water sources quality

BIOGAS RECOVERY FROM ANAEROBIC MEMBRANE BIOREACTOR EFFLUENT USING MEMBRANE CONTACTOR

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Abstract
Carbon dioxide (CO2) is believed to be a major contributor to greenhouse gases. Methane (CH4) emissions also affect the concentration of atmospheric greenhouse gas, because of its 28 times higher global warming potential than carbon dioxide [1]. The dissolved methane (dCH4) content in the anaerobic effluent could be between 10-25 mg L-1, but the super saturation indices could go to as high as 6.9 [2]. Other than environmental concerns, the dCH4 loss in the effluent could result in a significant amount of economic loss. Hollow fibber membrane contactor (HFMC) desorption process could provide a safe and efficient way to recover these dissolved gases.
The present work focuses on the recovery of biogas from anaerobic membrane bioreactor (AnMBR) effluent using sweep and vacuum desorption technology in porous and dense HFMCs. Effluent from the AnMBR as well as synthetic effluents of pure and mixed (60% CH4) CH4 and CO2 were used here. The anaerobic effluent comes from the outlet of the granular AnMBR operated at 25 °C, which produces ~12 L/day of the effluent. Synthetic effluents were prepared at 25 °C, in a tank of 9.5 L by bubbling (for 60 minutes) the pure/mixed gas using a gas diffuser inside the tank. HFMC was operated in a counter current arrangement for effluent flow and sweep gas/vacuum, to recover the dissolved biogas from the effluent.
Porous HFMC was able to achieve a very high degassing efficiency of up to 95% for CH4 and 78% for CO2. Results revealed that increase in both liquid flowrate and gas flowrate enhances the degassing process by enhancing the transmembrane mass transfer flux and membrane mass transfer coefficient. The total highest biogas recovery after two hours was recorded to be up to 92% for CH4 and 83% for CO2. Experimental mass transfer coefficients of 1.99 10-05 m s-1 and 1.01 10-05 m s-1, were recorded for CH4 and CO2, respectively. Furthermore, an in-depth investigation is being performed under the current work to analyse and characterize the porous and dense membrane fouling and its effect on the membrane performance. Moreover, a rigorous 2-D modelling approach will be used to extend the study and to make an approach toward possible scale-up.

Keywords: Degassing, Biogas Recovery, Membrane Contactor, Anaerobic Membrane Bioreactor.

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AIR DEHYDRATION WITH NEXAR BLOCK COPOLYMER COATED COMPOSITE HOLLOW FIBER MEMBRANE

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Abstract

Air conditioning is one of the essential requirements for households as well as work stations. Dehumidification in air conditioning is the highest energy-consuming component. Membrane based dehumidification, without involving any phase change, is an energy efficient system compared to the traditional vapor compression to its dew point based technologies. In this work, we propose the coating of NEXARTM, a commercial pentablock copolymer in tetrahydrofuran on polyetherimide hollow fibber support for separation of water vapor from humidified air. Hollow-fibber membrane in a shell-and-tube configuration was developed to deal with corrosion and crossover contamination of liquid desiccant in air dehydration. Coating of the membrane with 2 wt% block copolymers in THF and a subsequent solvent vapor annealing formed a lamellar/parallel cylindrical structure separated by equidistance during the morphological transformation process. This unique morphology provided the membrane with higher water vapor transfer efficiency at the optimum self-assembly conditions. Vacuum, sweep gas or liquid desiccants-based modes of membrane dehumidification strategies are investigated along with the detailed study of the morphological transformation process under a controlled environment, which is supported by comprehensive scanning electron microscopic and atomic force microscopic imaging. The membrane has shown water vapor permeance up to 9089 GPU with water vapor to nitrogen selectivity up to 3870 when vacuum was used as the driving force.

For liquid desiccant as the driving force, the absorption of water vapor from the shell side air into the lumen side liquid desiccant was weakly increased by liquid desiccant flow rate. Varying the desiccant temperature however has a huge impact. The fabricated composite membrane with the lamellar morphology promoted a great water vapor flux. Dehumidification at 22°C and 28°C,

which mimics an internally cooled system, was generally higher than the isothermal condition. A 15 cm effective membrane length was enough to achieve fast water vapor absorption by the liquid desiccant with a coefficient of performance (COP) 1, guiding us towards future system design for a broad scope of dehydration.

Keywords: dehydration, air conditioning, block copolymer, desiccant

HYDROPHILIC ADDITIVE IMMOBILIZATION ON POLYSULFONE MEMBRANE USING RADICAL INITIATED CROSS-LINKING

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Abstract

Among all commercially available polymers, polysulfone (PSU) is one of the most commonly used for ultrafiltration (UF) membranes. This polymer stood out for its high mechanical resistance during filtration process at large industrial scale and its excellent chemical and thermal resistance along on-line cleaning process. The main drawback of the PSU membrane is its inherent hydrophobic behavior, which often results in serious fouling when being in contact with biomolecules that are present in natural waters and/or hydrophobic molecules in wastewaters. Membrane manufacturers overcome this problem by incorporating hydrophilic additives, such as Poly(vinyl pyrrolidone) (PVP), in the dope solution before membrane preparation by phase separation. It reduces the material hydrophobicity and thus allows the preparation of membranes with improved fouling resistance. PVP is a water-soluble, nontoxic, chemically inert, pH-stable and biocompatible polymer. But the downside using PVP is that due to its inherent hydrophilicity it tends to swell water and it can leach out from the membrane during the filtration process, resulting in a deterioration of the hydrophilicity of the membrane and possibly blocking the pores leading to a reduction in water flux. The immobilization of a part of PVP is a way to increase the hydrophilicity of PVP-containing membranes, limiting PVP leaching out from membranes. However, it needs an additional step consisting on the crosslinking of the PVP. This post-modification on PVP can be achieved using different treatments such as γ-ray, UV irradiation, heat treatment or using chemical agent. Among these techniques, persulfate-initiated crosslinking offers the advantage to be easy to implement and to provide non-hazardous decomposition products.

In this work, PSU membranes were prepared using PVP as pore former but also as additive to increase the hydrophilicity. The immobilization of the residual PVP on the outer surface and in the cross-section of PSU flat sheet microporous membranes was performed via the cross-linking reaction using potassium persulfate (K2S2O8) as cross-linking agent. Different reaction conditions were investigated: temperature, reaction time and crosslinking agent concentration, in order to find the optimum conditions to improve the surface membrane hydrophilicity. We developed a method based on attenuated total reflectance–Fourier transform infrared (ATR–FTIR) analysis to evaluated PVP leaching and PVP immobilization. The hydrophilicity of the surface membrane was investigated by contact angle (CA) measurements and the morphology of the PSU/PVP membranes was observed by scanning electron microscope (SEM).

Keywords: Ultrafiltration, polysulfone, polyvinylpyrrolidone, hydrophilicity.

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A CAREFULLY DESIGNED FABRICATION OF ANTIFOULING HYDROPHOBIC MEMBRANES FOR USE IN MEMBRANE CRYSTALLIZATION

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Abstract:
The quality of selected industrial wastewater discharged from South African firms was studied over a period of one year. Some of the effluents discharged from these sources were found to contain high levels of salts contamination which pose a threat for discharge to the environment This study was aimed at developing novel membranes to be integrated to a membrane crystallization purification system for use in water purification which could be used for recovery of both water and minerals from the wastewater. It is worth noting that, like membrane distillation (MD, membranes used in membrane crystallization are affected by wettability and fouling. Wetting inside the pores of the membrane is elevated by the hydrophilic characteristic of the membrane, while fouling is mostly induced by the hydrophobic-hydrophobic interaction of pollutants and the surface of the hydrophobic membranes, hence block the pores of the membranes. These properties are not desirable. As such, a carefully designed polyvinylidene fluoride (PVDF) MDM composed of a super-hydrophobic modified backbone and a super-hydrophilic thin layer has been developed to concurrently overcome these challenges (Fig. 1). Several characterisation techniques were used to understand the physicochemical and intrinsic properties of the membranes. Also, the membranes were evaluated for their application in membrane distillation assisted crystallization. These processes demonstrated a potential to recover high purity water and salts minerals from the wastewater.

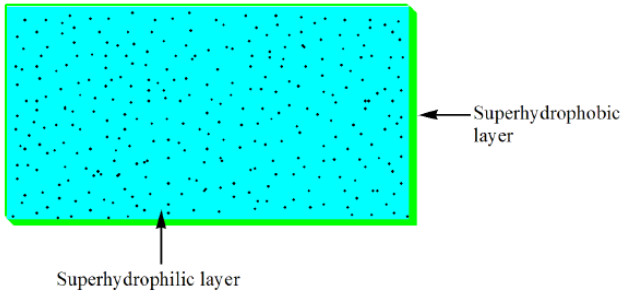

Figure 1: Membrane crystallization membrane composed of superhydrophilic and superhydrophobic layers to mitigate wetting and fouling challenges caused by the process conditions.

Keywords: fouling; membrane crystallization; mineral recovery; water treatment; wetting

RESILIENCE OF SMALL-SCALE SOLAR-POWERED MEMBRANE FILTRATION SYSTEMS FOR FLUORIDE REMOVAL FROM BRACKISH WATER

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Abstract:
Directly-powered photovoltaic membrane filtration (PV-membrane) systems have no energy storage components and thus experience fluctuations in power availability, caused by passing clouds. This disruption of the solar energy resource results in variations in the hydrodynamics, causing a decline in the permeate quantity and quality. Following such disruption, a PV-membrane system is able to recover its performance to a certain level defined by a recovery time (Figure 1). This means that a system can be described as highly resilient when it exhibits both a low performance loss and a fast recovery [1]. A robust PV-membrane system is further characterised by simple water quality indicators, which are especially useful for small-scale distributed systems deployed in remote regions.

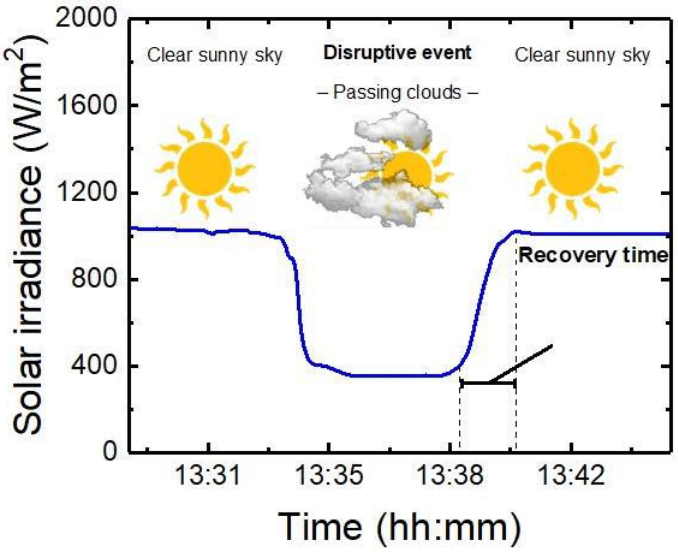

Figure 1. Graphical representation defining the concept of system resilience for a PV-membrane system (performance failure and recovery time) (adapted from [2])

A PV-membrane system [3] equipped with nanofiltration/reverse osmosis (NF/RO) membrane for surface and groundwater treatment was investigated. Four NF/RO membranes were used – NF270, NF90, LE, BW30 – to treat northern Tanzanian waters having different salinity, with all being characterised by high fluoride (F) contamination (>1.5 mg/L). For meaningful comparison, all experiments have been conducted with identical data of a recorded solar day characterized by four cloudy events. The resilience indicators of the PV-membrane system during the variable operation were resilience factor (RF) and recovery time [4]. The possibility of using the in-situ electroconductivity (EC) sensing as a substitute indicator of F concentration in the permeate was investigated.

Results showed that the PV-membrane system equipped with tighter NF/RO membranes (NF90, LE, BW30) exhibited high resilience to variations in permeate quality. This was in contrast to the loose membrane NF270, which exhibited a higher resilience to specific energy consumption (SEC) variations, but with a large decrease in permeate quality during fluctuations. System resilience exhibited a recovery time range of 50–350 s depending on duration of the fluctuation period and regardless to water quality or membrane type. Also, a high correlation between F concentration and EC was found, suggesting that EC is a good indicator for permeate quality. This work demonstrates the robustness of the decentralised PV-membrane system designed for drinking water production in remote conditions.

Keywords: drinking water, decentralised system, nanofiltration, reverse osmosis, energy fluctuations

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SCALING AND OSMOTIC BACKWASH CLEANING IN A BATTERYLESS PHOTOVOLTAIC-POWERED NANOFILTRATION/REVERSE OSMOSIS SYSTEM

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Abstract:
Small-scale decentralized directly coupled photovoltaic-powered nanofiltration/reverse osmosis (PV-NF/RO) membrane systems are a promising solution for the safe drinking water scarcity issue in off-grid rural areas with abundant solar energy resource, such as some communities in Africa [1]. However, some sparingly soluble inorganic salts in brackish water/groundwater may concentrate at the membrane surface during desalination and crystallize to cause the membrane scaling issue [2]. Membrane scaling reduces filtration efficiency, and increases energy consumption and cleaning frequency, consequently leading to high operation & maintenance costs. The nature of solar energy fluctuations causes unstable system performance and induces a direct osmotic backwash (OB) phenomenon in such systems [3]. OB is the process that the produced water is "suck-back" to the feed side, driven by the osmotic pressure difference across the membrane when applied pressure is lower than feed osmotic pressure [4]. As a potential self-cleaning method, OB may mitigate the scaling (as shown in Figure 1) during solar energy fluctuations. Thus, in this research, OB cleaning efficiency for different scaling (CaCO3 and CaSO4) with controlled fluctuating conditions were investigated to verify OB cleaning feasibility.
A lab-scale simulated PV-powered cross-flow NF/RO system was used for scaling experiments with OB (see Figure 1). The results showed that the OB restored 30 to 96% membrane flux and removed partial scaling crystals, depending on membrane type, scalant type, scalant concentration, and fluctuating conditions. It is demonstrated that solar energy fluctuations could be beneficial for the battery less PV-NF/RO system in terms of effective cleaning for scaling by spontaneous OB. This research suggests that shutting down the pump/reducing the operating pressure for a few minutes to induce the OB process could be regarded as a daily maintenance measure in practical [5]. It implies the potentials and reliability to apply such systems in Africa.

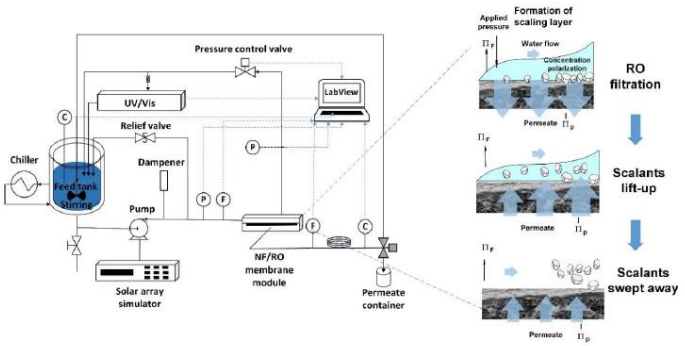

Figure 1. Schematic of lab-scale simulated PV-NF/RO system and osmotic backwash process for NF/RO scaling, adapted from [5].

Keywords: Brackish water desalination, decentralized water treatment system, membrane scaling, self-cleaning, solar energy fluctuations

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ELECTRODIALYSIS (ED) FOR NITRATE, ARSENIC (V) AND FLUORIDE REMOVAL FROM BRACKISH GROUND WATER

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Abstract:
Fresh water scarcity in arid and semi-arid regions requires unconventional water resources, such as brackish groundwater (i.e. <10 g/L total dissolved solids) to be used. The presence of inorganic contaminants, such as nitrate, arsenic and fluoride makes it necessary to provide sustainable desalination/decontamination technologies to produce safe, clean water from these resources [1]. Electrodialysis (ED) is the alternative to the state of the art nanofiltration (NF) and reverse osmosis (RO) processes, competing as a more efficient process at lower salinities with less waste/brine production [2]. While ED is used commercially for desalination and industrial purposes [3], this work studies the simultaneous removal of salinity and contaminants from brackish water for drinking water production. Nitrate, arsenic(V) and fluoride removal from a synthetic brackish water is investigated to identify the underlying ion transport mechanisms in ED. A lab-scale 100-Quadro stack (Deukum, Germany) with 10 cell-pairs of Neosepta AMX and CMX ion-exchange membranes (0.1 m2 effective area) in a batch system is used. Operational (flowrate and potential) and water quality (contaminant feed concentration, feed salinity and pH) parameters are studied. Ion chromatography (IC) and inductively coupled plasma mass spectrometry (ICP-MS) are used to analyse samples.
Concentration ratio of contaminants in the diluate tank as a function of time is presented in Figure 1. Over the studied potential range (5–25 V), ion transport follows a consistent order, similar to ionic mobility and diffusivity: nitrate, salinity, fluoride and at last arsenic(V) with lowest transport. While in low potentials arsenic(V) transfer is negligible, operating at high potentials proves to be an option for more effective arsenic(V) removal.

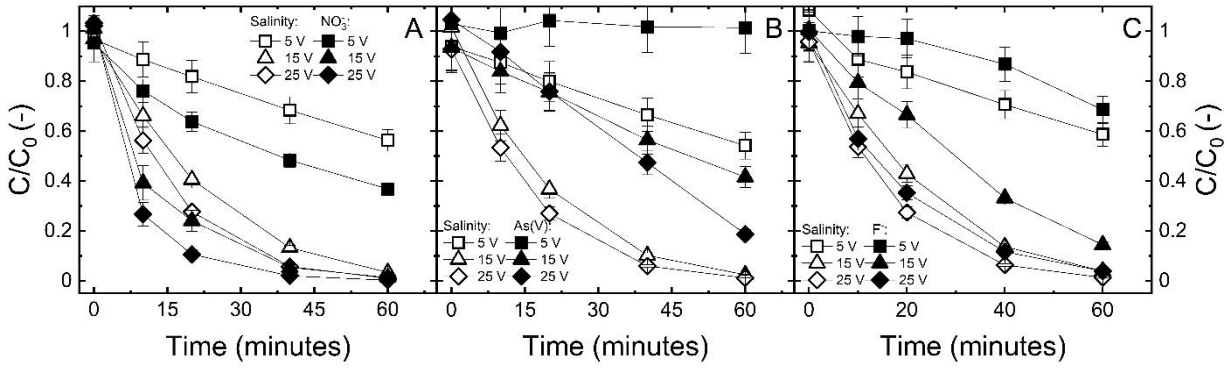

Figure 1. Concentration ratio of salinity and (A) NO3-, (B) As(V) and (C) F- over 1 hour in diluate tank at 5, 15 and 25 V potential, feed: 5 g/L NaCl, 1 mM NaHCO3, 1 g/L NO3-; 250 µg/L As(V); 100 mg/L F-, pH 8.0 ± 0.5, 50 L/h, 22 ± 1°C, results adapted from [4].

The *African Membrane Society* (AMSIC) is headquartered at the *Ecole Nationale d'Ingénieurs Abderhamane B. Touré* (ENI-ABT) located at 410 avenue Vollenhoven, BP 242, Bamako – Mali Links: ENI-ABT at https://www.eni-abt.ml/ and AMSIC at http://www.sam-ptf.com/

The prominent role of ionic characteristics is exposed in this study, however, with system and feed water quality modifications (working at high potentials and modifying solution pH [4]) it is possible to achieve more effective decontamination. This work, shows the capabilities of ED in removal and recovery of nitrate from water streams in different water quality and operational conditions. Compared to the competing NF and RO processes, ED uses less energy with low salinity feeds [2] and can provide sufficient denitrification levels.

Keywords: denitrification, arsenate, drinking water, ion-exchange membrane, water treatment

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ARSENIC(III, V) REMOVAL FROM WATER VIA NANOFILTRATION : ROLE OF WATER CHEMISTRY VARIATION AND ORGANIC MATTER

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Abstract:
Arsenic (As) in drinking water, with its both oxidation states As(III) and As(V), sources is a major public health concern [1]. Its mobilisation into water sources has been associated to the presence of organic matter (OM) [2]. Arsenic can co-exist with high salinity in the aquifers affected by sea water intrusion due to climate change [3]. The presence of OM and high salinity in As-contaminated groundwater can influence the performance of selected treatment process. Achieving high arsenic removal over harsh and changeable environments requires a process that does not need periodic regeneration and able to simultaneously remove salinity and OM. This implies that nanofiltration (NF), which requires lower specific energy consumption and operates at comparatively higher recoveries compared to reverse osmosis (RO), may be well suited for the treatment of different water types contaminated with As.
Nanofiltration experiments on As(III) and As(V) removal were carried with two different membranes (NF270 and NF90) placed in a macro cross-flow membrane filtration system. The operational conditions were at constant flow rates mode [4]. The experiments were conducted at different water chemistries; (i) pH from 2 to 12, (ii) different NaCl concentrations from 0.58 to 20 g/L and (iii) in the presence of humid acid (HA). Asymmetric Flow Field-flow fractionation coupled on-line with inductively coupled plasma – mass spectrometry (FFF-ICP-MS) was used to evaluate the As-HA complexation (Figure 1). Time-of-flight secondary ion mass spectrometry (ToF-SIMS) was performed to evaluate As deposition in the membrane active layer in the presence of HA (Figure 1).

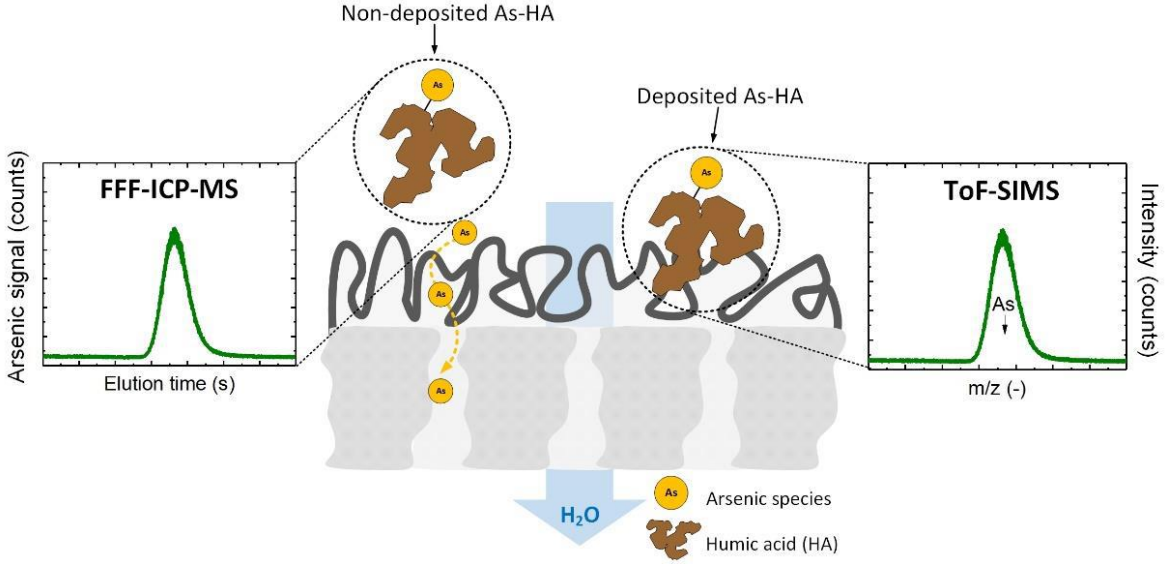

Figure 1. Schematic, not to scale, showing the retention of As with NF in presence of HA. The formation of As-HA complex is analysed by FFF-ICP-MS, where the deposited complex is detected by ToF-SIMS (adapted from [5]).

Results showed no measurable impact of salinity on the retention As(III) and As(V) with both NF membranes. Varying pH from 2 to 12, resulted in a significant increase in As(III) retention at pH>9 (from 40 to 77% for NF90), while the retention of As(V) remained high (>90% NF90) over the studied pH range. Increasing HA concentration to 100 mgC/L has significantly enhanced As(III) retention by 40%. This was attributed to the contribution of solute-solute interactions (As(III)-HA complexation) to the retention mechanisms. FFF-ICP-MS measurements has indeed showed that the bound As(III) increased with HA concentration (Figure 1). In addition, ToF-SIMS experiments showed that NF90, which had lower fouling potential than NF270, has exhibited lower As(III) deposition in the presence of HA, where As(III)-HA complex was formed in the feed solution. This finding is of importance for further investigations suggesting a hybrid process complexation enhanced NF using a complex agent with similar biding characteristics as HA.

Keywords: arsenate, arsenite, membrane filtration, water treatment, complexation

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COMPARATIVE STUDY ON THE RESISTANCE OF NF MEMBRANES EXPOSED TO OZONE

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Abstract
Ozone is a powerful oxidant applied in water treatment for disinfection and organic and inorganic pollutants removal. It can be coupled with membrane processes as a pre-treatment or post-treatment as well as in a hybrid configuration. In our study, we investigated the resistance of two commercial polymer nanofiltration membranes (NF90 and NF270) in contact with ozone (10 ppm for 1 h) at pH 3 and 7 to assess the influence of the ozone to hydroxyl radical concentrations balance. The surface properties of membranes were characterized before and after ozonation by means of various techniques, i.e. Fourier transform infrared spectroscopy in attenuated total reflectance mode (ATR-FTIR), zeta potential, water contact angle, atomic force microscopy (AFM) and scanning electron microscopy (SEM). For both membranes, the impact of ozonation on pure water permeability was greater at pH 7 than pH 3 due to the faster decomposition of ozone at pH 7 leading to the formation of more free radicals. The pure water permeability of the thin-film composite polyamide (PA) membranes dramatically increased after ozonation. The fully aromatic NF90 membrane appeared to be even more sensitive to ozone than the semi aromatic NF270. The different resistances of NF90 and NF270 membranes were attributed to the different amine monomers used for the synthesis of their active layer. Indeed, m-phenylenediamine used in interfacial polymerization of the NF90 active layer is an aromatic amine (aromatic rings are sensitive to ozonation) and is less basic than the non-aromatic piperazine used to develop the NF270 membrane (protonation of amines contributes to protect them from electrophilic attacks). For both PA membranes, ATR-FTIR and SEM indicated severely damaged active layers. The very sharp increase in the NF90 and NF270 permeabilities was attributed to the removal of active layer fragments, which was found compatible with both zeta potential and water contact angle measurements.

Keywords: Nanofiltration, ozonation, polyamide, ATR-FTIR, zeta potential

IMPACT OF SODIUM HYPOCHLORITE ON BIOMIMETIC AQUAPORIN FORWARD OSMOSIS MEMBRANES

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Abstract
Biomimetic forward osmosis membranes with a polyamide-based active layer containing polymersomes incorporating aquaporins were exposed to various free chlorine doses (free chlorine concentration x exposure time) and pH. Membrane chlorination was found to decrease the a polar/polar balance of the membrane surface energy and to increase its negative surface charge density. A substantial modification of the hydrogen-bond network in the membrane active layer was also highlighted. The separation performance of biomimetic membranes was also impacted by Chlorine-induced chemical ageing. For the lowest free chlorine doses (100 ppm h), the reverse salt flux was found to increase with respect to the pristine membrane while the water flux dropped by 10–20%. For higher free chlorine doses (1000 and 10 000 ppm h), both the reverse salt flux and the water flux were found higher than for the pristine membrane. These behaviors were explained by the combination of several mechanisms with possible antagonist effects, namely a reduced internal concentration polarization due to ageing of the membrane support material, and modifications of the hydrogen-bond network and surface charge density of the membrane active layer. Although the degradation caused by sodium hypochlorite increased the draw-solute loss per unit of water passed, the biomimetic membranes maintained their rejection ability towards naproxen and diclofenac as rejections higher than 95.9% were measured irrespective of the ageing conditions

Keywords: Biomimetic membranes, Forward osmosis, Sodium hypochlorite, Ageing, Pharmaceutical compounds.

SYNTHESIS OF NEW POLYANILINES DOPED WITH IONIC LIQUIDS FOR THE ELIMINATION OF HEAVY METALS BY ELECTRODIALYSIS TECHNIC

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Abstract
During the last decades, the levels of heavy metals such as copper (Cu2+), lead (Pb2+), cadmium (Cd2+), etc. have continued to increase in food and water. Some of these heavy metals are toxic and pollute the environment. Generally, heavy metals originate from to industrial processes, household waste, combustion of coal, petroleum, etc. Several separation technics allowing their removal were developed.
The application of polyaniline (PANI) and PANI doped by ionic liquids for the treatment of solutions containing Cu2+, Pb2+ and Cd2+ by electrodialysis technic was investigated. Firstly, the chemical synthesis of the conductive polymer (PANI) in the presence of HCl (1 M) and in the presence of two ionic liquids: 1-butyl-3-methylimidazolium tetrafluoroborate (BMimBF4) and 1-hexyl-2,3-dimethylimidazolium chloride (HMMimCl) was carried out. The polymers obtained were used in combination with polyvinyl alcohol for the fabrication of cationic exchange membranes. The membranes were characterized by optical microscopy, differential scanning microscopy, thermogravimetry and differential scanning calorimetry.
After synthesis and characterization, the membranes were used for the treatment of solutions of Cu2+, Pb2+ and Cd2+. The removal percentages of metals vary between: 80.63 to 96.04 % (Cu2+), 87.89 to 99.55 % (Pb2+) and 68.33 to 88.03 % (Cd2+).

Keywords : Polyaniline, onic liquids, Electrodialysis, Membranes, Heavy metal

OFF-GRID SUSTAINABLE DRINKING WATER TREATMENT SYSTEMS

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Abstract
800 billion inhabitants don't have secure access to water and 1,1 billion don't have access to electricity. Climate change will lead to 1,8 Billion inhabitants living in water stress areas. Decentralized water systems to provide safe water and electricity utilities powered by renewable energy are part of the solution to tackle this issue. We have developed a new concept of systems using Solar and wind energy combined with second life batteries storage capacities to offer new solutions for decentralized population and applications. According to local climate data and power required to produce a given volume of water together with other power usage, we design components of the system to satisfy needs minimizing CAPEX.
Using UF and RO membranes we adapt the systems to produce safe drinking water and irrigation water from any type of resources (groundwater/surface water, brackish and sea water). Thanks to an intelligent smart energy management tool we deliver water and power utilities 24/7. Our systems are such lego boxes well adapted to meet expectation of several situations that we will present. To illustrate such approach we will point out the combination of a water treatment system with solar powered drying equipment using thermovoltaic panels to preserve or dry agriculture crops.

Keywords membranes, solar energy, wind turbine, drinking water, desalination, drying, battery storage

NEW KAOLIN BASED MICROFILTRATION MEMBRANE SUPPORTED ON NATURAL SAND FOR THE REMOVAL OF OIL AND HEAVY METALS FROM ELECTROPLATING WASTEWATER.

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Abstract

High cost of high-purity materials is one of the major factors that limit the application of ceramic membranes. Consequently, focus has been shifted to using natural low cost materials like zeolite, clay, sand, … as alternatives to well-known other metallic oxides such as alumina, silica, zirconia and titania. As a contribution to this area, development and evaluation of new low cost microfiltration (MF) ceramic membrane made from natural Tunisian kaolin are presented in this work. The MF composite membrane was developed via the Layer-by-Layer method, and deposited on tubular macroporous support previously prepared from natural Tunisian sand via the extrusion process. The water permeability of the obtained membrane **Kaolin/Sand**, sintered at 900°C/3h, was 491 L/h.m^2.bar.

Oil and heavy metals removal efficiency of this membrane were evaluated using a home-made cross-flow MF plant operated at a transmembrane pressure (TMP) of 1 bar and a temperature of 60°C corresponding to the temperature of the produced oily wastewater imposed by the electroplating industry process.

During the treatment of oily wastewater (containing heavy metals) obtained from electroplating industry using the **Kaolin/Sand** membrane, a high stabilized permeate flux of 336 L/h.m^2.bar after 30 min of filtration was achieved. Almost total oil retention and chemical oxygen demand (COD) removal of 97% were observed. In addition, the **Kaolin/Sand** membrane displayed heavy metals removal efficiency of 99% for plumb, 96% for copper and 94% for zinc. The overall data suggest that the developed and tested composite MF membrane have potential for remediation of oily wastewater contaminated by heavy metals.

Keywords: Kaolin, Ceramic composite membrane, Microfiltration, Oily wastewater, heavy metals

NF FLUORIDE REMOVAL AND DESALINATION FOR DRINKING WATER IN SENEGAL 17 YEARS OF EXPERIENCE

POTABILISATION PAR NF DE L'EAU FLUORÉE ET SALÉE AU SÉNÉGAL 17 ANS DE PRATIQUES

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Résumé

Avec une estimation à 15 millions d'habitants, plus de 27% de la population du Sénégal sont exposés à une eau de boisson excessivement fluorée et salée entrainant des problèmes de santé tels que la fluorose dentaire et/ou osseuse.

Des résultats de laboratoires ont fait l'objet de plusieurs publications dans des revues scientifiques indiquant la possibilité d'élimination partielle du fluor dans l'eau par membranes de nanofiltration malgré sa taille d'ion très petit et d'une très forte électronégativité plutôt responsable d'une énergie d'hydratation élevée. Cette situation entraine l'organisation à Dakar d'un colloque international regroupant des universitaires, des industriels et des partenaires au développement [8]. La synergie développée lors de la rencontre aboutie à la conception et la mise en place en 2007 d'un module test en milieu rural dont la salinité dans l'eau de boisson varie autour de 2000 mg/L et le **fluor entre 5 et 15 mg/L**. C'est un module « Disc Tube™ » qui présente une forte résistance à l'encrassement, démontable puis réparable sur place et ne nécessite pas de prétraitement [9– 12]. Les résultats des tests obtenus ont permis l'installation d'une unité pilote en 2011 et de conclure sur la faisabilité et la fiabilité d'une production d'eau potable à partir d'eau très fluorée (73% d'abattement) et salée (48% d'abattement) [13]. Un nettoyage chimique est effectué après chaque 400 heures de fonctionnement du fait de la montée de la pression d'alimentation de 11 à 13 bars pour maintenir le même de débit de perméat. Lorsque les 4000 heures sont atteintes, nous procédons plutôt à un lavage mécanique qui consiste à démonter tout le module et laver les membranes manuellement avec de l'eau du perméat permettant alors de retrouver efficacement la pression initiale de 11 bars. La question du devenir du concentrât n'est pas abordée dans cette présentation.

Ce travail, source de 4 DEA et 3 thèses est présentement à l'origine de 23 unités de production de 500 L/h d'eau potable chacune à un taux de conversion de 70%. Ces unités sont installées pour l'essentiel en milieu rural, permettent l'accès à une eau de qualité, créent des emplois durables et améliorent la qualité de vie.

Mots clés : nanofiltration, fluor, dessalement, Sénégal
Keywords: nanofiltration, fluoride, desalination, Senegal

POSTER PAPER

SPECTROSCOPIC TOOLS TO CHARACTERIZE MEMBRANE FOULING POTENTIAL IN AN ANAEROBIC MEMBRANE BIOREACTOR

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Abstract

Nowadays, water pollution and energy shortage push governments and researchers to investigate technologies combined wastewater treatment and energy recycle. Anaerobic membrane bioreactor (AnMBR) has been widely considered as an attractive technology for wastewater treatment. AnMBR systems combine anaerobic biological treatment and membrane filtration technology, and possess advantages of both of them. Compared with conventional wastewater treatment systems such as activated sludge, AnMBR can reject all the sludge and microbials in the system, resulting in excellent quality of the effluent. Besides, AnMBR systems have other advantages, including high concentrations of mixed liquor suspended solids, low production of excess sludge and small foot print. Most importantly, methane can be produced by AnMBR systems, thus reducing energy consumption and even achieving energy positive in wastewater treatment plants.

However, membrane fouling still remains a challenge for the application of AnMBR. It is essential to identify fouling factors in the AnMBR system for stable operation and the early waning for membrane fouling. Dissolved organic matter (DOM) in the AnMBR system plays critical roles in membrane fouling. Numerous methods have been applied to characterize DOM such as Dubois and Lowry method, liquid chromatography combined with organic carbon and organic nitrogen detection, and monosaccharide composition analysis, but most of these conventional methods are laborious and time-consuming.

On the contrary, several methods based on optical principles, including infrared scattering, UV-visible absorption and fluorescence, provide more convenient in-situ monitoring techniques. Infrared scattering can be used to detect colloids or particles that are on the order of magnitude of infrared wavelengths and can cause light scattering effects.

These substances play an important role in the process of membrane pore blockage and cake layer formation. Indicators based on infrared scattering can be expressed by turbidity or total suspended solids (TSS). UV-visible absorption spectroscopy is a simple and versatile method for monitoring the structure of membrane foulants. Recent investigations demonstrated that excitation-emission matrix (EEM) fluorescence spectroscopy is a potential monitoring tool for DOM characterization in AnMBR because EEM fluorescence spectroscopy is quick, selective and highly sensitive and can provide large amount of information about material properties.

In this study, we aim to establish a comprehensive optical index system capable of quickly monitoring membrane foulants in AnMBR, and establish a response relationship between the optical indexes and the membrane foulant indexes. An AnMBR that combined continuous stirred tank reactor (CSTR) and membrane tank was run for almost 5 months.

Synthesis wastewater with different organic loading rate (OLR) was feed to the AnMBR to adjust the condition of mixed liquid. The fouling potentials of mixed liquid, centrifuge supernatant and SMP were examined by a dead-end filtration system. The total suspended solid (TSS) of mixed liquid were examined by a TSS detector, and turbidities of centrifuge supernatant and SMP were also examined. These two parameters are both based on infrared scattering principles. UV-vis and EEM spectrum of SMP were measured.

11 indexes were extracted from UV-Vis spectrum including absorbance values, absorbance ratios, spectral slope and slope ratio. 19 indexes were extracted from EEM spectrum, including average EEM intensity, fluorescence peaks, fluorescence regional integration (FRI), HIX, peak T/C, intrinsic lifetime, quantum yield, stokes shift. Furthermore, the relationship between these optical indexes and membrane fouling potentials were explored by correlation analysis, variance partitioning analysis (VPA) and regression analysis.
We found that the 254 and 280 nm UV absorbances (UV254 and UV280) displayed correlation coefficients of 0.57-0.77 with the fouling indexes, while the Peak1 and Peak2 fluorescence intensities (FIP1 and FIP2) displayed 0.84-0.92. SUV254, SUV280, A220/A254, HIXem, BIX, fT/C, FRI1, FRI2, FRI3, FRI5, HMP, SSP and ηWH≥ 320 were sensitive indicators of fouling potential with the concentration effect excluded. UV-vis spectrum and EEM spectrum are useful tools to monitoring DOM and membrane fouling potentials in AnMBR. It is promising to investigate in-situ devices to monitor membrane fouling potential of SMP in AnMBR based on UV-vis and EEM spectrum.

Keywords: anaerobic membrane bioreactor (AnMBR), dissolved organic matter (DOM), membrane fouling, spectroscopic tools

SUPER-HYDROPHOBIC PROPERTIES OF CASSIA SINGUEANA FOR FOG HARVESTING

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Abstract
During investigation of the wettability properties of cassia singueana, the lamina, midrib and margin regions of the adaxial part recorded average static contact angles of 150±5, 153±3 and 149±2 respectively, while the abaxial part is less hydrophobic with 152 ± 3, 147 ± 9 and 143 ± 4 respectively. Further analysis shows that the advancing and receding contact angles of the former were 152 and 141 respectively with a contact angle hysteresis of 11 and tilt angle of 20. These results, coupled with FESEM imaging of the leaf surface in SE detection mode shows the 3-dimensional epicuticular roughness fully covered with platelet-type waxes demonstrating cassia singueana as potential biomimetic material during fog harvesting.

Keywords: biomimetic, fog harvesting, super-hydrophobicity, SEM, contact angle

STATISTICAL STUDY OF WATER WITHDRAWALS IN INDUSTRIES

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Abstract

The scarcity of water resources is a global concern. In addition to human consumption, many sectors, such as the petroleum and textile industries, have very high water requirements. Large quantities of polluted water full of chemicals are released in the environment. Also, climate change has considerably accentuated the decline in water resources level.
The aim of our work is to carry out a statistical study on water resources and withdrawals and/or consumption in the world, where 768 km3/year of water are intended for industrial needs. In Algeria, 0.191 km3/year of water is collected by the industrial sector, and nearly 45.7% of the total is consumed by the hydrocarbon sector (Algeria is ranked 11th world producer of natural gas and 17th oil producer). Turkey's economy is largely based on the textile industry, ranked second for water consumption with approximately 0.160 km3/year. These different industries consume huge quantities of water, and most wastewaters are not treated for reuse.

Keywords: Water, industries, withdrawals, statistics, wastewater.

ASSESSMENT OF AIR POLLUTION LEVELS WITH PM1, PM2.5, PM10 AND ASSOCIATED REGULATED HEAVY METALS IN ALGIERS, ALGERIA DURING CONTAINMENT RELATED TO THE COVID-19 CONTAINMENT

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Abstract

Concentrations of particulate matter less than 10 µm, 2.5 µm and 1 mµ and their contents of regulated heavy metals and acid aerosols were investigated in urban side of Algiers (Algeria). The study was conducted during the very specific period of partial and total containment related to the Covid-19 pandemic. This period was characterized by a significant drop in road traffic and a slowdown in human activities, a unique and unprecedented situation for the study of particulate pollution levels in the absence of anthropogenic pollution sources. Sampling was conducted by a high volume samplers (HVS) equipped with a cascade impactor with fiberglass filters.
The characterization of the heavy metals and anions associated to the particulate matter (PM) was carried out respectively by X-Ray Fluorescence analysis (XRF) and ion chromatography inductively coupled with plasma mass spectrometry (ICP-MS). This study allowed us to make several interesting and relevant observations regarding the determination of the different sources of PM pollution in the three studied fractions and their contribution to pollution levels in general and associated heavy metals in particular

Keywords : Particulate matter, heavy metals, Covid-19 containment

EVALUATION OF DECENTRALIZED MEMBRANE WATER POTABILIZATION SYSTEMS FOR ISOLATED COMMUNITIES AND EMERGENCY SITUATIONS.

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Abstract:
The absence of water treatment infrastructures in isolated areas or the lack of means to maintain existing ones have fostered the development of decentralized systems. Such systems appear as indispensable today in emergency situations as well as in rural and urban areas suffering from poor water supply. In this study, two ultrafiltration membranes have been assessed, the Squirt system designed by Skyjuice and Orisa® system designed by Fonto de vivo. The systems were evaluated under a range of conditions (continuous vs. intermittent filtration for the Squirt and gravity-driven filtration vs. pumping filtration for the Orisa®). The rejection of suspended solids was high for both systems (99,5 % and 99,7 % for the Squirt and Orisa® respectively). However, the treatment of highly turbid water (300NTU) appeared to quickly decrease performances of both systems (up to 48 % permeability loss) despite the presence of prefilters (20 µm and 50 µm prefilters). To address this issue, a sedimentation pre-treatment would be the most appropriate alternative. The decentralized systems evaluated in this study are beneficial for emergency situations, rural areas and developing countries.