

# The African Membrane Society

## First International Congress:

SFAX 2016 – May 3<sup>rd</sup> – 5<sup>th</sup> 2016 - Tunisia

<http://www.sam-ptf.com/sfax.html>



### IMPLEMENTATION OF MEMBRANE PROCESSES FOR WATER TREATMENT IN SMALL COMMUNITIES & CITIES



#### PARTNERS:

THE AFRICAN MEMBRANE SOCIETY &

THE *FACULTE DES SCIENCES DE SFAX*

## Editorial par :



Pr. Raja Ben Amar



Dr. Abdoulaye Doucouré

L'African Membrane Society (AMS) est une société savante internationale qui regroupe les spécialistes de l'eau et des technologies membranaires.

L'AMS a vu officiellement le jour au mois d'août 2014. Son siège est établi à l'École Nationale d'Ingénieurs Abderrahmane Baba Toure de Bamako au Mali. Elle compte plus de 70 membres originaires de toutes les grandes régions d'Afrique (Afrique du Nord, Afrique de l'Ouest, Afrique Centrale, Afrique Australe et Afrique de l'Est) et quelques acteurs installés en Amérique du Nord et en Europe :

La liste des membres du Conseil de l'AMS (composé de douze représentants) se trouve en page suivante.

Notre association milite pour **l'étude et l'exploitation des procédés de filtration et s'intéresse aux axes stratégiques suivants : Eau, Santé, Énergie et Environnement**. La priorité et les défis pour l'AMS consistent à stimuler l'appropriation technologique via la formation d'une masse critique d'experts et la dissémination du savoir scientifique sur le continent africain tout en favorisant le rapprochement avec les acteurs de l'industrie.

Nous organisons cette année notre premier congrès international, AMSIC-1, du 3 au 5 Mai 2016 à Sfax. Cette manifestation sera tenue chaque deux ans dans différents pays d'Afrique.

Cette rencontre internationale s'appuie sur la participation d'éminents experts scientifiques, des professionnels et décideurs institutionnels du domaine de l'eau et des technologies à membrane.

Le congrès AMSIC-1 inclut des conférences sessions plénières et key-notes, des communications orales, des posters et la visite d'une station de dessalement d'eau de mer dans la région de Sfax.

Nous remercions nos collaborateurs membres du bureau de l'AMS et les différents sponsors. Nos remerciements s'adressent également aux participants qui contribuent à la réussite de cette grande manifestation scientifique. Nous sommes heureux d'avoir pu mobiliser toutes les pôles géographiques de l'Afrique en invitant d'éminents chercheurs, des experts européens et plusieurs décideurs issus de structures gouvernementales et industrielles.

## Editorial by:



Pr. Raja Ben Amar



Dr. Abdoulaye Doucouré

The African Membrane Society (AMS) is an international scientific society that brings together experts in membrane filtration and water treatment technologies.

The AMS was formally established in August 2014 and its headquarters are located at the National School of Engineers Abderrahmane Baba Toure in Bamako, Mali. It has over 70 members from all major regions of Africa (North Africa, West Africa, Central Africa, Southern Africa and East Africa) and some members are settled in North America and Europe:

AMS office is composed of twelve members (next page).

Our association is actively engaged in studying and implementing filtration processes and focuses its efforts on the following strategic areas: Water, Health, Energy and Environment. Our priorities and challenges are to promote technological ownership via the formation of a critical mass of experts, to disseminate scientific knowledge on the African continent and to foster academy-industry-government partnerships.

This year AMS first international congress (AMSIC-1) occurs between May 3<sup>rd</sup> and 5<sup>th</sup> in Sfax. Our goal is to organize AMSIC meetings every two years in different African countries.

This international meeting attracts world scientific experts, institutional professionals and decision makers from the membrane filtration and water treatment community.

The AMSIC-1 convention includes lectures plenary sessions and key-notes, oral presentations, posters and the visit of a seawater desalination plant in the Sfax region.

We would like to acknowledge the crucial support of all African Membrane Society members and our various sponsors. We are thankful to everyone that has been working closely with us to turn AMSIC-1 into a productive and memorable scientific gathering. This convention brings together many prominent researchers originating from all regions of Africa, several experts from western countries, and decision makers from the industrial and government sectors.



## AMS BOARD/ BUREAU DE L'AMS

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## [AMSIC-1 Program \(Golden Tulip Hotel\)](#)

Time	Monday, May 2 <sup>nd</sup>	
17:00-19:30	<b>Registration &amp; "O. Expo" installation</b>	
Time	Tuesday May 3 <sup>rd</sup> - Clean Water/ Desalination	
08:00-9:00	<b>Registration</b>	
08:30-9:00	<b>Opening Ceremony</b>	
09:00-09:45	<b>Plenary conference 1</b> <u>Design of membrane systems for drinking water supply in small communities</u> <b>Michel FARCY</b> , President - Aclaira S.A.S – France	
09:45-10:15	<b>Keynote 1</b> <u>Energy supply in desalination processes?</u> <b>Sadok BEN JABRALLAH</b> - Université de Carthage, Bizerte – Tunisia	
10:15-10:40	<b>Coffee Break</b>	
10:40-12:30	<b>Oral session A (I)</b> Carbon-based UF/NF Membranes for Water Treatment	<b>Oral session A (II)</b> Removal of Dissolved Minerals/Metals : Membranes Filtration for Water Consumption
	<b>Oral presentation numbers:</b> OC 1: OC 5	<b>Oral presentation numbers</b> OC6 : OC10
12:30-13:55	<b>Lunch &amp; Learn</b> <u>La stratégie de la SONEDE dans le domaine du dessalement</u> <b>M. Abderaouf NOUICIR</b> - SONEDE - Tunisia  <u>Water treatment using membranes: desalination of brackish water and/or seawater resources? Treatment of surface water and/or non-conventional water resources? Which kind of membranes and at which scale?</u> <b>Maxime PONTIE</b> - Université d'Angers - France	
14:00-14:45	<b>Keynote 2</b> <u>Membrane materials for desalination</u> <b>Andre DERATANI</b> - Institut Européen des Membranes, Université de Montpellier - France	
14:45-15:25	<b>Introduction to UNESCO-SIMEV</b> <u>Une décennie d'Initiatives de SIMEV au Service des Nouvelles Formes de Collaboration Nord-Sud</u> <b>Pierre MAGNES</b> (Firmus - France)	
15:30-17:10	<b>Oral session B(I)</b> Renewable Energy and Desalination Technologies	<b>Oral session B(II)</b> Surface Modified Membranes - Water Treatment Systems
	<b>Oral presentation numbers</b> OC11 : OC15	<b>Oral presentation numbers</b> OC6 - OC20



17:15-17:30	<b>Coffee Break</b>	
17:30-19:00	<b>Round table</b> <u>Implementation of Water Treatment Technologies in Small Communities and Urban Centers</u> Moderators : <b>Courfia DIAWARA, Senegal/ Roger BEN AIM, France</b>	
14:30-19:30	<b>O. Expo Exhibition (start)</b>	
19:15-20:30	<b>City Hall reception (Sfax Mayor)</b>	
22:00-23:00	<b>AMS members meet</b>	
<b>Time</b>	<b>Wednesday May 4<sup>th</sup>- Water reuse/ Industrial filtration</b>	
08:00-9:00	<b>Registration</b>	
09:00-09:45	<b>Plenary conference 2</b> <u>Membrane bioreactor: recent evolution and present status. A key technology for a more sustainable management of wastewater.</u> <b>Roger BEN AIM</b> , Institut de la Filtration & des Techniques Séparatives - Agen – France	
09:45-10:15	<b>Keynote 3</b> <u>2IE contribution in research and capacity building for water quality and water treatment in Africa.</u> <b>Amadou HAMA MAIGA</b> , International Institute for Water & Environmental Engineering, Ouagadougou - Burkina Faso	
10:15-10:40	<b>Coffee Break</b>	
10:45-12:30	<b>Oral session C (I)</b> Facilitated Transport Membranes: Performance and Applications	<b>Oral session C (II)Wastewater Treatment by Membranes and Alternative Technologies</b>
	<b>Oral presentation numbers:</b> OC 21- OC 25	<b>Oral presentation numbers:</b> OC 25 - OC 30
12:30-13:55	<b>Lunch &amp; Learn</b> <u>Treatment of industrial wastewater by membrane bioreactor with consideration of microbial community dynamics</u> <b>Sami SAYADI</b> , L.B.E. Centre de Biotechnologie de Sfax – Tunisia  <u>L'assainissement en Tunisie : l'expérience de l'ONAS</u> <b>Mohamed Ben MAKHLOUF</b> (ONAS -Tunisia)	
14:00-14:45	<b>Keynote 4</b> <u>Membrane science and technology research at the Nanotechnology and Water Sustainability Research Unit, of the University of South Africa.</u> <b>Mhlanga SABELO</b> - UNISA, Johannesburg - South Africa	
14:45-15:25	<b>IFTS presentation</b> <u>Testing protocols &amp; standards in filtration and transport studies:</u> <b>Vincent EDERY &amp; Hafedh SAIDANI</b>	



15:30-17:10	<b>Oral session D(I) :</b> Novel Membranes/Characterization Methods and Experimental Designs	<b>Oral session D(II) :</b> Membranes for Industrial Effluent Removal
	<b>Oral presentation numbers</b> OC31- OC35	<b>Oral presentation numbers</b> OC36 - OC40
17:15-17:30	<b>Coffee Break</b>	
17:30-19:00	<b>Poster session</b>	
08:30-17:00	<b>O. Expo Exhibition (ongoing)</b>	
19:00-19:45	<b>Poster review (AMSIC-1 JURY only)</b>	
Special time	<b>Dinner Gala - Poster awards</b>	
<b>Time</b>	<b>Thursday, May 5<sup>th</sup> - RO desalination (tour)</b>	
9:00-2:45	<b>Site tour of desalination station organized by Le Groupe Chimique Tunisien (GCT)</b>	
13:00-14:30	<b>Lunch (hosted by GCT)</b>	
14:45-15:45	<b>Downtown tour in Sfax</b>	
14:30-16:00	<b>O. Expo Exhibition (End)</b>	
16:00-17:30	<b>Closing ceremony &amp; awards</b>	
18:00-19:30	<b>Reception:</b> Sponsored by the Institut des Hautes Etudes de Tunis	



## List of oral contribution (OC)

**DAY 1 - Tuesday May 3<sup>rd</sup>, 2016 - Clean Water Access & Desalination**

**Morning: Session A - Afternoon: Session B**

OC	AUTHORS	TITLE	SESSION
1	A. Lhassani	Potabilisation des eaux saumâtres par les procédés membranaires	Removal of Dissolved Minerals/Metals Membranes for Water Consumption 10:45 – 12:30 (Session A)
2	R. Fakhfekh C. Charcosset R. Ben Amar	Removal of iron from Tunisian drinking water by an hybrid membrane process using oxidation/microfiltration	
3	S. N. Diop M. C. Faye M. M. Diém Diémé	Elimination du fluor et de la salinité par système membranaire en milieu rural au Sénégal : bilan de 02 ans de fonctionnement dans le village de Keur Mariama	
4	M. Cisse	Application de la nanofiltration pour la production d'eau potable au Sénégal	
5	D. Berdous D. E. Akretche	Ion Exchange Membrane textile bioreactor : A novel alternative approach for drinking water denitrification	
6	A. Oun R. Ben Amar S. Maouch-Chergui B Charbonnier G. Sahoo	Membrane d'ultrafiltration à base de dioxyde de titane déposé sur un support d'argile-alumine et destinée au traitement d'une eau de lac	Carbon-based Materials and UF/NF Membranes for Water Treatment 15:30 – 17:10 (Session B1)
7	E. N. Nxumalo S.D. Mhlanga B. B Mamba	Diverse Physicochemical and Performance Properties for CNT-based Membranes	
8	N. Tahri R. Ben Amar	Formation of an asymmetric carbon nanofiltration membrane for the treatment of industrial effluent	
9	K. Yokwana	Performance evaluation of nitrogen-doped carbon nanotubes/polysulfone mixed matrix membranes	
10	A. Karim M. Ouammou B. Achiou K. Khiat M. Bouhria A. Abdellah	Elaboration of flat ultrafiltration membrane fabricated from nano-pozzolan and obtained by a sono-chemical method	





**DAY 1 - Tuesday May 3<sup>rd</sup>, 2016 - Clean Water Access & Desalination**

**Afternoon: Sessions B (II, III)**

OC	AUTHORS	TITLE	SESSION
11	N. Kasbadji Merzouk Z. Tigrine D. Tassalit	L'apport des énergies renouvelables au dessalement: Relevance of renewable energy technologies in desalination	<b>Renewable Energy and Desalination Technologies 15:30 – 17:10 (Session BII)</b>
12	N. Frikha	Performance evaluation of an autonomous vacuum membrane distillation unit coupled with solar energy	
13	Z. Tigrine N. Kasbadji Merzouk H. Aburideh M. Abbas D. Belhout D. Zioui S. Hout M. Khateb	Characterization of pilot-scale desalination reverse osmosis membranes coupled with a sustainable energy source	
14	M. Haudebourg M. Vergnet	OMOSUN: an autonomous photovoltaic-solar desalination unit operating without electric storage battery	
15	P. Magnes	Water treatment derived from the coupling of membrane and renewable energy technologies	
16	P. Margnes	Introduction to a grey water recycling System	<b>Surface Modified Membranes - Water Treatment Systems 15:30 – 17:10 (Session BIII)</b>
17	K. Fethi	Performance de la station de dessalement de Gabes (30000 m3/j) après 20 ans de fonctionnement	
18	M. Khemakhem M. Lejeune S. Khemakhem R. Ben Amar	Study of ceramic membrane surface modification by thin-film deposition using PECVD technique	
19	A. Chaabouni F. Guesmi B. Hamrouni	Modification of CMX ion-exchange membrane: effect of temperature on ion-exchange equilibrium	
20	S. Gassara E. Dufour W. Chinpa Y. Shih D. Quemener R. Ben Amar Y. Chang O. Lorain A. Deratani	Improvement of membrane filtration performance by use of hydrophilic polymers	



## DAY 2 - Wednesday May 4<sup>th</sup> - *Water reuse & Industrial filtration*

### Morning: Session C - Afternoon: Session D

OC	AUTHORS	TITLE	SESSION
21	I. Khouni S. Abdelkader L. Bousselmi A.hmed Ghrabi	Investigation of cheese whey wastewater treatment using coagulation/flocculation and membrane filtration: New hybrid process	<b>Facilitated Transport Membranes FTM: Applications 10:45 – 12:30 (Session C)</b>  <b>Performance &amp;</b>
22	T. Eljaddi M. Riri, M. Hor Y. Chaouqi L. Lebrun M. Hlaibi	Preparation of new polymeric membranes used for studying the facilitated transport of cadmium ions in aqueous solutions	
23	T. Eljaddi A. Benjjar M. Riri, H.E. Atmani I. Mourtah L. Lebrun M. Hlaibi	New supported liquid membranes containing TBP and MC as carriers for the facilitated transport of cadmium ions from acidic mediums: Parameters and mechanism	
24	E.A. El Houssaine M. Habib Y. Chaouqi I. Touarsi L. Laurent M. Hlaibi	Influence des facteurs acidité et température sur l'évolution des paramètres relatifs au processus de l'extraction facilitée des cations Co <sup>2+</sup> et Ni <sup>2+</sup> à travers une membrane polymère type SLM contenant des agents extractifs phosphatés	
25	M. Habib S. Majid E.A. El Houssaine S. Tarhouchi M. Hlaibi L. Laurent	Determination of specific parameters related to the directed process of facilitated extraction of Oleic acid through polymer inclusion membranes.	
26	K. Touaj S. Majid N. Sefiani L. Lebrun M. Hlaibi	L'Association substrat-agent extractif: principe de base pour l'extraction et la séparation facilitée par procédés membranaires	<b>Wastewater Treatment by Membranes &amp; Alternative Technologies: 15:30 – 17:10 (Session D I)</b>
27	B. Moslah A. Jrad	Decontamination of residual antibiotics-loaded wastewater by combining solar TiO <sub>2</sub> photocatalysis and biological treatment	
28	H. I. Abdel-Shafy	Treatment enhancement of blackwater Using ZnO-nanoparticles coupled with an efficient mixed micro-organism and membrane bioreactor	
29	A. Tolofoudye	Challenges of residential, domestic and industrial wastewater management in Mali: case study in Bamako city	
30	C. Fersi	Wastewater treatment of tannery effluents via an hybrid process of coagulation-flocculation / NF	



**DAY 2 - Wednesday May 4<sup>th</sup> - Water reuse & Industrial filtration**

**Afternoon: Sessions D (II, III)**

OC	AUTHORS	TITLE	SESSION
31	H. Aloulou A. Ghorbel R. Ben Amar Raja S. Khemakhem	Elaboration et caractérisation d'un nouveau support membranaire à base de zéolite : Elaboration and characterization of a new membrane support derived from a zeolite	<b>Novel Membranes/Characterization Methods and Experimental Designs</b> <b>15:30 – 17:10</b> <b>(Session DII)</b>
32	I. Louati F. Guesmi C. Hannachi B. Hamrouni	Optimization of nitrate removal from water by electrodialysis	
33	A. Doucoure	Advanced nonwoven filtration materials for enhanced water pretreatment	
34	So. Rekik A. Deratani	Study of ceramic membranes from naturally-occurring Kaolin clays for microfiltration applications	
35	D. Tassalit N. Kasbadji Merzouk O. Mouzaoui W. Naceur Wahib N. Chekir O. Benhabiles	Use of an experimental design for the heterogeneous photocatalysis of organic pollutants in aqueous TiO <sub>2</sub> suspension	
36	A. Hammami C. Charcosset R. Ben Amar	Removing of AO7 dye by an hybrid process based on adsorption/membrane separation	<b>Membranes for Industrial Effluent Removal (MIER):</b> <b>15:30 – 17:10</b> <b>(Session DIII)</b>
37	D. Dadi B. Van der Bruggen	Bioethanol production from coffee waste fractions and quality upgrading using an alcohol selective pervaporation membrane	
38	B. Dembele A. Tolofoudye A. Doucoure	Traitement des eaux de drainage minier du Mali par nanofiltration / Treatment of Mali drainage mining water by nanofiltration	
39	S. Louhichi A. Ghorbel S. Khemakhem	Elaboration of a new ceramic membrane from Turkish zeolite for hydrogen sulfide removal by ultrafiltration.	
40	R. Haouche H. Mabrouki D. E. Akretche	Membrane treatment of an effluent derived from the pharmaceutical industry	



## Poster session (Golden Tulip Hotel)

**Wednesday, May 4<sup>th</sup>: 17:30 – 19:00**

N°	AUTHORS	TITLE
1	Catherine Charcosset Assma Alharati Koffi Fiaty	Elimination du bore contenu dans l'eau par un procédé membranaire hybride associant résine échangeuse d'ions et microfiltration
2	Imen Derbel Mouna Khemakhem Raja Ben Amar	Elaboration and characterization of a carbon-based ultrafiltration Membrane: Application to membrane distillation
3	Diaf Amine Seddini Abdelali Debbal Zakaria	Traitement des eaux sur des filtres gravitaire à composition variée/Water treatment based on trickling filters of various compositions
4	Kholiswa Yokwana Sabelo.D Mhlanga Bhekie.B Mamba Edward.N Nxumalo	Performance evaluation of nitrogen-doped carbon nanotubes/polysulfone mixed matrix membranes
5	Jamel Kheriji Béchir Hamrouni	Le bore comme élément problématique dans le domaine de dessalement
6	Ghazza Masmoudi Raja Ben Amar	Comparison between coagulation/ultrafiltration hybrid treatment and combination of membrane processes for the treatment and reuse of dyeing effluents
7	Aloulou Wala Hamza Wiem Khemakhem Sabeur Ben Zina Mourad Ben Amar Raja	Développement de membranes poreuses de filtration à base de nano-composites argileux.
8	Imen Ben Belgacem, Hazem Bouhamed and Sabeur Khemakhem	Elaboration and characterization of ZnO-SiO <sub>2</sub> nano-composite made of a nanofiltration layer
9	Sofian Louhichi Ghorbel Ali Sabeur Khemakhem	Elaboration and characterization of a novel ceramic microfiltration membrane From Tunisian natural kaolinite
10	Mahzoura Missaoui Fakhfekh Rahma Ben Amar Raja Charcosset Catherine	Defluorination of Tunisian drinking water (region of Gafsa, South)
11	Mohamad M. Dieme	Sustainable conversion of agricultural wastes into activated carbons devoted to arsenic (V) and fluoride removal from natural water
12	Nabil Jallouli Mohamed Ksibi	UV and solar photo-degradation of Naproxen: Reaction kinetics, product identification and assessment of toxicity
13	Ahmed Hammami Ghazza Masmoudi Catherine Charcosset Raja Ben Amar	Application of microfiltration and ultrafiltration in hybrid processes for dyeing wastewater treatment



14	Mohamed Aiman Kammoun Sana Gassara André Deratani Raja Ben Amar	Adoucissement des eaux saumâtres par membrane de nanofiltration NF270
15	Radek Oborný	Sustainable and robust DEWATS- sidestream AnMBR with the Helix Technology
16	Hassen Khazri Ibtissem Ghorbel-Abid Rafik Kalfat	Removal of drugs in aqueous solution onto natural clay
17	Tassalit Djilali Kasbadji M. Nachida Mouzaoui Oussama Naceur Wahib Chekir Nadia Benhabiles Ouassila	Use of an experimental design for the heterogeneous photocatalysis of organic pollutants in aqueous TiO <sub>2</sub> suspension
18	Ilhem Ben Salah Sayadi	Study of CaCO <sub>3</sub> scaling of ion-exchange membranes
19	Hafedh Saidani Vincent Edery Roger Ben-Aim	New testing method: Effectiveness of submicron cartridges and membranes



Chers collègues,

Les organisateurs du congrès de Sfax ont le plaisir de vous informer que les quatre candidats ci-dessous (étudiants ou professionnels en début de carrière) ont été choisis pour représenter les premiers lauréats de l'AMSIC. L'association European Membrane Society ayant sponsorisé cette compétition chaque lauréat recevra un diplôme cosigné par les responsables de l'EMS et de l'AMS et une récompense de 150 euros.

Dear colleagues,

The Sfax congress organizers are delighted to inform you that the four candidates whose names are listed below (students and early career professionals) were selected as first laureates of AMSIC. Since this activity is sponsored by the European Membrane Society the award recipients will receive a certificate signed by EMS and AMS leadership as well 150 euros.

<b><i>Best Oral Presentation by Students &amp; Young Professionals</i></b>		
1	<b>Kholiswa YOKWANA (South Africa)</b>	
	Performance evaluation of nitrogen-doped carbon nanotube/polysulfone mixed matrix membranes	
<b><i>Best 3 Posters by Students &amp; Young Professionals</i></b>		
1	<b>Ghazza MASMOUDI Tunisia</b>	Comparison between coagulation /ultrafiltration and combination of membrane processes for the treatment of dyeing effluent
2	<b>Jamel KHERIJI Tunisia</b>	Le bore comme élément problématique dans le domaine du dessalement
3	<b>Zahia TIGRINE Algeria</b>	Characterization of a pilot-scale reverse osmosis membrane coupled with a self-sustained energy source

Nous remercions l'EMS pour ce geste généreux et félicitons Kholiswa, Ghazza, Jamel, et Zahia pour leur excellent travail. L'AMS et ses partenaires sont extrêmement reconnaissants envers tous les sponsors et les participants qui ont contribué au succès de cette rencontre et vous donnent rendez-vous en Afrique du Sud pour l'AMSIC-2 prévu en 2018.

We would like thank EMS for its generous support and congratulate Kholiswa, Ghazza, Jamel, et Zahia for their outstanding work. AMS and its partners are deeply grateful to their sponsors and participants who have made this meeting successful. We would like to invite you to join us again during AMSIC-2 in South Africa in 2018.

Salutations Cordiales / Kindest regards.



Participant à la rencontre / 04 mai 2016, Hotel Golden Tulip



Visite de la station d'Osiose Inverse (Groupe Chimique Tunisien ) de  
dessalement de mer de Skhira, e, banlieue de Sfax, Tunisia



Cérémonie d'inauguration du congrès à l'intérieur de la Mairie de Sfax



Mairie de Sfax by night





## **Objectifs de la Conférence**

Une gestion rigoureuse des ressources en eau s'impose dans toutes les régions du globe à cause principalement de l'assèchement des sols ou des contraintes d'ordre économique et géopolitique.

La croissance de la demande en eau, associée à la situation de stress hydrique, et aux contraintes d'ordre économique et géopolitique, nécessite la mobilisation de nouvelles richesses et une gestion rigoureuse des ressources avérées. En Afrique, les menaces climatiques ont causé une baisse sensible en approvisionnement en eau de surface, ce qui entrave le développement économique de la région. Ainsi, il devient urgent d'exploiter les technologies filtrantes, certaines ressources non conventionnelles et les énergies renouvelables pour favoriser l'accès à l'eau potable, l'irrigation des sols, et l'épuration des eaux usées à des fins de réutilisation ou de recyclage.

La rencontre internationale de Sfax (Tunisie), mettra l'accent sur les principales avancées de la recherche académique et industrielle dans le domaine des technologies membranaires et de filtration pour le traitement de l'eau.

Les experts se réuniront pour échanger les données et résultats des projets de recherche engagés en Afrique, et formuler les recommandations et orientations futures en matière de gestion efficace de l'eau. Les objectifs à long terme visent à renforcer les capacités scientifiques et technologiques, stimuler la croissance économique à travers la valorisation des ressources en eau et énergie afin de freiner la progression de la pauvreté en Afrique et ses conséquences dévastatrices.

## **Objective of the conference**

The prevalence of physical water scarcity, economic limits, and complex geopolitical development around the globe call for pressing action and better management of water resources. In Africa, environmental and climate challenges have resulted in diminishing surface water supply that has hindered economic development.

In this context, it is worth assessing the relevance of filtration processes vis-a-vis potable water resource management, land irrigation, renewable energy production, and wastewater treatment for reuse or recycling.

The international meeting in Sfax (Tunisia) will focus on key advances in academic and industrial research targeting membrane technologies for water treatment. Experts will gather to share research data, discuss water projects initiated in Africa, and make recommendations for future directions. The underlying goals for Africa are to build scientific and technological capacity, stimulate economic growth, and play an active role in the fight against poverty.

AMS will organize two days of research sessions and training to discuss membrane filtration in developing countries (May 3rd and 4th). The third and final day will be devoted to visiting a water desalination plant followed by the closing ceremony.



## **Comité d'Édition et de Publication**

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## Characterization of Pilot-Scale Desalination Reverse Osmosis Membrane Coupled With Sustainable Energy Source

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### **Abstract**

Since the last decade, water desalination has emerged as a suitable alternative to overcome water scarcity and ensures a good water quality in most of the Middle East and North Africa region (MENA) and especially in arid and semiarid countries. Water is an important factor for the economic and social development of a any society. Several membrane separation technologies were scaled up to increase water production for domestic, agricultural and industrial purposes.

In Algeria, membrane seawater desalination technology is used along the Algerian coast to overcome a growing water scarcity due to population growth and climate change. It is a quick solution to meet the significant water demand in some overcrowded coastal cities. Reverse osmosis desalination process is the prevailing technology to produce clean water from salt water for many domestic and industrial applications. Due to a severe continuous drought, a huge desalination program was adopted to address the water deficit. Thirteen seawater desalination projects are operational with a total capacity of 2,260 million cubic meters that is 2.26 billion liters per day.

The present work provides an experimental analysis of a small capacity reverse osmosis unit designed for desalination and water treatment. In this preliminary study we use brackish well water of UDES for experimental testing. The main goal is to explore the effect of pressure on the permeate and reject water flow rate in order to control system production and operation for various parameters affect the process. The design and optimization of a stand-alone renewable energy generator is being investigated for powering a RO unit using battery storage. This research work also examines several informative water analysis tests prior and post treatment.

**Keywords:** Desalination; Membrane; Reverse osmosis; Seawater; Solar energy.



## L'Association Substrat-Agent Extractif. Principe de Base pour l'Extraction et la Séparation Facilitées par procédés Membranaires

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### **Résumé**

Le principe de l'association des différentes composantes de la matière, est la base pour comprendre les différents types des évolutions rencontrées. Plusieurs travaux ont utilisés ce principe de base pour, synthétiser des nouveaux produits [1], expliquer des mécanismes réactionnels [2,3], ou créer des voies détournées pour doser d'une manière spécifique un composé dans un milieu réactionnel complexe [4], ou identifier des édifices moléculaires complexes en solution [5,6].

Dans le présent travail, nous présentons des travaux basés sur le principe de l'association Substrat-Agent extractif pour les processus dirigés à travers des membranes polymères (SLMs, PIMs et GPMs). Ces membranes sont élaborées à l'aide des supra molécules amphiphiles dites agents extractifs, et des supports polymères inertes, qui permettent la réalisation des processus d'extraction et facilitent la récupération ou la séparation spécifique par procédés membranaires. Les paramètres macroscopiques, à savoir la perméabilité et flux (P et J) et microscopiques, à savoir la constante d'association et le coefficient apparent de diffusion ( $K_{ass}$  et  $D^*$ ), ont été déterminés et la nature du mouvement du substrat (S) à travers chaque type de membrane adoptée, a été élucidée [7-9].

Afin de comprendre le déroulement de ces processus dirigés et avoir une idée sur leurs mécanismes, nous avons examiné l'influence de la température. Les résultats indiquent une nette amélioration de la performance des membranes et une évolution des paramètres P, J,  $K_{ass}$  et  $D^*$ , [10]. Par ailleurs, Les valeurs des paramètres d'activation  $E_a$ ,  $\Delta H^\ddagger$  et  $\Delta S^\ddagger$  indiquent que la température est un facteur prédominant et que le mécanisme de ces processus dirigés est gouverné par un terme structural lié à l'association du substrat avec l'agent extractif, alors que l'influence du terme énergétique est négligeable.

**Mots clés:** Procédés membranaires; processus dirigés; perméabilité; flux; constante d'association; coefficient de diffusion; paramètres d'activation.

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## Elaboration of Flat Ultrafiltration Membrane Based on Nano-Pozzolan Obtained by Sonochemical Method

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### **Abstract**

The ceramic membranes are extensively used due to their excellent mechanical strength, chemical resistance, thermal stability and long working time. The exploitation of geomaterials such as clays, phosphate and perlite could play a significant role for the elaboration of low cost membranes.

The objective of this work is the development of ceramic membrane based on Moroccan natural pozzolan. XRF, XRD and TGA techniques were used for characterization of raw material. The support elaborated by dry process and sintered at 950°C, has a planar shape of 40 mm in diameter and  $2 \pm 0.2$  mm in thickness. The nano-pozzolan powder was prepared from dispersion of natural pozzolan in water using ultrasound irradiation with frequency of 24 kHz for 6h. The active layer was deposited on flat support by slip-casting process using a mixture of nano-pozzolan, polyvinyl alcohol as blender and water. The membrane was dried at room temperature then sintered at 950 °C. The top surface and cross-section of elaborated membrane were observed by a scanning electron microscope. The performance of membrane was evaluated by cross-flow filtration test of industrial colored effluents in order to remove the turbidity, chemical oxygen and color absorbance.

**Keywords:** Nano-pozzolan; Ceramic membrane; Ultrafiltration; Slip-casting; Industrial effluents.

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## New Supported Liquid Membranes Containing TBP and MC as Carriers for the Facilitated Transport of Cadmium Ions from Acidic Mediums: Parameters and Mechanism

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### **Abstract**

In this work, we have developed two new supported liquid membranes (SLMs) for the recovery of cadmium ions Cd(II) from acidic media. To prepare this type of membrane, we have used the PVDF polymer as support, the compounds methyl Cholate (MC) and Tri-butyl phosphate (TBP) as carriers, and toluene solvent as the organic phase. We have developed a kinetic model to calculate the macroscopic parameters (permeability P and the initial flux J<sub>0</sub>) related to each membrane prepared. We have also developed a thermodynamic model to determine the microscopic parameters K<sub>ass</sub> (association constant) and D\* (apparent diffusion coefficient) that are specific to the diffusion of the complex (TS) formed between the substrate and the carrier used through the organic phase. The proposed models were verified by the experimental results found.

Next, we studied the influence of the carrier nature and the initial concentration of the substrate cadmium ions. Furthermore, these results indicate that the migration of cadmium ions through the organic phase of the SLM is not a pure diffusion but successive jumps of the substrate from one site to the other of the carrier.

**Keywords:** facilitated transport supported liquid membrane (SLM); cadmium; permeability; flux; diffusion.



## Removal of Iron from Tunisian Drinking Water by Hybrid Membrane Using Oxidation/Microfiltration-Process

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### **Abstract**

Iron is one of the major components of earth hence it is highly present in ground water while it is almost not in the ventilated surface waters because of its oxidation reaction with oxygen. This element doesn't represent any danger to human health or to the environment, it is responsible for unpleasant taste and color, induces the neutralization of disinfectant or corrosion issues

Several current methods are remove iron from water among them are the oxidation of the soluble iron form ( $\text{Fe}^{2+}$ ) into ferrous hydroxide precipitates ( $\text{Fe}(\text{OH})_3$ ). The oxidation process is relatively slow at temperatures under  $60^\circ\text{C}$ . Consequently, it is carried out using powerful chemical oxidant as such as chlorine, ozone or potassium permanganate. The use of catalysts like  $\text{NiO}$ ,  $\text{MnO}_2$  and  $\text{MgO}$  can also significantly increase the reaction rate, allowing the separation process to be performed at room temperature. Moreover, several authors reported that the presence of  $\text{Fe}(\text{OH})_3$  in solution allows an autocatalytic activity against oxidation, [1,2,3].

During the last three decades, membranes processes have received increased attention and are now used in several industrial applications, particularly for process intensification and easy scale-up. One of the most common industrial applications of membranes is in drinking water treatment and the wastewater treatment.

This work deals with the removal of iron from drinking water by using a hybrid process combining oxidation and microfiltration to make use of the autocatalytic effect of  $\text{Fe}(\text{OH})_3$  reported in the literature, [1,2,3] . For this, two processes are compared: aeration in batch followed or not by microfiltration and a hybrid aeration/microfiltration process with recirculation mode. Water samples containing  $\text{Fe}^{2+}$  were aerated by air bubbling at constant flow rate and pH, giving  $\text{Fe}(\text{OH})_3$  precipitates. The  $\text{Fe}^{2+}$  concentration was determined by UV spectroscopy thanks to the 1, 10 - phenanthroline method (Norme Afnor NF90-017). The microfiltration membrane is a tubular Kerasep membrane (Novasep, France) with  $0.2 \mu\text{m}$  pore size and  $7.63 \cdot 10^{-3}\text{m}^2$  active area.

It was clearly observed that the hybrid oxidation/microfiltration process significantly improved the iron removal by oxidation. The permeate flux increases from  $250 \text{ L/m}^2\text{h}$  with discontinue process to  $450 \text{ L/m}^2\text{h}$  with hybrid process.



A quasi-total removal of iron was observed in the first minutes of microfiltration. This can be attributed to the increase in concentration of  $\text{Fe}(\text{OH})_3$  by microfiltration and its catalytic effect on the oxidation reaction in the aerated batch reactor. Treatment by aeration in batch reactor followed by microfiltration seems clearly less efficient since a slight increase of iron removal between 20% and 50% was achieved during the 60 minutes of filtration. The hybrid treatment requires no addition of oxidant and catalyst thus resulting to a green process.

**Keywords:** Hybrid process; Oxidation/Microfiltration; Iron removal; Tunisian drinking water.

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## Elaboration and characterization of Carbon Ultrafiltration Membrane: Application to Membrane Distillation

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### **Abstract**

The preparation of a new tubular carbon ultrafiltration (UF) membrane was presented. A plastic paste was prepared using some graphite powder mixed with organic additives and phenolic resin solution and was shaped into a tube by extrusion molding. After curing and carbonization at 700°C under nitrogen atmosphere a support was formed exhibiting an average pore diameter of about 3 microns and a porosity of 37%.

A 20-micron thick film of graphite powder with an average pore size of 0.7 micron was deposited by slip casting on the inner surface of the graphite macroporous support.

Next, the mesoporous top layer was deposited by the same protocol using a viscous suspension made of commercial carbon black powder (average particle size of 60 nanometers) that was mixed with an alcoholic solution of novolac-phenolic resin. The UF membrane formed exhibited an average pore diameter of 5 nanometers and a thickness around 7 microns.

After each embedding step, the same cycle of curing and carbonization was repeated.

The UF membrane produced displayed some attractive properties in terms of mechanical and chemical resistance. It was successfully tested in the field of membrane distillation using brackish water and car wash waste water. Results indicated that high salt and oil retention could be achieved.

**Keywords:** Graphite; Ultrafiltration membrane; Phenolic resin, Membrane distillation.



## Influence des Facteurs Acidité et Température sur l'Evolution des Paramètres Relatifs au Processus de l'Extraction Facilitée des Cations $\text{Co}^{2+}$ Et $\text{Ni}^{2+}$ à travers une Membrane Polymère type SLM Contenant des Agents Extractifs Phosphates

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### Résumé

Actuellement, le développement des procédés relatifs à l'extraction des métaux à valeur ajoutée, à partir des matrices environnementales ainsi que leur récupération à partir des rejets industriels, présente un intérêt économique majeur et fait l'objet de plusieurs recherches techniques et scientifiques. En effet les procédés membranaires font partie des nouvelles technologies d'extraction, de séparation et de récupération les plus prometteuses dans le domaine industriel, grâce aux avantages qu'ils présentent par rapport aux autres techniques, notamment les membranes liquides supportées (SLMs) qui ont montré des bonnes performances. Dans le présent travail, deux membranes type SLM, à base du support polyvinylidène fluoride (PVDF) et de deux agents extractifs le Bis (2-éthylhexyl) phosphate (DEHPA) pour la SLM<sub>1</sub> et l'Oxyde de trioctylphosphine (TOPO) pour la SLM<sub>2</sub>, ont été élaborées et adoptées. L'étude porte sur l'influence des facteurs d'acidité et de température sur l'évolution des paramètres relatifs au processus de l'extraction facilitée des deux cations  $\text{Co}^{2+}$  et  $\text{Ni}^{2+}$ , issus des métaux cobalt et nickel dont les propriétés physico-chimiques sont très similaires et l'utilisation industrielle particulières (les superalliages, la sidérurgie: élaboration d'aciers inoxydables et réfractaires). Les résultats obtenus ont permis de déterminer les valeurs des *paramètres macroscopiques*, (perméabilité  $P$  et flux initial  $J_0$ ) relatives au processus de l'extraction facilitée de ces deux ions à travers les deux membranes (SLMs) préparées, pour différentes acidités (PH: 1, 2 et 3), et pour les températures 293, 298 et 303 K. Afin d'expliquer ces résultats et élucider le mécanisme relatif au processus étudié et de déterminer les conditions optimales de l'extraction et de la séparation facilitée de ces deux ions, un modèle thermodynamique a été adopté pour déterminer les valeurs des *paramètres microscopiques*, (constante d'association  $K_{\text{ass}}$  et le coefficient apparent de diffusion  $D^*$ ), relatifs à l'interaction du substrat S (Ion étudié) avec chacun des agents extractifs utilisés. De même, les valeurs des paramètres d'activation ( $E_a$ ,  $\Delta S^\#$  et  $\Delta H^\#$ ) relatifs à ce processus d'extraction des ions  $\text{Co}(\text{II})$  et  $\text{Ni}(\text{II})$  à travers la SLM, PVDF+DEHPA ont été déterminés.

**Mots clé:** Membrane liquide supportée; extraction facilitée; agent extractif; perméabilité flux; coefficient de diffusion; paramètres d'activation.



## The Determination of Specific Parameters Related to the Directed Process of Facilitated Extraction of Oleic Acid through Polymer Inclusion Membranes

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### **Abstract**

Cyclodextrins (CDs) are natural molecules derived from starch compound that have a remarkable capacity to form inclusion complexes with a variety of hydrophobic molecules.

This ability to form inclusion complexes with guest molecules is a function of two key factors. The first is steric and depends on the relative size of the cyclodextrin to the size of the guest molecule. The second important factor is related to the nature of interactions between various components of the system (cyclodextrin guest molecule, solvent, etc.). The aim of our study is to develop a separation technique according to a directed process for facilitated extraction through polymer inclusion membranes (PIMs) for the selective extraction of oleic acid (O.A.).

A PIM was developed from thermoplastic polymer polyvinyl alcohol (PVA) as a mechanical support, the  $\beta$ -CD as extractive agent and TBP as a plasticizer to increase the flexibility and permeability of the synthesized membrane. To conduct this study, PVA polymer supports with different weight ratios of  $\beta$ -CD have been developed and characterized by IR spectroscopy and Scanning Electron Microscopy (SEM). Kinetic and thermodynamic models based on the interaction between the substrate (O.A.) and the extractive agent ( $\beta$ -CD) were adopted for the determination of macroscopic parameters, permeability  $P$  and initial flux  $J_0$ , and microscopic parameters, association constant  $K_{ass}$  and apparent diffusion coefficient  $D^*$  related to the association of the substrate with the extractive agent, and the diffusion of the formed entity through the membrane phase, for this facilitated extraction process of oleic acid substrate.

On the other hand, the influence of the temperature has determined the activation parameter values, energy  $E_a$ , enthalpy  $\Delta H^\ddagger$  and entropy  $\Delta S^\ddagger$ , and so explained the results and elucidated the mechanism of the directed process to facilitated extraction of Oleic acid by this membrane type.

**Keywords:** Membrane separation technology; Oleic acid; Polymer inclusion membranes; Cyclodextrins; facilitated extraction; activation parameters.



## Energy Aspect of Desalination Processes

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### **Abstract**

The freshwater resources in the world, responding to population growth and increasing human needs become insufficient and are increasingly threatened by any kind of pollution. To solve this problem of shortage of drinking water sources, we often use desalination.

Desalination processes have a remarkable development. However, they still remain major consumers of energy. Much of the cost of desalinated water is defined by the price of energy.

For each process, we indicate the different forms of energy requirements and we are studying the possibilities to reduce consumption. We envision coupling with renewable energy and particularly solar energy and geothermal water.

As examples, we present a few pilot installations operating in real sites, in different regions of the world.

**Keywords:** Desalination; energy.



## Surface Modification of Polyacrylonitrile Co-Polymer Membranes Using Pulsed Direct Current Plasma

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### **Abstract**

Low temperature plasma treatment using pulsed direct current discharge of nitrogen and ammonia gases was employed to enhance hydrophilicity of the polyacrylonitrile co-polymer membranes. The membranes were characterized in terms of morphology, structure, hydrophilicity and membrane performance. Properties and functional groups on the surface of polyacrylonitrile co-polymer membranes were investigated by contact angle, scanning electron microscopy, and atomic force microscopy and x-ray photoelectron spectroscopy. Nitrogen plasma treatment increases the pore size of the membranes due to etching.

Whereas in case of ammonia plasma treatment the pore size remains same but the hydrophilicity is improved significantly. Oxygen and nitrogen functional groups were identified to be responsible for surface hydrophilicity. Thus ammonia plasma treated membranes were used for oil water separation. It was found that the anti-fouling property of membrane improved remarkably after plasma treatment by enhancement of permeate flux without significant changes in oil rejection.

**Keywords:** Polyacrylonitrile co-polymer membrane; plasma treatment; hydrophilicity; permeability; contact angle.

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## **Ultra Lost Cost Spinning of Hollow Fibers and their Applications**

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### **Abstract**

Membrane is a phase that allows selective transport of a species through them, resulting to physical separation of a species. Among the modules, hollow fibers are quite common as they have large surface area in small volume for compact design. In the present talk, we discuss a novel, ultra-low cost technology for spinning hollow fibers using disposable syringes. This reduces the cost of the hollow fiber cartridges order of magnitude less compared to the commercially available one.

Various applications of hollow fiber membranes ranging from water treatment, juice clarification and even hemodialysis will be discussed in this talk.

**Keywords** : Membrane ; spinning hollow fibers



## Bioethanol Production from Coffee Waste Fractions and Quality Upgrading Using an Alcohol Selective Pervaporation Membrane

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### **Abstract**

Industrial residue management is a critical aspect of sustainable development. This paper considers residues obtained in coffee production. Coffee is one of the most popular beverages of the world and the second largest traded commodity after petroleum. By-products, which are considered waste, are rich in carbohydrates, proteins, pectins, and bioactive compounds like polyphenols and may be considered cheap renewable resources. In this work, the potential of bioethanol production from different coffee waste fractions (husk, spent coffee, parchment, silver skin and defected coffee bean) has been studied by pretreatment of the samples with distilled water or 3% H<sub>2</sub>SO<sub>4</sub> and hydrolysis using commercial enzymes. The fermentation was conducted using two different yeasts (baker's yeast and lignocellulose yeast). From the results, it was concluded that the optimum yield of bioethanol is obtained after 12 h using lignocellulosic yeast GSE16-T18 strain, and after 24 h for baker's yeast. By using the lignocellulosic yeast, a higher bioethanol yield (upgraded by a factor of 8.5 for husk and 6.5 for spent coffee) was achieved than when using baker's yeast. Further purification of the fermented filtrate was carried out by alcohol selective pervaporation membrane at 4 temperatures (23, 30, 40 and 50°C).

Hydrolysis of the samples using cellulose complex and  $\beta$ -glucosidase enzymes and fermentation with lignocellulosic yeast, followed by purification by pervaporation gives a superior bioethanol yield ( $51.7 \pm 7.4$  g/L for spent coffee and  $132.2 \pm 40$  g/L for husk). Husk hydrolysis using cellulolytic enzymes and fermentation with lignocellulose yeast, followed by product recovery through pervaporation membrane, was found to be the optimal procedure, producing ethanol at a concentration of 172 g/L.

**Keywords:** Coffee waste; enzymatic hydrolysis; pervaporation; lignocellulosic yeast.



## Performance Evaluation of Nitrogen Doped Carbon Nanotubes /Polysulfide Mixed Matrix Membranes

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### **Abstract**

This study investigates the use of nitrogen doped carbon nanotubes (CNTs) on the production of polysulfone (PSf) mixed matrix membranes. PSf blend membranes were prepared *via* a conventional phase inversion method using N-doped CNTs (alias N-CNTs) as functional additives. Results reveal that the morphological parameters, flux and rejection performance of the membranes have a significant inter-relationship with the surface and structural properties of the type of CNTs added on the matrix. In addition, the structural morphology, hydrophilicity, and thermal properties of the blend membranes were found to be dependent on the amount and type of CNTs incorporated. In particular the PSf composite membranes modified with N-CNTs appeared to be more hydrophilic, and have significantly improved thermal stability, water uptake, and surface charge compared to membranes modified with pristine CNTs or even the bare PSf membranes.

It is demonstrated that the addition of the doped CNTs resulted in the formation of 'finger-like' structures subsequently leading to increased membrane porosities and pore sizes. Thus, doped CNTs imparted on the transport mechanism of the parent membranes resulting in enhanced flow rates and better selectivity. This increase could be due to a combination of steric limitations from the surface functional groups leading to electrostatic repulsions between oxidative groups present in the membranes and the rejected humic acid molecules.

**Keywords** : Polysulfone; carbon nanotubes; fouling; hydrophilicity; microstructure

## Treatment of Mali Drainage Mining Water by Nanofiltration

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### **Abstract**

High levels of heavy metals in sludge and waste rock in the gold mining regions of Mali contributes to the spread of acid mine drainage. Furthermore, cyanidation of gold compounds causes contamination of the surrounding groundwater that needs to be eliminated. The objective of this work is to evaluate the performance of nanofiltration (NF) membranes selected for Mali's gold mine water treatment. The filtration tests were conducted on synthetic water (lead and nitrate solutions) and mining raw water with commercial membranes SEPRO NF2, NF20 and NF200. They were subjected to a post-treatment targeting the deposition of alternated layers of polyethylenimine (cation) and polyacrylic acid (anion) polyelectrolytes.

The permselective properties of these nano-filters were analyzed before and after surface modification for an effective treatment of the mining effluent. Despite a high concentration of heavy metals, all three commercial membranes - especially NF2 and NF200- yielded a water quality that complies with Malian national standards. The subsequent trials aim to develop new surface modification protocols for the NF membranes and to optimize their permselective properties.

**Keywords** : Membrane; Permselective; polyelectrolyte.



## Développement de Membranes Poreuses de Filtration à base de nanocomposites Argileux

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### **Résumé**

Le développement de nouvelles techniques pour le traitement des eaux (dépollution et dessalement) par les procédés membranaires dépend de la maîtrise des procédés d'élaboration de membranes mais également de la connaissance très précise de leurs propriétés de surface dans une gamme d'échelles de porosité allant de la nanofiltration à l'ultrafiltration en particulier.

Ce travail se devise en deux parties: la première partie concerne la modification d'argile par pontage. Plusieurs caractérisations ont été effectuées pour s'assurer de l'efficacité du traitement (RX, IR, ATG/ATD, BET et MEB). L'étude minéralogique, par diffraction des rayons X du matériau argileux brut et modifié, montre un accroissement de l'espace interfoliaire pour la Bentonite pontée qui atteint jusqu'à presque 17.5 Å. La seconde partie concerne l'utilisation de l'argile déjà préparée pour effectuer des dépôts de couches filtrantes de différentes compositions pour l'obtention de membranes de filtration opérant en mode de nanofiltration et de basse ultrafiltration. Une couche de TiO<sub>2</sub> a été déposée par méthode slip-casting sur un substrat formé d'une membrane céramique pour obtenir une couche d'Ultrafiltration. La détermination de la perméabilité à l'eau perméabilité conduit à une valeur de 180 l / hm<sup>2</sup>bar, ce qui confirme bien que la membrane obtenue peut être classée comme membrane d'ultrafiltration.

Une deuxième membrane a été préparée par dépôt d'une couche d'argile modifiée précédemment obtenue sur la membrane d'ultrafiltration élaborée. L'objectif étant d'obtenir une membrane fonctionnant dans le domaine de la nanofiltration.

**Mots clés:** Procédés membranaires ; Ultrafiltration ; nanofiltration.

## Diverse Physicochemical and Performance Properties for CNT-based Membranes

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### Abstract

Firstly, the work presents an overview of the production processes, physicochemical properties, and effective application of membranes incorporating carbon nanostructures in water remediation. In particular, carbon nanotube (CNT) membranes have been categorized into mixed matrix composite CNT membranes and vertically oriented CNT membranes.

The formation of CNT-polymer matrices (*alias* CNT mixed matrix membranes (CNT MMMs)) is achieved *via* the use of a wide range of polymers including among others PSf, PES, PVDF, CA and polyamide in order to increase their performance properties. Indeed, factors such as dispersion and surface reactivities are fundamentally correlated to CNT MMM performance.

On the other hand, the unique properties of the aligned CNT membrane materials lies on the vertical geometry of CNTs (CNT configuration) and CNT pore sizes. We present all the important aspects on this subject with respect to our recent results.

**Keywords:** Carbon nanostructures; mechanical strength; pore sizes; porosity; antifouling.





## Ceramic Membrane Surface Modification by a Film Deposition using PECVD Technique

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### **Abstract**

For membrane separation, the selectivity and the permeate flux depend on the textural and the chemical composition of the modifying agent when membrane surface modification was considered. For this purpose, new ceramic hydrophobic membranes were prepared by developing a surface using the technique of plasma polymerization. A thin film a-CFx, was synthesized using the radio-frequency (13.56 MHz) plasma enhanced chemical vapor deposition (PECVD) technique. The PECVD technique provides large area processing and high reproducibility.

The influence of the perfluorohexane (C<sub>6</sub>F<sub>14</sub>) precursor on the membrane surface properties was studied. Several different experiments were conducted to determine the optimal conditions of surface modification. The efficiency of modification process was characterized by TGA, contact angle, FTIR and liquid water entry pressure (LEP) measurements. The different films obtained exhibit contact angles from 70° up to 178° depending of the preparation conditions. The morphology of the membrane surface given by scanning electron microscopy (SEM) reveals the presence of a thin compact film on the membrane surface with a good adhesion on the ceramic membrane..

**Keywords:** Ceramic membrane; Surface modification; Polymerization; Plasma, PECVD.



## Removing of AO7 Dye by Hybrid Process Adsorption/Membrane Separation

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### **Abstract**

This work concerns the decolonization of an aqueous dye acid orange 7 (AO7) solution by an hybrid process composed of an activated carbon adsorption and ultrafiltration (Adsorption/Ultrafiltration). Tests were conducted primarily considering the treatment of an aqueous dye solution at a concentration of 35 mg/L by only Ultrafiltration (UF) (zirconium oxide membrane) and UF combined with carbon adsorption at different doses (50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L and 300 mg/L) under the following conditions: pH=7 and T=25°C.

The doses of activated carbon were chosen after adsorption tests on batch. 300 mg/L was found as the optimal dose for the total color removal. The application of the hybrid process composed of adsorption on activated carbon combined to UF leads to the obtention of a stabilized permeate flux of 480 L/h.m<sup>2</sup> when an activated carbon doses of 150 mg/L was used.

However, in presence of UF alone, the permeate flux decreases from 530 L/h.m<sup>2</sup> to 330 L/h.m<sup>2</sup> after 60 minutes of filtration. In term of quality, the color removal increases from 55% in presence of UF to 80% and 100% with AC dose of 50 mg/L and 150 mg/L respectively.

The second part of this work deals with the use of an UF ceramic membrane prepared in our laboratory from mud which represents a sub product obtained from washing the phosphate rocks (Ph/Ph). This material is composed mostly on silica and alumina. The hybrid process was applied in presence of the optimal dose of CA (150 mg/L). An enhancement of permeate flux was obtained from 410 l/h.m<sup>2</sup> to 445 l/h.m<sup>2</sup> when an hybrid process was used in comparison with the UF alone. The color removal increases then from 62 % in presence with UF to 100 % with hybrid process.

The application of the hybrid process over a long period (8 hours) operating at constant feed volume with addition alternatively of two types of solutions: an aqueous solution of dye and an aqueous solution containing the adsorbent suspension at the optimal dose of 150 mg/L.

The addition of both solutions to the feed tank was performed according two phases: one with the simple aqueous dyeing solution and the second with the aqueous dyeing solution containing the AC suspension.

The transition phase corresponding to the change from one phase to the other was controlled by the pressure drop and the decrease of the permeate flux. It appears that the pressure drop using the Ph/Zr UF membrane is less important than in presence of Al / Zr UF membrane.



A significant reduction of the amount of the AC used was noted during the long period filtration in comparison that used in the short period filtration: the average quantity of carbon used per liter of permeate recovered decreases from 150 mg with short period test to 54 mg (membrane Al/Zr) and 39.8 mg (membrane Ph/Zr) during long period tests.

**Keywords:** Activated carbon; Adsorption; Ultrafiltration; Hybrid process; Aqueous dye solution.



## Elaboration et Caractérisation d'un Nouveau Support Membranaire à Base de Zéolite

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### Résumé

Les membranes séparatrices peuvent être préparées à partir de matériaux organiques ou minéraux. Les membranes inorganiques ont l'avantage d'être plus robustes que les membranes organiques sur le plan résistance, chimique et mécanique. En effet, l'utilisation de membranes céramiques à base d'oxydes métalliques purs tels que:  $Al_2O_3$ ,  $SiO_2$ ,  $TiO_2$  reste limitée en raison de leurs coûts élevés et des difficultés de fabrication (mise en forme et dimensionnement).

La présente étude porte sur la mise au point de nouveaux supports membranaires à base de zéolite naturelle. Le choix de ce matériau est basé principalement sur son faible coût. Pour cela, une pâte plastique a été préparée à partir d'une poudre de zéolite (taille des particules inférieures à 100  $\mu m$ ) des additifs organiques et de l'eau. La pâte obtenue est extrudée afin d'élaborer des tubes microporeux. La température de frittage des supports élaborés est de 900°C.

La porosité, mesurée à l'aide d'un pycnomètre à hélium, est de 43,69% et le diamètre moyen des pores obtenus par porosimétrie à mercure est de l'ordre de 0,55 $\mu m$ . Les tubes présentent une bonne résistance mécanique et chimique qui permet de les utiliser comme des supports pour micro et ultrafiltration tangentielle. La perméabilité à l'eau de ce support est de l'ordre de 1062 l/hm<sup>2</sup>bar.

**Mots clés** : Support céramique; Zéolite ; Extrusion; Membrane.



## Elaboration and Characterization of (ZnO-SiO<sub>2</sub>) Nanocomposite for Nanofiltration Layer

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### **Abstract**

Although several studies explored the use of nanocomposites as additives in membrane structures, mixed matrix membranes still suffer from difficulties in synthesis and applications.

In this work a new method of use nanocomposites as filter layer is proposed by using ZnO/SiO<sub>2</sub> nanocomposite with best performance. The nanocomposite ZnO/SiO<sub>2</sub> has been successfully elaborated using sol-gel technique and sintering at different temperatures.

The obtained samples have been characterized by various techniques, such as X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), Raman spectroscopy and photoluminescence (PL).

The found results, have been encouraging to use ZnO-SiO<sub>2</sub> nanomaterial in nanofiltration membrane applications thanks to its porous texture and good properties.

**Keywords:** Sol-gel; ZnO; SiO<sub>2</sub>; nanocomposite; nanofiltration.



## Optimization of Nitrate Removal from Water by Electrodialysis

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### **Abstract:**

The main purpose of this work is to study the removal of nitrate from water using electrodialysis. The influence of several parameters, such as flow rates, initial feed concentration, co-existing anions and initial pH on process efficiency were studied. Nitrate removal by electrodialysis showed to be independent of pH of feed solution.

The flow rate as well as the initial salt concentration and also the coexisting anions on the feed solution play a significant role on the denitrification efficiency. Response Surface Methodology was applied in the development of statistical analysis, modeling and interpretation of the resulted treatment data of nitrate removal by electrodialysis.

Fractional factorial design has been applied for the simultaneous study of the effects of operating parameters on nitrate removal response. The effectiveness of the considered design parameters was well examined to find the optimum experiment condition.

**Keywords:** Electrodialysis; Nitrate; Response Surface Methodology; Factorial design; Optimization.

## Elaboration and Characterization of a New Ceramic Membranes from Turk

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### **Abstract**

The new research is generally addressed to the reducing of these gases by means of suitable filtering materials. The ceramic membranes are very competitive in terms of chemical, mechanical and thermal resistance; these membranes have gained, in this years, an important place in chemical technology being in a lot range of applications.

The aim of this work is preparing and characterizing a membrane from Turk zeolite. This natural powder could be also the best material to make low price membranes also it can be found easily. The elaboration of the ultrafiltration layer based on Turk Zeolite, is performed by slip-casting method. The sintering temperature of the ultrafiltration membrane is 850 °C.

The morphology of the surface and the cross-section observed on scanning electron microscopy (SEM) are homogeneous and don't present any macro defects (cracks, etc....).

The mercury porosimetry showed mean pore diameters of about 77 nm for ultrafiltration layer. The ceramic membrane was tested as hydrogen sulfide ultrafiltering. This material showed a significant improvement in the capacity for H<sub>2</sub>S removal.

**Keywords:** Ceramic Membrane; Turk Zeolite; Ultrafiltration; Hydrogen Sulfide.



## Advanced Nonwoven Filtration Media and Optimized Water Pretreatment

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### Abstract

Materials science studies devoted to advances in filtration research tend to concentrate on submicron Microfiltration (MF) and Ultrafiltration (UF) membranes and Nanofiltration (NF) or Reverse Osmosis (RO) semipermeable films. Despite some impressive flexibility in filtration and water quality control, any membrane is prompt to fouling, which constitutes its Achilles heel. In order to protect membrane barriers and extend their service life, scientists have devised innovative methods such as tools including the development of antifouling materials, design of sophisticated cleaning protocols, advanced module development and filtration processes, etc. Membrane service life is a critical operational factor since clogging can yield some substantial and irreversible losses in filtering performance. The merits of nonwoven materials utilized as prefilters to critical filters are often overlooked, yet they occupy a strong market space in water pretreatment applications [1].

This study will highlight municipal and industrial water treatment processes whereby pleated cartridges and vessel bags made of non-woven media- are synergistically used with membranes to protect them (See figure 1), [2].

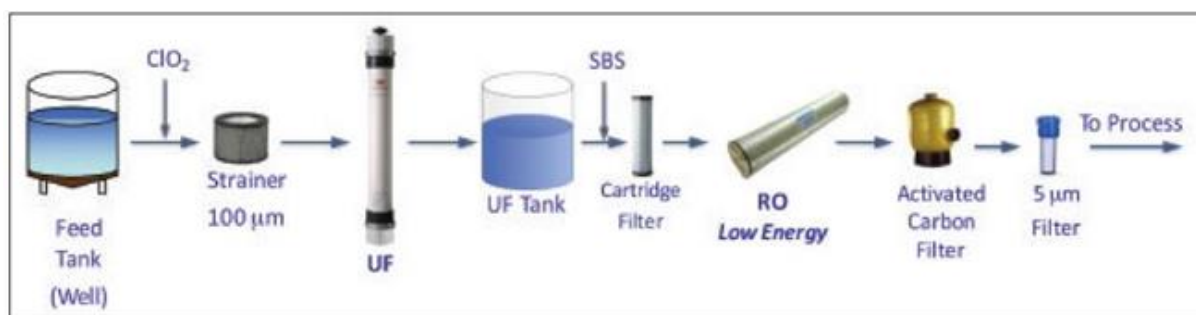




Fig. 1: Process scheme of soft drink production plan.

Specifically, synthetic wetlaid and meltblown materials display attractive depth filtration features and can capture any micron-sized particulate. The research advances on fibrous media that will be invoked by focusing on merits derived from structural attributes and those derived from compositional features.

The structural enhancement of fiber-based porous materials is tied to the control of fiber size/surface area, void volume and pore connectivity; while the optimization of a nonwoven chemical composition can be achieved by incorporating functional additives in the porous matrix.





	
Commercial filter bags in polypropylene and comprised of spunbond and meltblown filtering layers	A pleated cartridge filter–Nonwoven polyester media, with polypropylene core and vinyl end-caps
Fig. 2: Nonwoven filters used for water treatment: vessel bag (left) and polyester pleated element (right)	

**Keywords:** Filtration Media, Optimized Water, Pretreatment.

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## Defluoridation of Tunisian Drinking Water (The South of Tunisia Region of Gafsa)

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### **Abstract**

Fluoride is one of the major components of earth hence it is highly present in ground waters. This element can have harmful effects on the human health and on the environment. That is the reason why the concentration of fluoride should be controlled under strict limit (1.5 mg/L according to the WHO). Several methods are available to remove fluoride from water among them membranes processes, ion exchange, precipitation and adsorption.

This work deals with the removal of fluoride from synthetic water samples and drinking water. For this, four processes are compared: adsorption on cuttlefish, precipitation of fluoride with use of calcium carbonate with adding acetic acid followed by microfiltration, ion exchange with use of commercial resin Purolite A520E and nanofiltration process with using 2 membranes (ie NF5 and NF9).

Fluoride removal by nanofiltration was conducted first on synthetic water samples (i.e. distilled water doped with NaF) and ground water sampled from Louza 2 region of Gafsa in Tunisia using a pilot plant. The performances of two commercial spiral membranes (NF5 and NF9) were presented. Results show that both membranes were efficient for fluoride removal. The results obtained for the treatment of groundwater indicate that the more the ions hydrated, the better it is retained. This is derived from the hydration energy of the ions by water. Since fluoride ions have been more solvated, they are better retained than chloride. NF9 and NF5, membrane had a fluoride retention 88 and 57% respectively at 25°C, FRV=3 and PTM=8 bar. Fluoride retention rates were slightly lower than those mentioned in literature. This is due to the quality of the water. Ground water from Louza 2 had high concentrations of calcium and magnesium. We have shown that these two elements decrease the fluoride retention rate. The fluoride and other ions were rejected by NF9 membrane. These results can be attributed to the nature of this membrane which has properties close to RO membranes.

The use of the cuttlefish process significantly improve the performance of fluoride removal from synthetic and ground water. Removal of iron was in order of 67.7% at pH equal to 7.2 for initial fluoride concentration of 5 mg/L within 60 minutes for an optimum adsorbent dose of 15 mg/l. The treatment by precipitation of fluoride with use of calcium carbonate followed by microfiltration was found to be less efficient since a slight increase of fluoride removal between 38.2% was achieved during the 60 minutes filtration using an initial fluoride concentration of 5 mg/L for both.

**Keywords:** Defluoridation; Membrane processes; Adsorption on cuttlefish; precipitation.



## Sustainable Conversion of Agriculture Wastes into Activated Carbons Used to Arsenic (V) and Fluoride Removal from Natural Water

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### **Abstract**

The aim of this study is to investigate the production of activated carbons (AC) from agriculture wastes (millet stalk), food waste and coagulation-flocculation sludge. The activated carbons were produced by a combined pyrolysis and activation with water stream at 850 °C; no other chemical compounds were added. The activated carbon from millet stalk was named MS- H<sub>2</sub>O while that produced from food waste and coagulation-flocculation sludge was named FW/CFS- H<sub>2</sub>O. The MS- H<sub>2</sub>O was modified with iron solution for arsenic (V) removal by adsorption. The FW/CFS- H<sub>2</sub>O presents high calcium content (39.3 %). Consequently, this AC will be used in fluoride adsorption.

The MS-H<sub>2</sub>O shows very good features as adsorbent; it has a carbon percentage of 86 % and develops a BET surface area of 1234 m<sup>2</sup>.g<sup>-1</sup>. The carbon content and BET surface area of FW/CFS-H<sub>2</sub>O are 32 % and 225 m<sup>2</sup>.g<sup>-1</sup> respectively. After modification with iron solution, the AC from millet stalk was called MS-H<sub>2</sub>O-Fe and its BET surface area was reduced from 1234 m<sup>2</sup>.g<sup>-1</sup> to 664 m<sup>2</sup>.g<sup>-1</sup> because MS- H<sub>2</sub>O -Fe has fixed 22 % of iron.

For arsenic and fluoride adsorption purpose, these ACs have shown a good adsorption capacity. MS-H<sub>2</sub>O-Fe reaches an adsorption capacity of 7.93 mg.g<sup>-1</sup> and with Langmuir model, a maximum adsorption capacity of 9.24 mg.g<sup>-1</sup> in naturel water. Concerning the fluoride adsorption, a maximum adsorption capacity of 28.48 mg.g<sup>-1</sup> has been reached with FW/FCS-H<sub>2</sub>O.

**Keywords:** Arsenic and fluoride adsorption; Fluoride adsorption, Maximum adsorption.



## Ion Exchange Membrane Textile Bioreactor as a New Alternative for Drinking Water Denitrification

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### **Abstract**

This work, enters in the optic of the denitrification of a polluted water by two membrane techniques, the Donnan dialysis (DD) and the ion exchange membrane bioreactor (IEMB), using a conventional barrier, composed by an anion exchange membrane (AEM), and an hybrid barrier, where the AEM is combined to an anion exchange textile (AET).

The effects of the hydrodynamic factor and the nature of the carbon source on the transfer and the reduction of nitrate ions were studied. The study results conducted through the (DD) showed the effectiveness of the hybrid barrier to the recovery and concentration of nitrate ions. This was also recorded during the denitrification by the hybrid process, called the ion exchange membrane textile bioreactor (IEMTB), with a significant reduction of the nitrates, compared to IEMB, due to the efficiency of the *Pseudomonas aeruginosa* biofilm formed at the surface of the AET. Here, the permselectivity of the membrane and a good bioreduction of the pollutants are no longer majors conditions to the better performance of the process.

The application of the IEMTB in the denitrification of a groundwater, having a concentration of the nitrates equal to 96.67 ppm, shows a total reduction of the nitrate ions without any changing the quality of the water. Indeed, the analysis of the recovered water, or yet the treated water, shows the absence of the bacterium by-products and concentrations in the nitrates and nitrites 1 equal to  $0.02 \pm 0.01$  ppm and inferiors to the detection limit ( $< 0.02$  ppm), respectively.

**Keywords:** Drinking water denitrification; *Pseudomonas aeruginosa* biofilm; Ion exchange membrane bioreactor; Donnan dialysis; Anion exchange textile.



## Potabilisation des Eaux Saumâtres par les Procédés Membranaires

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### **Résumé**

Un procédé membranaire en compétition avec l'osmose inverse (RO) pour le dessalement de l'eau saumâtre dans un avenir proche reste la nanofiltration (NF). Dans ce travail, la possibilité de produire de l'eau potable à partir des eaux saumâtres (TDS ~ 4 g/l) en utilisant le procédé de nanofiltration a été étudiée.

Des essais à l'échelle pilote ont été réalisés dans l'usine de la ville de Tan Tan (sud du Maroc) en utilisant des membranes spiralées NF/OI (7,6 m<sup>2</sup> de surface de membranaire). Les performances des modules NF et LPRO commercialisés ont été évalués en termes de productivité de l'eau, l'efficacité de dessalement et de l'énergie. Ces modules ont été testés dans diverses conditions de fonctionnement telles que le flux d'alimentation, débit de perméat et de récupération.

Les résultats ont montré que la NF présente en fait, une meilleure efficacité contre l'OI à basse pression car elle réduit fortement la salinité des eaux saumâtres (> 80% de rejet) avec des taux de récupération plus élevés et des pressions appliquées plus basses.

Cette étude confirme les potentialités de la NF pour le dessalement de l'eau saumâtre et prouve que la NF est techniquement et économiquement viable pour faire face à la pénurie d'eau et de surmonter le déficit de l'eau au Maroc.

**Mots clés** : Eaux saumâtres; Dessalement; Eau potable; N/OI.

## Application of Microfiltration and Ultrafiltration in hybrid process for dyeing waste water treatment

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### **Abstract**

The textile industry is one that demands large amount of water and produces huge amounts of waste water characterized by undesirable color that can cause environmental damage if discharging into the hydrosphere. Conventional wastewater treatment methods were found to be inefficient for complete removal of pollution and especially of dye from waste water.

In this study, the investigation of hybrid treatment involving adsorption/Microfiltration (A/MF) and Coagulation/Microfiltration (C/MF) was undertaken to exploit respectively the high adsorption and coagulation capabilities and the particle removal ability of Microfiltration.

Various experimental conditions were investigated with and without the hybrid processes considered in this study. The hybrid process with adsorption using activated carbon was found to be very efficient with quasi-total removal of dye. High permeate flux beyond 400 l/hm<sup>2</sup> was obtained at ambient temperature, neutral pH, TMP of 3bars and AC dose of 150 mg/l, indicating low membrane fouling.

With a hybrid treatment using 0.9 g/l of Alum and 0.5 g/l of Amerfloc445 (organic polymer), experimental data indicated that the removal of dye was higher in presence of amerfloc rather than in presence of Alum. These two coagulants are usually used in textile waste water treatment with traditional coagulation process installed in the textile company where this work was achieved. The hybrid treatment leads to color and COD removal of 55% and 63% respectively in presence of Alum.

However a completely discolored effluent was obtained with amerfloc445. In this case, higher COD removal of 92% was also achieved. In term of filtration performances, a quasi-stabilized flux between 50 and 60 l/hm<sup>2</sup> at a maximum VRF of 4.3 was achieved. This indicated that fouling has not significant effect on MF behavior.

**Keywords:** hybrid treatment; Textile; Coagulant; Filtration.



## **Sustainable and Robust DEWATS- Sidestream a MBR with the Helix Technology**

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### **Abstract**

Whilst the preparation of clean drinking water is in the spotlight, sanitation and treatment of human waste and sludge gets relatively little attention. Numerous studies have indicated, that improper sanitation habits and lack of facilities lead to propagation of diseases such as typhoid fever, helminth infections, cholera and hepatitis A to name a few. When a centralized water treatment system is lacking, local solutions are the best option.

Common DEWATS – (Decentralized Water Treatment Systems) include septic and anaerobic baffled reactors. Anaerobic systems can be efficiently enhanced by membranes to create an anaerobic membrane bioreactor (AnMBR). AnMBR ensures practically complete retention of pathogens, concentration of wastewater and decoupled HRT/SRT which enables the creation of compact systems.

Pentair's expertise in side stream anaerobic MBRs together with the award winning Helix-Flux enhancing technology may offer a sustainable option for small scale AnMBRs for municipal wastewater treatment. Side stream AnMBRs combine high productivity (flux) and robust operation with easy maintenance. Currently, pilot trials are taking place to optimize design and process with municipal waste water at the Glanerbrug site in Enschede. The primary focus lies on developing a minimal design, reducing the number of moving parts and controllers whilst maintaining functionality and sufficient process control. In the second phase, we will focus on stability and long term operation, membrane fouling and biogas production.

In this paper, the design of the MBR will be presented and challenges faced during the startup.

**Keywords** : MBR; Pentair; Membrane fouling; Biogas production.

### **References**

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## Removal of Drugs in Aqueous Solution onto Natural Clay

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### **Abstract**

Fluoride is one of the major components of earth hence it is highly present in ground waters. This element can have harmful effects on the human health and on the environment. That is the reason why the concentration of fluoride should be controlled under strict limit (1.5 mg/L according to the WHO). Several methods are available to remove fluoride from water among them membranes processes, ion exchange, precipitation and adsorption.

This work deals with the removal of fluoride from synthetic water samples and drinking water. For this, four processes are compared: adsorption on cuttlefish, precipitation of fluoride with use of calcium carbonate with adding acetic acid followed by microfiltration, ion exchange with use of commercial resin Purolite A520E and nanofiltration process with using 2 membranes (ie NF5 and NF9).

Fluoride removal by nanofiltration was conducted first on synthetic water samples (i.e. distilled water doped with NaF) and ground water sampled from Louza 2 region of Gafsa in Tunisia using a pilot plant. The performances of two commercial spiral membranes (NF5 and NF9) were presented. Results show that both membranes were efficient for fluoride removal. The results obtained for the treatment of groundwater indicate that the more the ions hydrated, the better it is retained. This is derived from the hydration energy of the ions by water. Since fluoride ions have been more solvated, they are better retained than chloride. NF9 and NF5, membrane had a fluoride retention 88 and 57% respectively at 25°C, FRV=3 and PTM=8 bar. Fluoride retention rates were slightly lower than those mentioned in literature. This is due to the quality of the water. Ground water from Louza 2 had high concentrations of calcium and magnesium. We have shown that these two elements decrease the fluoride retention rate. The fluoride and other ions were rejected by NF9 membrane. These results can be attributed to the nature of this membrane which has properties close to RO membranes. The use of the cuttlefish process significantly improve the performance of fluoride removal from synthetic and ground water. Removal of iron was in order of 67.7% at pH equal to 7.2 for initial fluoride concentration of 5 mg/L within 60 minutes for an optimum adsorbent dose of 15 mg/l. The treatment by precipitation of fluoride with use of calcium carbonate followed by microfiltration was found to be less efficient since a slight increase of fluoride removal between 38.2% was achieved during the 60 minutes filtration using an initial fluoride concentration of 5 mg/L for both.

**Keywords:** Defluoridation, Membrane processes, Adsorption on cuttlefish, Tunisian drinking water, Precipitation, Ion exchange.





## Coupling Water Treatment by Membrane Technology Renewable Energy

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### **Abstract**

This project stems from a meeting in spring 2012 between BELECTRIC France and FIRMUS France, both based in Languedoc - Roussillon and respectively specialized in the production and storage of photovoltaic and water treatment by membrane technology. They decided to gather their knowledge to set up the coupling of water treatment process functioning with photovoltaic electricity. They presented this project to Professor Louis COT, head of the nearby "Chaire UNESCO SIMEV" whose office is located in Montpellier, to materialize this coupling process and its monitoring through the Chaire.

"Chaire UNESCO-SIMEV" chose to implant this demonstration process in Morocco, in collaboration with the University of Kenitra. The specifications given by the Chaire UNESCO-SIMEV required to provide for three liters of drinking water per day and per capita for 1000-inhabitant village, hence 3 m<sup>3</sup> of water per day.

Companies that brought in and designed the project have decided to go beyond those objectives and to design a real demonstration and training pilot monitored in Morocco by the University of Kenitra. It has been chosen to store electricity so as to give it back in time of low sunshine or at night. Storing renewable energy will be indeed one of the great issues in the next few years.

Users of this process will then be able to supply for water at night: a supply terminal will be set up outside of the high -school for the population. Additional electricity none used by the water treatment process will remain at the disposal of the high school that does not have any junction to the network yet. The school will then become autonomous in energy; the remainder in photovoltaic will be studied after observing the process functioning.

Water treatment consists in a treatment by membranes (nanofiltration) with a capacity of 500 liters per hour (hence 12 m<sup>3</sup>/day), which enables to produce water free of virus and bacteria and with a concentration in mineral salts below the standards (mainly nitrate). This process incorporates sensors that allow to measure and record the functioning parameters.

Downstream of FIRMUS equipment is the new Sun Pure system developed by BELECTRIC that enables to purify water produced by a new electrolysis process.

Wind power production (COMODOS) consists in a turbine with vertical axis design (UrWInd 2.2) with a highly efficient design (Darrieus, Savonius). This technology enables to capture wind in any direction. The power of this turbine is about 2.2 kW and allows producing from 2 000 to 4 000 kWh per year.

Photovoltaic production, electricity storage (BELECTRIC) is composed by 158 photovoltaic panels of a unit power of 145 Wc (for 96 panels) and 150 Wc (for the remaining 62) will be installed in Morocco. Those thin film solar cells amount to a total power 23.22 kWc for an annual production estimated to about 40 MWh.

The technical container designed by BELECTRIC is equipped with a filtration system as well as all electronic components and storage batteries.



Lead-gel batteries have been chosen (OpzV). The storage capacity is of 48 kWh and those batteries are compatible with a load generated by a photovoltaic generator. The batteries load is regulated by a power-inverter made for isolated sites. An intelligent system manages the energy allocation in real time. Indeed, it will be able to couple wind power or photovoltaic with energy stored in batteries according to the consumption of the filtration system and the photovoltaic production.

The entire installation will be overlooked remotely so as to prevent any necessary maintenance. The supervision will enable to detect any breakdown and will allow a quick and precise intervention. A telemonitoring system will enable to know the daily, monthly and yearly production of the installation.

**Keywords:** Water; Treatment by Membrane Technology.



## Grey Water Recycling System

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### **Abstract**

FIRMUS France has developed a specific grey water recycling technology based on that which was setup in 2005, in cooperation with the European Space Agency (ESA) at the Concordia station in Antarctica for the French Polar Institute, Paul Emile Victor (IPEV) and the Italian Antarctica Research Program (PNRA). This treatment unit offers a daily treatment capacity up to 2,400 or 2,800 liters, the equivalent grey water production of approximately 25 people. The unit was designed by FIRMUS France's technical director, who is still in charge of monitoring the system today.

This technology, which includes a purification process using organic and inorganic membrane technologies, recycles between 75% and 85% of grey water. Depending on the requirements and sanitary standards to be respected, the process used for this solution can produce drinking quality water, enabling full recycling back into the sanitary network (showers and washbasins).

Grey Water Treatment in a building must be comprehended from a global perspective and coupled with a process recovering thermal energy. The whole must be included in the global management of the building for the purpose of its energy optimization.

Consequently, FIRMUS France has formed a consortium with EDF Optimal Solutions (leader), SHERPA Engineering (service provider in system engineering) and MRI (to define elements enabling to respect country-specific health standards).

The technology developed by our consortium is widely approved since more than 1,000 people in Concordia Station have used recycled grey water so far, while its hygienic quality has been constantly checked since 2005.

Using this process is of great interest in many countries where water is rarer and whose use must be optimised. Our consortium can intervene in those countries.

**Keywords:** Grey water; Firmus france.



## Elimination du Fluor et de la Salinité par Système Membranaire en Milieu Rural au Sénégal : Bilan de 02 ans de Fonctionnement dans le Village de Keur Mariama

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### **Résumé**

Au Sénégal et particulièrement dans le Sine Saloum, la présence des ions fluorures à des doses excessives dans les eaux de consommation humaine est à l'origine d'un réel problème de santé publique. Parallèlement, la salinité des eaux de forages ne cesse de croître, à cause de leur surexploitation.

L'élimination sélective du fluor et le dessalement partiel par Osmose Inverse à Basse Pression (OIBP) de l'eau de boisson de Keur Mariama provenant des eaux souterraines a été entamé depuis le mois de Juillet 2012. Le taux de rejet en sels et la perméabilité des membranes ont été suivis pendant deux années de fonctionnement.

Les résultats quantitatifs obtenus concernant le taux de rejet en conductivité montrent que ce paramètre diminue légèrement au cours des années. Cependant, la baisse relative qui n'est pas importante, prouve que les membranes rejettent bien les ions et donc sont toujours performantes. Pour la pression de fonctionnement, elle augmente relativement d'année en année avec une valeur de 4 % entre 2012 et 2013 et de 2 % entre 2013 et 2014. Ce phénomène résulte de l'accumulation progressive des éléments colmatants. Par conséquent, les membranes s'encrassent de façon progressive d'année en année et leur perméabilité baisse d'une année à l'autre. En effet, on note une baisse relative de 7 % entre 2012 et 2013 et de 12% entre 2013 et 2014. Cette diminution de la perméabilité est en parfaite corrélation au colmatage des membranes mais également à la baisse du taux de conversion.

Les résultats obtenus au bout de deux ans et demi de fonctionnement de l'unité de Keur Mariama, montrent que ce système reste performant malgré une légère baisse des taux de rejet en conductivité, de la perméabilité et du taux de conversion. Le respect des conditions de fonctionnement ainsi que des entretiens périodiques permettent d'avoir une durée de vie des membranes et de l'installation relativement longue.

**Mots clés:** Fluor; Eaux saumâtres; Dessalement partiel; Osmose Inverse à Basse Pression.



## Traitement Membranaire d'Un Effluent Issu de l'Industrie Pharmaceutique

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### Résumé

Actuellement, le développement des procédés relatifs à l'extraction des métaux à valeur ajoutée, à partir des matrices environnementales ainsi que leur récupération à partir des rejets industriels, présente un intérêt économique majeur et fait l'objet de plusieurs recherches techniques et scientifiques afin de réduire d'une part, la pression de la demande mondiale sur les ressources naturelles déjà épuisées, et d'autre part, de répondre aux enjeux environnementaux des industries modernes. En effet, les procédés membranaires font partie des nouvelles technologies d'extraction, de séparation et de récupération les plus prometteuses dans le domaine industriel, grâce aux avantages qu'ils présentent par rapport aux autres techniques, notamment les membranes liquides supportées (SLMs) qui ont montré des bonnes performances. Les industries pharmaceutiques génèrent des effluents, qui proviennent principalement des procédés de production ou de nettoyage. Ces effluents doivent être traités et épurés avant d'être rejetés ou recyclés. La valorisation des composants d'un effluent pharmaceutique reste un secteur non exploité.

Les techniques de traitements membranaires sont largement utilisées en industrie, et permettent, selon la technique, de débarrasser l'eau de tout contaminant. La maîtrise des procédés de filtration et la connaissance des propriétés des membranes sont primordiales afin d'établir un plan de filtration optimal et tenter de valoriser les concentrats.

L'objectif de ce travail consiste en l'étude du traitement d'un rejet issu de l'industrie pharmaceutique par procédés membranaires tels que l'ultrafiltration et la nanofiltration. Le procédé permettra d'une part l'épuration du rejet et d'autre part la valorisation du principe actif qui est le « Diclofenac de sodium » un anti-inflammatoire non stéroïdien présent dans l'effluent. L'approche adoptée pour la filtration consiste d'abord en l'optimisation des paramètres de l'ultrafiltration et la nanofiltration tels que la pression, le débit de flux, le pH et le temps de filtration, ceci afin d'obtenir des perméats optimaux et comparer l'efficacité des deux méthodes quant au traitement de l'effluent dans les conditions optimales.

Le taux de rétention de la membrane de nanofiltration au Diclofénac de sodium est plus élevé que celui de l'ultrafiltration. En effet le taux, est de 94,31% pour la membrane de nanofiltration « NF270 » et de 61,57% pour la membrane d'ultrafiltration « Carbolpol ».

La nanofiltration a donc été appliquée afin de concentrer le Diclofénac de sodium. Une concentration de 2.56 mg/ml a été obtenue.

**Mots clés** : Nanofiltration; Ultrafiltration; Perméat; Industrie pharmaceutique.



## **Design of membrane systems for drinking water supply in small communities**

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### **Abstract**

Aclaira has developed solutions for remote communities based on the following observations:

- Water is scarce and its quality is most of the time very mediocre
- Changes in the raw water quality (rainy and dry seasons, floods,) make conventional treatment extremely difficult to operate or even ineffective when toxic chemicals contaminate water.

It is difficult to train or maintain a team – in each community – that can master conventional treatment over the long run and also manage all situations of degraded water quality.

For the contaminants present in the water, the right absolute barrier can be provided: membrane filtration for microbes and suspended solids, reverse osmosis or nano-filtration for dissolved contaminants.

The absolute barrier of the Membrane is a key feature that eases unit operation and improves quality of the water passing through the membrane. Efforts must therefore solely focus on periodical cleaning of the membranes through effective design, maintenance and operation. We can perform chemical cleanings safely, efficiently, manually and cost effectively in units designed on purpose.

Aclaira has developed two families of units: Aclaira®C membrane filtration units for treating surface water and Aclaira®P low pressure reverse osmosis units for treating borehole water contaminated with chemicals (fluorides, arsenic, nitrates, excess of sodium chloride...).

These units share the following features in common:

- Total modularity thanks to identical equipment and components regardless of capacity (eg. modules, pumps, valves, controllers, etc.). This design enables low cost manufacturing. Moreover, it simplifies logistics and supply of spare parts.
- The chemical cleaning of the membranes is based on very simple manual procedures. The cleaning can be performed at a frequency depending on the raw water quality. The design also reduces manufacturing costs, and allows for varying water qualities. This also makes it easier to operate the unit for the teams and allows them to take remedial actions.
- The Heart of Aclaira® units is the membrane modules. They are selected from the most reputable suppliers for their quality, reliability and ruggedness: Pall DT, Microza or BASF Inge modules.

The kiosk is Aclaira social business corner stone. This service requires mainly local resources to ensure drinking water supply to a community. Typically a kiosk serves two thousand persons.



Water operators, often women, are in charge of the day-to-day operation of the kiosk. A team of technicians visits the kiosks regularly and performs preventive maintenance of the treatment unit, including cleaning of the membranes. Most of the maintenance technicians hold a degree from the country universities and they can usually assume full responsibility for the periodic maintenance tasks after about 3 months of training. The organizational arrangement and the membrane treatment of choice guarantee water quality. Water is distributed in 20 liter-cans. Thus the kiosks serve both as a treatment plant (for example for fluoride removal) and as a distribution centre where water is sold to the community at the most affordable price.

Kiosks are established on land carefully selected in consultation and collaboration with the municipalities. Kiosks must be located in a region where quality water is lacking, nearby a gathering spot such as a market place or the heart of a community. Projects based on several kiosks are particularly interesting as “multi-site” construction minimizes costs while enhancing decentralization, and multiply water access points.

Aclaira has drawn on experience gained from existing kiosks to improve services proposed to villagers’s e.g. returnable cans, and conditioned base maintenance thanks to remote monitoring...

Kiosks eventually become a gathering spot that can attract other businesses (eg. battery rental, refrigerated storage, etc.) and drive economic development.

**Keywords:** Drinking water; Small communities; Nanofiltration and reverse osmosis; Microfiltration and ultrafiltration; surface water and bore hole water.



## **Performances de la Station de Dessalement de Gabes (30000 m<sup>3</sup>/J) après Vingt Ans de Fonctionnement**

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### **Résumé:**

La mise en service de la station de dessalement de Gabès en juin 1995, a permis d'enrichir l'expérience tunisienne en matière de dessalement. L'exploitation de cette station, de capacité 30000 m<sup>3</sup>/j, durant plus que vingt ans a contribué considérablement à la maîtrise de la technique membranaire d'osmose inverse.

Trois aspects phares illustrent les performances de cette station, qui traitent les eaux saumâtres de la nappe continentale, intercalaire de salinité égale à 3.2 g/l. Le premier aspect se traduit par le fait qu'uniquement 15% de 1584 modules en polyamide spiralé que comporte la station ont été remplacés après vingt ans de production, quoique le taux annuel habituel de remplacement dans les stations de dessalement à travers le monde soit de 10%. Le second aspect, consiste dans la stabilité de la salinité d'eau osmosée à des concentrations acceptables qui demeure au-dessous de 400ppm. La garantie du constructeur pour une période maximale de trois ans est de 200 ppm. Le troisième volet intéresse la réduction du coût de mètre cube d'eau osmosée produit qui a été ramené de 777 millièmes/m<sup>3</sup> en 1995 à 300 en l'an 2015 y compris l'amortissement.

Ces performances enregistrées, malgré le problème de colmatage biologique rencontré la première année, s'expliquent essentiellement par la bonne exploitation de la station, l'efficacité du prétraitement, un entretien sans faille, la qualification du personnel et un encadrement judicieux. De surcroît, il était possible d'augmenter la capacité de la station durant la saison estivale à 34000 m<sup>3</sup>/j sans ajouter aucun module et retarder par conséquent des investissements lourds en différant la réalisation d'autres stations.

**Mots clés** : Dessalement; Eau saumâtre; Eau osmosée.





## Application of Experimental Design for the Heterogeneous Photocatalysis of Organic Pollutants in Aqueous $\text{TiO}_2$ Suspension

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### **Abstract:**

A new development in the variety of fields to meet the ever-increasing requirements of human beings have also led to the presence of a wide variety of organic pollutants in the effluent streams, especially pesticides, which are not readily degraded by the conventional effluent treatment methods. Their dissipation in the environment and presence in the surface and in ground waters represent a serious threat to wildlife as well as to public health.

Advanced oxidation processes AOP, which utilize free radical reactions to directly degrade chemical contaminants are a good alternative to the traditional water treatment processes. At the end of 20th century, heterogeneous photocatalysis appeared as a new emerging AOP. Heterogeneous photocatalysis is based on the double aptitude of the photocatalyst (essentially titania) to simultaneously adsorb reactants and absorb efficient photons, which are an energy source to initiating chemical reactions that attack and destroy the organic pollutants. In the present paper, we present the development of a new system employing the titanium dioxide ( $\text{TiO}_2$ ) in a hexagonal photocatalytic reactor for the degradation of an insecticide Acetamiprid under UV light irradiation. An experimental design was adapted to optimize the influence of different parameters on the photocatalytic activity. The degradation performance was studied under various conditions such as substrate and catalyst concentrations and pH of the solution. The degradation performance rates were found to be strongly influenced by these parameters. The optimum photodegradation was obtained in basic pH, its kinetic followed the first-order and the reaction rate was well fitted with Langmuir–Hinshelwood model. The results of this work prove that heterogeneous photocatalysis is a promising technology to reduce persistent substances like Acetamiprid and can be suggested for the degradation of pesticides.

**Keywords:** Photocatalysis; Titanium dioxide; Wastewater treatment; Acétamiprid, pesticides; Experimental design.



## Application de la Nano-filtration pour la Production d'Eau Potable au Sénégal

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### **Résumé**

L'utilisation des membranes a pris une expansion considérable depuis une trentaine d'année. Les marchés pour les procédés membranaires sont loin d'être limités et croissent rapidement (Humphrey et al.2010). Leur taux de croissance se situe entre 7 et 10 % par an (Guillon, 2009).

Les technologies membranaires sont devenues une véritable technologie de séparation lors de la dernière décennie. Elles sont actuellement très utilisées dans pratiquement tous les secteurs industriels y compris l'agro-industrie.

La nanofiltration (NF) est une technique membranaire de séparation relativement récente dont le champ d'application se situe entre ceux de l'osmose inverse et de l'ultrafiltration. La nanofiltration, technologie membranaire innovante fait l'objet de nombreuses applications dans le domaine du traitement des eaux : eau potable, traitement des effluents, etc. (Ben Amar et al., 2009).

La nanofiltration a été alors utilisée dans la localité de Thiadiaye à 90 km de Dakar pour traiter l'eau brute. Une membrane de nanofiltration Skid GBW6036 a été utilisée à la station de traitement d'eau de cette localité. Elle a permis de traiter une eau brute non potable avec des concentrations en sodium, chlorure, fluor et fer respectivement de 235 mg/L, 280 mg/L, 0.4 mg/L et 4.67 mg/L. Ces teneurs sont largement supérieures à celles recommandées par l'OMS. En fin de traitement, l'eau est apte à la consommation humaine et animale avec des teneurs en sodium, chlorure, fluor et fer de 15 mg/L, 23 mg/L, 0.1 mg/L et 0.4 mg/L respectivement.

**Mots clés** : Nanofiltration; Eau; Traitement; Qualité, Thiadiaye.



## Treatment Enhancement of Blackwater Using ZnO-Nanoparticles Followed By Combination of Effective Micro-Organism and Membrane Bioreactor

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### **Abstract**

The aim of this study is to achieve efficient treatment of black wastewater for the purpose of reuse. In the present study blackwater was obtained by separating the domestic wastewater from a house across the pilot plant site of NRC into grey and black water. The separated wastewaters were connected to the NRC pilot plant using piping system. Each type of water was connected to a Manhole in the pilot plant site. The physical and chemical characteristic of blackwater was conducted extensively. On the other hand, ZnO nanoparticles were synthesizing using the extract of black tea solid waste and Zn acetate dehydrate. To enhance the treatment system: bench-scale study was carried out using jar-test and variable doses of ZnO nanoparticle to determine the optimum dose for the removal the pollution parameters namely : TSS, BOD, COD, oil and grease. The determined optimum dose of ZnO was 150 mg/L as which the optimum removal of the pollution parameters was achieved. Further study was carried out in a continuous pilot plant study in which the treatment of blackwater was the subject. Blackwater was pumped to three successive sedimentation tanks. The pre-determined optimum dose of ZnO-nanoparticle was added to the first sedimentation tank of the backwater. After three successive sedimentation tanks, the effluent was directed to membrane bioreactor (MBR). The designed study was operated continuously for the treatment of the separated blackwater. This investigation was correlated with a similar study for the same blackwater without adding the ZnO-nanoparticle. On the other hand, the efficiency of the Effective Micro-Organism (EM) on the performance of MBR was examined. For this purpose, the effluent of the sedimentation tanks was collected for EM examination. Jar-test was employed to determine the optimum dose of the EM. Different doses of EM ranged from 0.5 to 3.0 mL/L were examined. The determined optimum dose of EM was 2.0 mL/L the efficiency of adding the effective microorganisms (EM) to the membrane bioreactor (MBR) for the treatment of blackwater was investigated. The overall results of indicated that the continuous treatment system using ZnO-nano-particles in the sedimentation tanks followed by MBR as enhanced by EM were very effective in the treatment of blackwater. The overall removal rate exceeded 99%. Meanwhile, the treatment system succeeded to improve the physical and chemical characteristics of the final treated effluent. This final treated effluent can be safely used for agriculture purposes without any environmental threat.

**Keyword:** ZnO nanoparticles; Green synthesis; Chemical coagulation; Effective Micro-organisms, Sewage separation; Water reuse; Membrane bioreactor.



## **Problématique de la gestion des eaux usées industrielles, domestiques et artisanales au Mali : cas de la ville de Bamako**

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### **Résumé**

La très mauvaise gestion des déchets d'origine industrielle, domestique ou artisanale de Bamako compromet la qualité du cadre de vie de la population et affecte leur santé. Cette situation d'autant plus préoccupante que la capitale malienne compte plus de 60% des industries du Mali. Il y a une dizaine d'année, à Bamako, tous les effluents des eaux usées artisanales et domestiques et surtout ceux des unités industrielles étaient déversés dans le fleuve Niger sans n'avoir subi aucun prétraitement, accentuant ainsi le taux de prévalence des maladies hydriques à plus de 17 % à Bamako.

Ainsi on notait seulement :

- 2% d'unités industrielles (243) possédaient une station de traitement de leurs effluents liquides
- 1.6% d'hôtels (242) disposaient d'un système de traitement de leur eau usée
- 16 000 m<sup>3</sup>/an d'eaux usées des 300 teinturiers installés à Bamako sont déversés directement dans le fleuve Niger ou dans les caniveaux sans traitement.

Les eaux usées domestiques, pluviales et des grandes villes sont drainées par un même collecteur se déversent directement dans le fleuve sans subir aucun traitement.

Afin d'améliorer davantage le bien-être des populations urbaines de la ville de Bamako et protéger le fleuve Niger, une station de traitement des eaux usées industrielles a été construite en 2008 avec l'appui de la coopération néerlandaise. Elle est conçue pour recevoir 60 effluents d'unités industrielles diverses (tannerie, lait, pile, abattoir, tanneries, agro-alimentaires, peintures, plastiques...) totalisant un débit de 5000 m<sup>3</sup>/j.

Le procédé de traitement de la station est le lagunage naturel. La station comprend 2 bassins anaérobies et 8 bassins de décantation. On note l'absence des opérations unitaires de dégraissage et de désodorisation malgré la présence de graisses et dégagement d'odeur forte et très nauséabonde. Le milieu récepteur final de la station reste toujours le Fleuve Niger. Aujourd'hui encore à Bamako on note :

- 27 unités industrielles raccordées à cette station déversent près de 1 095 000 m<sup>3</sup> /an d'eaux usées
- Les 4 tanneries déversent dans la station en moyenne près de 300 000 m<sup>3</sup>/an d'eaux usées contenant près de 0.25 mg /L de chrome et rejetant dans l'atmosphère plus 2 à 11 ppm de sulfure d'hydrogène très corrosif.

Une analyse des eaux usées des unités industrielles par secteur d'activité raccordées au réseau de la Station d'épuration [3] révèlent que :

- 34.6% de ces eaux sont basiques (8.33 < PH < 11.75). Il s'agit des effluents des unités SOACAP-TAO-SAD.ASA-SEGMA-MALI-LAIT-BATEX-CI-TOLE.MALI.
- 11.5% de ces eaux sont très acides (3.75 < PH < 5.68). Il s'agit des effluents des unités EURO-LAIT-TAMALI-PILES.



- Plus de 77 % des eaux usées sont caractérisées par leur valeur très élevée en matière en suspension, en DCO et DBO5.

Les effluents industriels raccordés à la station sont également très riches en matière azotés (ammonium, nitrates) favorable au développement algues vertes et des plantes mais nuisibles pour le milieu aquatique (poissons, batraciens...).

Les teneurs en chrome III et VI des effluents des tanneries sont supérieures aux valeurs recommandées par les normes maliennes de rejet respectivement 0.2 mg/L et 0.05 mg/L.

Les teneurs en Plomb des effluents de TOL.MALI 0.579 mg/L ne conviennent ni pour l'irrigation (<0.2 mg/L), le bétail (<0.1 mg/L) et le milieu aquatique (0.065 mg/L).

Il est alors grand temps de réduire la pollution de la ville de Bamako en appliquant seulement les textes législatifs et réglementaires pour la protection de notre environnement.

**Mots clés** : Station d'épuration; Eau usée; Lagunage; Prétraitement; Sanitation station; Wastewater; Lagoon; Pre-treatment.



## Testing protocols and standards in filtration and transport studies

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### **Abstract**

IFTS is a research and test center. IFTS offers standardized and custom-made methods to compare evaluate or qualify filters and membranes. Accredited to ISO 17025, certified to ISO9001, we host the sole European center that can offer such a wide range of standardized and custom-made methods to compare and evaluate filters. IFTS is the world leading expert in testing efficiency, capacity, flow restriction, burst, cleanliness and compatibilities of all liquid filters and for any application.

IFTS now offers a service aimed to assess the performance of manufactured products under the label "IFTS Certified Performances". Air filtration is also becoming a field of competence. IFTS is one of the world leaders in filter test stand design and manufacturing. IFTS company is headquartered in France and owns two subsidiaries in the US and China.

To address the increasing demand from the filtration industry and new applications in NF, UF and MF membranes, IFTS has implemented an internal project to develop new test methods and test benches applicable to different means of characterization:

- Structural & Intrinsic: Porosity, pore size distribution, thickness, roughness, grain size distribution, Zeta potential, surface tension,
- Hydraulic: Permeability, filtration & back-flush
- Performance: Filtration efficiency □ rating, LRV, cut-off, Retention capacity, filtrate quality, initial, versus time, average, steady or cyclic flow...
- Compatibilities: Chemical, thermal, mechanical, hydraulic «stresses», Wear, media migration
- Cleanliness: detachable fibers and particle counting.

IFTS will highlight its latest studies and new foreseen perspectives for filter media and membranes testing.

**Keywords:** Testing protocols; Filtration standards; ISO certification; Characterization techniques.

## **New Method of Testing: the Effectiveness of "Submicron" Cartridges and Membranes**

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### **Résumé**

Microfiltration is the separation of particles within the size range of 0.01 to 5 microns. No standard method exists to measure the filtration efficiency of microfilters except by using standard microorganisms.

Current practice is the use of media/filter manufacturers in-house test methods. End users request harmonization and standardization of testing protocols to allow a reliable comparison of performance claims made by global providers.

To address the increasing demand from the filtration industry and new applications in sub-micron / low micron filtration, IFTS has implemented an internal project to develop a test bench for filters and filter media with a filtration threshold from 0.01 to 2 µm (submicron filter) More and more industry partners have shown interest in validation methods for this level of filtration, including the design of ultrafiltration membranes, antibacterial filters, filtering materials for nuclear power and semiconductors.

The new sub-micron test method IFTS\_FEEIS\_01 2013 has now been calibrated and validated and several industry/university partners have moved forward with the test implementation.

**Keywords:** Sub-micron / low micron filtration; Standardization of testing protocols.

## La Stratégie de la SONEDE dans le Domaine du Dessalement

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### **Résumé**

La Tunisie, avec des ressources exploitables évaluées à environ 4.7 milliards de mètre cube par an, est considérée comme un pays qui gère la pénurie d'eau. De plus, cette ressource en eau est mal répartie dans le temps et l'espace et sa qualité diffère d'une région à une autre.

Cette problématique de la ressource a conduit la Société Nationale d'Exploitation et de Distribution des Eaux (SONEDE) à concevoir des adductions de transfert sur des longues distances pour subvenir au besoin en eau potable des consommateurs.

Devant la rareté de la ressource et pour assurer le besoin en eau potable pour la population qui ne cesse d'augmenter, la SONEDE a eu recours au dessalement des eaux saumâtres et des eaux de mer.

La réduction des coûts, par la maîtrise des systèmes de récupération d'énergie et le procédé d'osmose, a permis un développement très important du dessalement d'eau de mer.

Cependant, le dessalement peut porter préjudice à l'environnement, si des mesures d'atténuation des impacts négatifs ne sont pas prises en compte.

L'utilisation des énergies renouvelables dans le dessalement contribue non seulement à la réduction des émissions de CO<sub>2</sub> mais aussi à la réduction des coûts d'exploitation de l'eau produite.

**Mots clés** : Pénurie d'eau; Dessalement; Energie Renouvelable.





## Préparation de Membranes d'Ultrafiltration à Base de Dioxyde de Titane Déposé sur un Support d'Argile-Alumine Destinée pour la Purification des Eaux de Lacs

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### **Résumé**

Cette étude porte sur le développement de nouvelles membranes inorganiques mono-tubulaires. L'extrusion d'une pâte céramique en kaolin, alumine (Al<sub>2</sub>O<sub>3</sub>) a permis de préparer des supports de configuration tubulaire. Le frittage à une température  $T_f = 1350$  °C pendant 90 min offre à la matrice préparée, une structure poreuse et une haute résistance mécanique, soit une porosité totale de 45% et une contrainte de flexion maximale de 37,05 MPa.

Le dépôt de la couche d'ultrafiltration (UF) à base de dioxyde de titane a été réalisé par le coulage d'une barbotine de composition bien déterminée. La calcination à 700 °C conduit à une couche de TiO<sub>2</sub> anatase avec une dimension moyenne des pores de 50 nm. La membrane préparée a été appliquée pour traiter les eaux de lacs Bengaliens dans le but de réduire la turbidité et la grande teneur en carbone organique (COT). Les résultats obtenus ont montré un flux de filtration stabilisé de 130 l/h m<sup>2</sup> pour une pression transmembranaire de 3 bars et une forte rétention de la turbidité (98,5%), de la couleur (100%) et du COT (96%).

**Mots Clés:** Membrane céramique d'Ultrafiltration; Slip-casting; Membrane TiO<sub>2</sub>, Clarification; Eaux de lacs.



## Water Treatment Using Membranes: Desalination of Brackish Water and/or Seawater Resources? Treatment of Surface Water and/or Non-Conventional Water Resources? Which Kind of Membranes and at Which Scale?

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### **Abstract**

The conference deals with the potentialities of membrane processes for water treatment dedicated to drinking water production, taking into account the resource quality and the regulation (World Health Organization, WHO). I will develop my experience acquired in Senegal (Thiadiaye, the first world nanofiltration unit for brackish water defluoridation), [1], in Morocco (Tan-Tan), in Mauritania (Nouakchott), in Cameroon (Dschang) and very recently in Colombia (Barrancabermeja), [2].

I had the chance to work in partnership with industrial companies (very big or very short ones), keeping my freedom in research topics but with clear aims conducted together with the objectives of concrete realizations to give fresh water to inhabitants and also to exchange knowledge. Academic – Private cooperation is the key for a sustainable development of countries and success in local water research-development projects.

**Keywords:** Membrane; water; partnership academic-private; sustainable development.

### **References**

- [1] M. Pontié, M. Rumeau et Coll., "Water defluoridation using nanofiltration vs. reverse osmosis: the first world unit, Thiadiaye (Senegal)", *Desalination and Water Treatment*, 51 164–168, 2013.



## **Elimination du Bore Contenu dans l'Eau par un Procédé Membranaire Hybride Associant Résine Echangeuse d'Ions et Microfiltration**

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### **Résumé**

Le dessalement de l'eau de mer connaît un intérêt croissant depuis une vingtaine d'années afin de répondre aux besoins en eau potable et en eau d'irrigation dans de nombreuses régions du monde. Le bore contenu dans l'eau de mer est incomplètement éliminé par osmose inverse (OI) et des concentrations supérieures à la valeur limite de 0,3 ppm sont obtenues.

L'objectif de cette étude est de mettre en œuvre et d'optimiser un procédé hybride combinant l'adsorption sur résines échangeuses d'ions et la microfiltration en utilisant une membrane céramique. Afin d'optimiser le procédé, une étude de l'influence des paramètres opératoires est menée. La membrane de microfiltration est placée dans une boucle de recirculation couplée au réacteur. Elle permet de recueillir l'eau traitée comme filtrat tout en retenant les particules de résine.

Les principaux produits chimiques utilisés au cours de ce travail sont l'acide borique ( $H_3BO_3$ ) et la résine Amberlite IRA743, fournis par Sigma-Aldrich (France). La concentration en bore dans le filtrat et le flux de filtration ont été mesurés au cours du temps pour plusieurs paramètres, parmi lesquels la quantité de résine, la concentration initiale en bore et la pression transmembranaire.

Un système de régénération (résine + membrane) est mise en place afin de valoriser le procédé sur le plan industriel. Deux étapes principales sont nécessaires pour la régénération : (1) lavage avec une solution acide (HCl) pour libérer l'acide borique, (2) lavage avec une solution de soude (NaOH) pour remettre la résine sous forme basique. Le procédé membranaire ainsi mis au point permet d'éliminer le bore jusqu'à une concentration inférieure à 0,3 ppm. Une augmentation de la pression transmembranaire permet de diminuer la durée du procédé, alors qu'une augmentation de la masse de résine permet d'accroître la capacité d'adsorption du système.

Lors de la procédure de régénération, l'optimisation des quantités et concentrations de soude et d'acide a permis de récupérer la capacité et la perméabilité initiales des résines et de la membrane.