مرفق

6-1-3-12

المؤتمرات العلمية

= **في** يوم الثلاثاء الموافق ٢ مايو ٢٠٢٣ توجه وفد برئاسة السيد أ.د اوسامي سعيد راجح - عميد المعهد للمشاركة في المؤتمر الدولي الأول للحلول الهندسية نحو التنمية المستدامة - جامعة بورسعيد وذلك بدعوة كريمة من السيد أ.د طه ابراهيم فراج - القائم بأعمال عميد كلية الهندسة جامعة بورسعيد

المؤتمر الدولي الهندسي للعلوم والابتكار - جامعة الدلتا نوفمبر 2022

المؤتمر الدولي لأنظمة الطاقة - جامعة كفر الشيخ- **ديسمبر** 2022

مشاركة المعهد بمشاريع قسم هندسة الأتصالات بؤتمر IEEE EGYPT-AP-S IC-SIT2023باكاديمية كينج مريوط وكان المعهد من منظمى المؤتمر

IEEE Egypt AP-S / MTT-S Joint Chapter • متابعة

٣٨ د ·

The International Competition on Smart Innovation Technologies (IC-SIT'2023) will be organized by the IEEE Egypt AP-S/MTT-S Joint Chapter with our Technical Cosponsor.
More technical cosponsor will be announced soon.

For more details, please go to our official website:
https://r8.ieee.org/egypt-apmtt/ic-sit-competition/

عرض الترجمة

مشاركة ببالمؤتمر الثالث للاتصالات بكلية الدفاع الجوى وفوز قسم الاتصالات بالمركز الثالث للابتكارات العلمية

4th International Conference for Membrane Technology & Its Applications

Monday & Tusday

28-29 Augest 2023

Grand Hotel

Port Said, Egypt

تقرير عن المؤتمر الدولى الرابع لتكنولوجيا الأغشية وتطبيقاتها

فى إطار سعى المعهد للتقدم للاعتماد، شارك المعهد فى تنظيم المؤتمر الدولى الرابع لتكنولوجيا الأغشية وتطبيقاتها والمقام فى فندق جراند بمدينة بور سعيد وذلك فى أيام 28-29 اغسطس 2023 ، جامعة بورسعيد - وزارة البحث العلمي- هيئة قناه السويس - وزارة التجارة والصناعة - جمعية تكنولوجيا المياه - المركز القومي للبحوث- الهيئة العربية للتصنيع - جمعية الاغشية- الشركات الراعية (شركة هاسكو للتوريدات الصناعية - Soul Water لمعالجة المياه وتكنولوجيا البيئة - شركة ووتر اكسبرس - واتكس لمعالجة المياه)

وشارك المعهد بوفد يتكون من:

السيد الاستاذ الدكتور اوسامى راجح عميد المعهد ...رئيسا للوفد، ورئيسا لإحدى الجلسات فى المؤتمر ومتقدما بورقة بحثية بعنوان:

1. Approach to designing a vertical sub-surface flow constructed wetland for wastewater treatment in arid climates.

السيد الاستاذ الدكتور / خالد سمير وكيل المعهد لشئون الطلاب مشاركا بالحضور

ا.د. محمد الكيكى، رئيس قسم الهندسة المدنية رئيسا لأحد الجلسات فى المؤتمر، ومتقدما بورقتين بحثيتين:

1. Joint Effect of Sediment Transport and Floodplain Divergence on Flow Pattern in Compound Channels.

2. Predicting Seepage Losses from Cracked Lined Canals Using ANN and GEP Models.

ا.م.د. محمد جبر، الاستاذ المساعد بقسم الهندسة المدنية رئيسا لأحد الجلسات فى المؤتمر ، ومشارك بثلاثة ابحاث:

1. Approach to designing a vertical sub-surface flow constructed wetland for wastewater treatment in arid climates.

2. Management and treatment of brine solutions: A review.

3. Technologies for wastewater treatment in aquaponics and their sustainability: A review.

ا.م.د. رمضان عبدالغنى الكاتب الاستاذ المساعد بقسم العلوم الأساسية والهندسية ومدير وحدة ضمان الجودة بالمعهد..رئيسا لأحد الجلسات فى المؤتمر ، ومشاركا بورقة بحثية:

1. Residual Soil as Low-cost natural adsorbent for adsorption of cationic dye from aqueous solutions.

.ا.م.د. هند السيد جادو رئيس قسم الهندسة الكيميائية مشاركة بالحضور.

ا.م.د. امل بحيرى رئيس قسم العلوم الأساسية والهندسية مشاركة بالحضور

د. سهير ابو بكر، المدرس بقسم الهندسة الكيميائية مشاركة بورقة بحثية:

1. Magnetite-Cellulose Core Shell Nano Structure in Polymer Composite Materials for Storage Energy Applications.

د. أميرة السنباطى، رئيس قسم هندسة اتصالات والالكترونيات ومشاركة بورقة بحثية:

1. Stability, Analysis and Control of Power System Using Artificial

د. ريهام عاطف المدرس بقسم الهندسة الكيميائية مشاركة بورقة بحثية:

1. Residual Soil as Low-cost natural adsorbent for adsorption of cationic dye from aqueous solutions.

د. ياسر توفيق المدرس بقسم الهندسة الكيميائية مشاركا بورقة بحثية:

1. Synthesis of Zinc Oxide Nanoparticles by co-precipitation Methods and their activity against bacteria.

د. احمد قابيل المدرس بقسم هندسة اتصالات والالكترونيات مشاركا بعدة ابحاث، ومعرضا ل IEEE :

1. Solar Panel Optimization Based on Graphene-Silicon-Droplet Integration.

2. Energy harvesting System based on transparent microstrip patch antenna combined with solar sill system for environmental application.

د. رباب رضا المدرس قسم هندسة اتصالات والالكترونيات مشاركة بورقة بحثية:

1. Stability, Analysis and Control of Power System Using Artificial Intelligence.

الجنة الرئيسية لتنظيم المؤتمر والجلسات العلمية وتضم كل من:

1- **الأستاذ الدكتور/ أوسامي سعيد راجح**

أستاذ هندسة المواني وعميد المعهد العالي للهندسة والتكنولوجيا بدمياط الجديدة وعضو لجنة المحكمين باللجنة العلمية الدائمة (الموارد المائية) لترقية الاساتذة الاستاتذة المساعدين- وعضو لجنة الكود المصري للمراسي النهرية ومحكم بمجلة الاسكندرية للعلوم الهندسية.

2- **الأستاذ الدكتور/ محمد حسن الكيكي**

أستاذ الري والهيدروليكا ورئيس قسم الهندسة المدنية بالمعهد العالي للهندسة والتكنولوجيا بدمياط الجديدة وعضو لجنة المحكمين باللجنة العلمية الدائمة (الموارد المائية) لترقية الاساتذة الاستاتذة المساعدين- ومحكم بمجلات بورسعيد البحثية الهندسية– مجلة المصرية للعلوم هندسة الزقازيق- مجلة العلوم الهندسية جامعة اسيوط- المجلة الامريكية لعلوم وهندسة المياه.

3- **الاستاذ المساعد دكتور/ محمد السيد احمد جبر**

الاستاذ المساعد بقسم الهندسة المدنية بالمعهد العالي للهندسة والتكنولوجيا بدمياط الجديدة – ومحكم بمجلة ادارة الموارد المائية و مجلة الهندسة المدنية بدار النشر اسبرنجر.

4- **الاستاذ المساعد دكتور/ رمضان عبد الغني علي الكاتب**

أستاذ مساعد الكيمياء الفيزيائية – قسم العلوم الاساسية والهندسية بالمعهد العالي للهندسة والتكنولوجيا بدمياط الجديدة- استشاري معتمد تقييم الاثر البيئي بوزارة البيئة – محكم في مجلة كلية العلوم جامعة دمياط.

وقد انضم الي فريق تنظيم المؤتمر **السيد المهندس / أحمد صالح** المدرس المساعد بقسم هندسة الاتصالات والالكترونيات رئيس اللجنة التنظيمة للمؤتمر ومعه فريق من طلبة وخرجين المعهد كالتالي:

1- الطالب / مجدي كامل (خامس)

٢ الطالب / -اسامه احمد (رابع)

٣ -الطالب /عمار العواد (تالت)

٤ - الطالب /نور عصام (تالت)

٥ -الطالب /عبدالرحمن رمضان (خامس)

٦ -الطالبة /الاء الشرقاوي (خامس)

٧ -الطالب /علاء رزق (خامس)

٨ - الطالبة /حنين النحراوي (رابع)

٩ - الطالبة / جني طه (رابع)

١٠ - الطالب /محمد الباز (خامس)

١١ -الطالب /محمد سمير (خامس)

١٣ –المهندس / محمد عفيفي (خريج)

١٤ -الطالبة /شهد عبدالله (تالت)

١٥- المهندس / احمد مختار (خريج)

كما قام السيد الدكتور / أحمد قابيل بتنظيم معرض لقسم هندسة الاتصالات والالكترونيات لمشاريع طلبة المعهد بالتعاون مع IEEE:

اليوم الأول

الطالب / عبدالرحمن حموده

الطالب /احمد المغربي

الطالبة /أيه عباس

الطالب /نور نبيل

الطالبة /منه دعبس

اليوم التانى

الطالب /عبدالرحمن حموده

الطالبة /أروى أبو زاهر

الطالبة /حنين صلاح

الطالبة /ندى عبدالشافى

الطالب /كريم ايمن

وهذا وقد أثنى رئيس المؤتمر ا.د. احمد شعبان رئيس المركز القومى للبحوث السابق على المستوى البحثى، والحضور المتميز لوفد المعهد، وذلك فى معرض الجلسة الختامية للمؤتمر.

جدير بالذكر أن المؤتمر كان دوليا به العلماء من دول عديده مثل السويد، والهند، واسبانيا، وتركيا ، وألمانيا.

وحضر الجلسة الافتتاحية كل من:

الدكتور سيد إسماعيل نائب وزير الاسكان للبنية الاساسية

والدكتور اشرف الشيحي وزير البحث العلمي السابق

ودكتور ايمن إبراهيم رئيس جامعة بورسعيد

والدكتورة راوية رزق نائب رئيس جامعة بورسعيد للدراسات العليا والبحوث.

ودكتور محمد هاشم الرئيس الاسبق للمركز القومي للبحوث

دكتور محمود بهجت المشرف العام علي شبكة المعامل المركزية بالمركز القومي للبحوث

ويهدف المؤتمر إلى توضيح دور تقنية الأغشية في التطبيقات الصناعية المختلفة واستخداماتها في تنقية مياه الشرب وتحلية مياه البحر وتحسين عملية معالجة الصرف الصحي بغرض إعادة الاستخدام الآمن، كما يستهدف المؤتمر تعميق دور البحث العلمي في فتح قنوات جديدة لربط الأوساط الاكاديمية بالصناعة في هذا المجال واستخدام أدوات الذكاء الاصطناعي في صناعة الأغشية وزيادة تطبيقات الأغشية التي تساهم في الحفاظ على البيئة، كما تضمن المؤتمر نقاشاً واسعاً حول توطين صناعة الاغشية محليا لسد الاحتياجات المطلوبة للصيانات الدورية لمحطات التحلية القائمة وتوفير متطلبات تنفيذ محطات التحلية من الخطة الإستراتيجية للتحلية.

وتشمل موضوعات المؤتمر علي التالي:

1- الأغشية والذكاء االاصطناعي.

2- ألاغشية وتغير المناخ.

3- العمليات البيئية وحمايتها.

4- أغشية التحلية.

5- عمليات الاغشية الحرارية (التقطير باألاغشية والتبخير).

6- معالجة مياه الصرف الصحي.

7- عمليات فصل باألغشية.

8- ألاغشية الكهربية (الديلزه الكهربائية، وخاليا الوقود.)

9- ألاغشية والطاقة المتجددة.

10 -ألاغشية في التطبيقات الطبية.

واستهل السيد الدكتور / كمال النحاس سكرتير المؤتمر وممثلا عن جمعية تكنولوجيات المياه كلمة الافتتاح للمؤتمر ورحب بالسادة الحضور وابرز اهمية المؤتمر في تحقيق اهداف التنمية المستدامة .

كما شارك الدكتور سيد إسماعيل، نائب وزير الإسكان لشئون البنية الأساسية، ممثلاً عن وزارة الإسكان والمرافق والمجتمعات العمرانية، في فعاليات المؤتمر الدولي الرابع لتكنولوجيا الأغشية وتطبيقاتها كما رافق نائب وزير الإسكان كل من قيادات جهاز تنظيم مياه الشرب والصرف الصحي وحماية المستهلك والشركة القابضة لمياه الشرب والصرف الصحي. واستهل الدكتور سيد إسماعيل، كلمته خلال مشاركته بالمؤتمر بالترحيب بالحضور، وتقديم نبذة عن هيكل قطاع مرافق مياه الشرب والصرف الصحي بوزارة الإسكان، وتوضيح حجم الجهود المبذولة لتنفيذ المشروعات خلال الأعوام السابقة لزيادة نسب تغطية خدمات مياه الشرب والصرف الصحي وتحسين مستوى الخدمات المقدمة، مع الحفاظ على استدامة تقديمها، مشيرا إلى نسب تغطية خدمات مياه الشرب والصرف الصحي الحالية وخطة ترشيد استهلاك المياه وتعظيم الاستفادة من الموارد المائية المتاحة.

واستعرض نائب وزير الإسكان لشئون البنية الأساسية، خلال مشاركته، موقف محطات التحلية القائمة والجاري تنفيذها والمحطات المستهدف إنشائها ضمن الخطة الإستراتيجية لتحلية مياه البحر حتى عام 2050، والتي تعتبر فرصة للبحث العلمي والتطوير للمساعدة في اختيار أنسب التكنولوجيات والأفكار المبتكرة في تحلية مياه البحر أو إعادة الاستخدام الآمن للمياه المالحة المعادة مع تقليل تكلفة التشغيل والصيانة واستخدامات الطاقة الجديدة والمتجددة في تشغيل تلك المحطات، مؤكداً أهمية التصنيع المحلي للأغشية ومختلف المهمات المطلوبة لتنفيذ محطات التحلية، وكذا ضرورة التعاون وتكاتف الجهود لإنجاح عملية تصنيع الأغشية محلياً لسد احتياجات السوق المحلية منها، وضرورة تواجد البحث العلمي بقوة كأحد أطراف تلك الجهود.

وعرض الدكتور سيد إسماعيل، خطط الوزارة في تشجيع مشاركة القطاع الخاص في تنفيذ مشروعات محطات تحلية مياه البحر ومشروعات الإدارة المتكاملة للحمأة الناتجة عن عملية معالجة الصرف الصحي ومشروعات محطات معالجة الصرف الصحي والصناعي الثنائية والثلاثية، وذلك في إطار تحقيق أهداف وثيقة سياسة ملكية الدولة لتشجيع مشاركة القطاع الخاص وتذليل أي عقبات قد تواجهه.

وتجدر الإشارة إلى أنه تم تنفيذ 99 محطة تحلية بطاقة إجمالية 1.21 مليون م3/يوم، وجارٍ تنفيذ 11 محطة تحلية بطاقة إجمالية 228 ألف م3/يوم ليصل إجمالي الطاقة للمحطات التي تم وجارٍ تنفيذها إلى 1.44 مليون م3/يوم، ومخطط الوصول إلى حوالي 10 ملايين م3/يوم من المياه المحلاة من خلال تنفيذ محطات الخُطة الإستراتيجية للتحلية والتي تم إعدادها لتغطية الاحتياجات المطلوبة بالمحافظات الساحلية حتى عام 2050 بطاقة إجمالية حوالي 8.85 مليون م3/يوم، كما تم الانتهاء من تأهيل حوالي 17 تحالفاً محلياً وعالمياً من خلال صندوق مصر السيادي بالتعاون مع ممثلي وزارة الإسكان وهيئة قناة السويس تجهيزاً لبدء أعمال التنفيذ بمحطات التحلية ضمن الخطة.

بعض صور المؤتمر

Conference participants and organizing team
Higher Institute for Engineering and Technology in New Damietta


Aim of the work
Session 7
DAY 2
15:00 - 16:00 PM
Tues, 28 Aug 2023
Grand Hotel, Port-Said, Egypt


Results and Discussion
DAY 2
Session 7
15:00 - 16:00 PM
Tues, 28 Aug 2023
Grand Hotel, Port-Said, Egypt


Problem definition:
DAY 2
Session 7
15:00 - 16:00 PM
Tues, 28 Aug 2023
Grand Hotel, Port-Said, Egypt


Construction of Antenna over Solar Cell
DAY 2
Session 7
15:00 - 16:00 PM
Tues, 28 Aug 2023
Grand Hotel, Port-Said, Egypt

يعتمد

ا.د / اوسامي سعيد راجح

عميد المعهد العلي للهندسة والتكنولوجيا بدمياط الجديدة

Ministry of Higher Education
Higher Institute of
Engineering And Technology
New Damietta

وزارة التعليم العالي
المعهد العالي
للهندسة و التكنولوجيا
بدمياط الجديدة

قرار رقم (٧٢) بتاريخ ٠٧/٠٨/٢٠٢٣

عميد المعهد :

- بعد الإطلاع على القانون رقم ٥٢ لسنة ١٩٧٠ بشأن تنظيم المعاهد العالية الخاصة .
- وعلى قانون رقم ٨١ لسنة ٢٠١٦ بشأن الخدمة المدنية
- وعلى القرار الوزاري رقم ١٠٨٨ لسنة ١٩٧٨ بإصدار لائحة المعاهد التابعة والخاضعة لإشراف وزارة التعليم العالي.
- وعلى اللائحة الداخلية للمعهد العالي للهندسة والتكنولوجيا بمدينة دمياط الجديدة والمعتمدة والصادر بها القرار الوزاري رقم (٢٠٣٦) بتاريخ ٢٠١٢/٣/٣ (بنظام الساعات المعتمدة).
- وعلى اللائحة الداخلية للمعهد والمعتمدة والصادر بها القرارات الوزارية (رقم ١٣٢٨ في ٢٠١٩/٠٤/١٤ الجزء الاكاديمي، رقم ١٩٩٩ في ٢٠٢٠/٠٧/٠٨ الجزء الاداري) بنظام الفصول الدراسية.
- وعلى المؤتمر الدولي الرابع لتكنولوجيا الأغذية وتطبيقاتها المقرر عقدة خلال الفترة من ٢٨ – ٢٩ أغسطس ٢٠٢٣ والمنعقد بفندق جراند ببورسعيد والجهات المنظمة للمؤتمر هي :
  - جامعة بورسعيد
  - المركز القومي للبحوث
  - جمعية المياه والتكنولوجيا بجامعة المنصورة
  - المعهد العالي للهندسة والتكنولوجيا بدمياط الجديدة

قرر

أولاً : تشكل لجنة من السادة أعضاء هيئة التدريس ممثلين المعهد في اللجنة التنظيمية وجلسات المؤتمر وهم :

١- الأستاذ الدكتور/ اوسامي سعيد راجح أستاذ هندسة الموانى بكلية الهندسة جامعة المنصورة وعميد المعهد العالي للهندسة والتكنولوجيا بدمياط الجديدة وعضو لجنة المحكمين باللجنة العلمية الدائمة (الموارد المائية) لترقية الأساتذة والأساتذة المساعدين- وعضو لجنة الكود المصري للمراسي النهرية ومحكم بمجلة الإسكندرية للعلوم الهندسية.

٢- الأستاذ الدكتور/ محمد حسن الكيكي أستاذ الري والهيدروليكا ورئيس قسم الهندسة المدنية بالمعهد العالي للهندسة والتكنولوجيا بدمياط الجديدة وعضو لجنة المحكمين باللجنة العلمية الدائمة (الموارد المائية) لترقية الاساتذة والاساتذة المساعدين- ومحكم بمجلات بورسعيد البحثية الهندسية- مجلة المصرية للعلوم هندسة الزقازيق- مجلة العلوم الهندسية جامعة أسيوط- المجلة الأمريكية لعلوم وهندسة المياه.

٣- الدكتور/ محمد السيد احمد جبر الاستاذ المساعد بقسم الهندسة المدنية بالمعهد العالي للهندسة والتكنولوجيا بدمياط الجديدة- ومحكم بمجلة إدارة الموارد المائية و مجلة الهندسة المدنية بدار النشر اسبرنجر.

٤- الدكتور/ رمضان عبد الغني علي الكاتب أستاذ مساعد الكيمياء الفيزيائية – قسم العلوم الأساسية والهندسية بالمعهد العالي للهندسة والتكنولوجيا بدمياط الجديدة، استشاري معتمد تقييم الاثر البيئي بوزارة البيئة – محكم في مجلة كلية العلوم جامعة دمياط.

ثانيا : على جهات الاختصاص مراعاة تنفيذ ذلك .

عميد المعهد

أ.د . اوسامي سعيد راجح

وزارة التعليم العالي
المعهد العالي للهندسة والتكنولوجيا
بدمياط الجديدة

Ministry of Higher Education
Higher Institute of
Engineering And Technology
New Damietta

وزارة التعليم العالي
المعهد العالي
للهندسة و التكنولوجيا
بدمياط الجديدة

السيد الأستاذ الدكتور/ **أحمد شعبان**

رئيس الجمعية المصرية لتكنولوجيا الأغشية

تحية طيبه ... وبعد

فانه يطيب لي بداية أن أتقدم لسيادتكم بأصدق تحياتي وخالص أمنياتي لسيادتكم ، داعيا المولى عز وجل أن ينعم عليكم بموفور الصحة ودوام التوفيق.

بالاشارة إلي المؤتمر الدولي الرابع لتكنولوجيا الأغشية المقرر عقدة يومي ٢٨ -٢٩ أغسطس ٢٠٢٣ بفندق جراند بمدينة بورسعيد ، والمعهد أحد منظمي هذا المؤتمر .

نتشرف بالاحاطة بأن المعهد شكل لجنة من السادة أعضاء هيئة التدريس بالمعهد للمشاركة في تنظيم وإدارة المؤتمر من السادة أعضاء هيئة التدريس الآتية أسماؤهم بعد :

١- الأستاذ الدكتور/ أوسامي سعيد راجح أستاذ هندسة الموانى بكلية الهندسة جامعة المنصورة وعميد المعهد العالي للهندسة والتكنولوجيا بدمياط الجديدة وعضو لجنة المحكمين باللجنة العلمية الدائمة (الموارد المائية) لترقية الأساتذة والأساتذة المساعدين- وعضو لجنة الكود المصري للمراسي النهرية ومحكم بمجلتي المنصورة والإسكندرية للعلوم الهندسية.

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٤- الدكتور/ رمضان عبد الغني علي الكاتب أستاذ مساعد الكيمياء الفيزيائية – قسم العلوم الأساسية والهندسية بالمعهد العالي للهندسة والتكنولوجيا بدمياط الجديدة- استشاري معتمد تقييم الأثر البيئي بوزارة البيئة – محكم في مجلة كلية العلوم جامعة دمياط.

وتفضلوا سيادتكم بقبول وافر التحية والإحترام ...

عميد المعهد

أ.د. اوسامى سعيد راجح

وزارة التعليم العالي
المعهد العالي للهندسة والتكنولوجيا
بدمياط الجديدة

The 4th International Conference for Membrane Technology & Its Applications

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السيد الأستاذ الدكتور / أوسامي سعيد راجح

عميد المعهد العالي للهندسة والتكنولوجيا بدمياط الجديدة

تحية طيبة وبعد

بالإحالة الي كتاب سيادتكم بخصوص الاشتراك في تنظيم المؤتمر الرابع للأغشية وتطبيقاتها

4th International Conference for Membrane Technology and its Applications

والمقرر عقدة في الفترة من 28 الي 29 أغسطس 2023 بفندق جراند ببورسعيد. يرجي التفضل بالإحاطة بأن الجهات المنفذة للمؤتمر قد وافقت علي أضافة معهدكم كشريك في التنظيم والمشاركة بالمؤتمر ليصبح عدد الجهات المنظمة للمؤتمر خمس جهات بيانها كالتالي:

1. الجمعية المصرية لتكنولوجيا الاغشية (ESMT)
2. المركز القومي للبحوث (National Research Center)
3. جامعة بورسعيد (Port Said University)
4. الجمعية العالمية لتكنولوجيا المياه (International Water Technology Association (IWTA)
5. المعهد العالي للهندسة والتكنولوجيا بدمياط الجديدة
(Higher Institute for Engineering and Technology, New Damietta)

وجاري التنسيق مع فريق المعهد لعمل الترتيبات المطلوبة للتنظيم والمشاركة بالابحاث.

ونشكر حسن تعاونكم معنا

وتفضلوا بقبول فائق الاحترام والتقدير

الأستاذ الدكتور / أحمد محمود شعبان

رئيس الجمعية المصرية لتكنولوجيا الاغشية و المؤتمر

Proceedings of the 4th International Conference for Membrane Technology & Its Applications

Monday & Tusday

28-29 Augest 2023

Grand Hotel

Port Said, Egypt

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PREFACE

Proceedings of the 4th International Conference for "Membrane Technology and Its Applications" (MTAIC 2023) Held on Grand Hotel _ Port Said _ Egypt in hybrid mode (Physically and via Zoom) From 28 to 29 August 2023

The 4th international conference for Membrane technology and its applications- MTAIC 2023- will be held in Hybrid mode at Grand Hotel, Port Said Governorate, Egypt.

MTAIC 2023 is organized by **the Flat sheet membrane group** in **the National Research Center** and **Egyptian Society of Membrane Technology** in Cooperation with **Port Said University** and the **International Water Technology Association**.

In addition to virtual contributions through the ZOOM platform. This international conference series represents a forum to provide, discuss and exchange innovative ideas in the field of membrane technology in different applications with their recent developments.

This proceeding contains MTAIC 2023 papers and abstracts. The purpose of the conference is to provide a forum for discussion on the application of membranes in problems in agricultural, and industrial sciences in addition to water desalination and gas separation. Papers that are presented at the conference and included in the proceedings are intended to provide information to both the experimental and modeling studies in which researchers innovate on current issues of their interest.

Keynote speakers from different countries present speeches in various fields on membrane-based processes.

Each contributed paper was peer-reviewed before being accepted for publication in these proceedings.

Sincere thanks to all scientific committees by their individuals for referring submitted manuscripts, in addition to other volunteers for help in conference planning and organization.

Special thanks to **Port Said University** and **International Water Technology Association and** all sponsors for their continued support.

Conference Chairman

Prof. Ahmed Shaban

Chairman of the Egyptian Society of Membrane Technology and Head of Flat Sheet Membrane Group, NRC, Egypt. Former vice President of the National Research Centre for Technical Affairs in Egypt.

He leads the group to exhibit their products of different kinds of membranes in *1st Cairo international exhibition of Innovation in* November 2014 in American University in Egypt. He is a consultant in a number of desalination projects in Sinai and he is a consultant in Production of Reverse Osmosis Membranes for Water project funded from the Science and Technology Development Fund (STDF) in Egypt, 2014-2023.He had contributed in many national and international conferences as chairman and organizer; and supervised more than 25 Master and Ph.D. theses with more than 70 publications in the last 10 years. He has many patents.

Conference Co-chairmen

Prof. Heba Abdallah	Prof. Marwa Shalaby
Vice-chairman for the Egyptian Society of Membrane Technology.	**Secretary General for the Egyptian Society of Membrane Technology**
She is a professor in the Chemical Engineering Department, Institute of Engineering Research, Energy & Renewable Energy at the National Research Centre. She is a consultant engineer in the field of research of designing and manufacturing special membranes for water treatment processes in the Egyptian Engineering Syndicate. She *has 85 international publication articles*. She has *14 granted patents* from the Egyptian Academy of Science & Technology. She is a PI for many International and National Research Projects in the Membrane Technology Field.	She is a professor in the Chemical Engineering department, at the Institute of Engineering Research, Energy & Renewable Energy in the National Research Centre. She is a consultant engineer in the field of manufacturing membranes. She has participated in many internationally funded projects in the field of water desalination. She has 65 publication articles. She has 3 patents in membrane preparation and application from the Egyptian Academy of Science & Technology. She was PI of many International and national projects.

MTAIC 2023 Organizers

Prof. Rawya Y. Rizk	Port Said University
	Conference General Chairs
Dr. Kamal El-Nahhas	International Water Technology Association
	Conference Secretary General
Prof. Sahar Saad	National Research Centre
Prof. Shereen Kamel	National Research Centre
Prof. Ayman El Gandi	National Research Centre
Prof. Mohamed Bassyouni	Port Said University
Prof. Abdel Naby Kabeel	International Water Technology Association
Prof. Nabil Hassan Mostafa	International Water Technology Association
Prof. Osamy Said Rajh	Higher Institute for Engineering and Technology, New Damietta
Prof. Mohamed Hassen Elkiki	Higher Institute for Engineering and Technology, New Damietta
Ass. Prof. Mohamed Elsayed Gabr	Higher Institute for Engineering and Technology, New Damietta
Ass.Prof. Ramadan Abd-Alghany	Higher Institute for Engineering and Technology, New Damietta
Ass. Prof. Rania Sabry	National Research Centre
Ass. Prof. Sayeda Mohamed	National Research Centre
Ass. Prof. Eman Sobhy	National Research Centre
Dr. Rehab Hamdy	National Research Centre
Dr. Marwa Hosny	National Research Centre
Eng. Rania Ramadan	National Research Centre

Session [1]

Desalination & Water Treatment

Presenting Author
Prof. Frank Lipnizki

Short Biography
Professor in Chemical Engineering with a focus on Membrane Processes in the Department of Chemical Engineering at Lund University, Sweden, since 2017. He heads the Membrane Group and manages Mem Lab – the Industrial membrane process research and development center –at Lund University. His main research focuses on the integration and optimization of separation processes in particular membrane processes in the food, biotech, pulp, and paper industry as well as water and wastewater treatment plus fouling and cleaning of membranes. Prof. Frank Lipnizki has authored over 50 publications in reviewed journals and books and gave more than 100 presentations at international conferences and workshops.

Title: Membrane Concepts from Drinking Water Preparation to Wastewater Treatment

Frank Lipnizki and Tobias Hey

Department of Chemical Engineering, Lund University, Sweden

Abstract:
Membrane processes are widely used for desalination and wastewater treatment worldwide. In this presentation, we will review some interesting membrane concepts which are either currently used or are under development. The initial focus will be on drinking water preparation from lake and river water and desalination of brackish water which are well-established in Sweden. Furthermore, new will be presented which converts industrial wastewater and brackish water to drinking water. Regarding wastewater, the latest developments of membrane bioreactors and direct membrane filtration will be presented. And, we will discuss two new concepts related to the European projects: REWAISE and DESOLINATION. In the REWAISE project, a new concept for rain- and stormwater harvesting with ultrafiltration will be developed, while in the DESOLINATION project, a new desalination concept will be established using forward osmosis and membrane distillation (MD). Overall, the presentation will show that membrane concepts are well established in water treatment and new concepts are under development, Acknowledgements: The research is partly funded by the REWAISE "Resilient Water Innovation for Smart Economy" (Project No. 869496) and DESALINATION (Project No. 101022686) under the European Horizon 2020 program.

Keywords: drinking water; wastewater; membrane bioreactor, desalination.

Presenting Author
Prof. Dr. M. Gamal Khedr

Short Biography
Awarded the State Doctor of Science, Très Honorable, University of Strasbourg, France, Prof. Khedr occupied the following positions:

- Professor, Water Desalination/Treatment, National Research Centre, Egypt.
- Technical Manager of "Saudi Industries for Desalination Membranes and Systems" the first manufacturer of the modern technology Reverse Osmosis and Nanofiltration Membranes in the Middle East, Riyadh.
- Selected by the Ministry of Water & Electricity, Riyadh, as a Consultant of Water Desalination/Treatment and of the Central Committee of Radiation.
- Vice-President Technical of the Water Desalination Contractor, Saudi-Geman Company, "Preussag Arabia", Riyadh.
- Head of the Water Technologies Center, Technology Experts Global, Riyadh

Title: Towards Promotion of Reverse Osmosis Process Efficiency, Cost Effectiveness, and Environmental Safety

Prof. Dr. M. Gamal Khedr

National Research Centre

Abstract:
Results of our research works are described which, upon application, are confirmed to develop Reverse Osmosis performance:

1- Development of water desalination efficiency of Reverse Osmosis, Nanofiltration, Electro deionization, and Forward Osmosis through processing of the desalination reject water.
2- Nanofiltration to replace hot or cold lime softening for efficient removal of hardness in pretreatment of Reverse Osmosis plants.
3- Introduction of high temperature Reverse Osmosis with increase of process efficiency and control of membrane fouling.
4- Low energy Reverse Osmosis in rejection of radioactive and heavy metals contamination of waste waters quite better than conventional waste water treatment techniques.
5- Development of application of Solar Energy in Reverse Osmosis operation.

- On the other hand, it may be worthy to refer to some significant applications which are thought to contribute to Reverse Osmosis process development.

a- Use of 16 inches Reverse Osmosis membranes installed in 60 inches pressure vessels which are vertical installed.
b- The introduction of graphene membranes in Reverse Osmosis.

Keywords: Reverse Osmosis; Reject processing; High-temperature RO; Waste Waters Treatment

Presenting Author

Prof. Dr. Sabu Thomas

Short Biography

Prof. Dr. Sabu Thomas has about 37 years of experience working in the area of macromolecular science and green composites for a wide range of technological applications. He currently holds the positions of Vice-Chancellor of Mahatma Gandhi University and the Founder Director and Professor of School of Energy Materials, Mahatma Gandhi University, Kottayam, Kerala, India.

Title: Recent Advances in Nanocellulose for Water Purification

SABU THOMAS

Mahatma Gandhi University, Priyadarshini Hills P. O.
Kottayam, Kerala, India -686 560,

Abstract:

The remarkable potential of nanocellulose-based membranes for water purification is presented. Access to clean water is a critical global concern, as the majority of Earth's water resources are unsuitable for human consumption. With the world's population projected to surpass 8 billion by 2025, the need for effective water purification techniques is more depressing than ever. Traditional methods such as chemical and biological purification, along with mechanical processes, have limitations. However, membranes, especially polymeric membranes, have emerged as highly efficient tools for removing pollutants from water. Polymeric membranes offer advantages such as tunable porosity, mechanical flexibility, and stable behavior across a wide pH range. Among them, nano-cellulose, derived from biological waste, has garnered significant attention. Professor Thomas presents their research on producing nano cellulose through a steam explosion process, followed by purification and modification steps. The resulting nano cellulose exhibits unique properties, including surface charge control and pH tolerance, making it an ideal candidate for water purification. The talk highlights the applications of nanocellulose membranes, ranging from the removal of diverse dyes, nanoparticles, heavy metals, oils, bacteria, and viruses. By modifying the nano cellulose surface, researchers can selectively trap different contaminants, harnessing electrostatic interactions to achieve high separation efficiencies. The membranes can effectively remove pollutants like chromium, nickel, cadmium, and lead, offering a promising solution to the global challenge of heavy metal pollution. Additionally, nanocellulose membranes demonstrate exceptional performance in oil removal from water bodies. The use of aerogels, hybrid configurations, and chemically modified nanocellulose structures significantly enhances oil adsorption and facilitates subsequent separation for reuse or disposal. Furthermore, the superhydrophobic nature of these membranes enables efficient oil removal while repelling water, providing a sustainable solution to oil spills and industrial wastewater treatment.

Keywords: Cellulose nanofiber, Electrospinning, Meldrum's acid, Dye adsorption, Nanoparticle removal

Presenting Author
Mohamed Zaki Ewiss

Short Biography

Dr.Ewiss is a Professor of Physics at the Faculty of Science, Cairo University. He is a former consultant for the Graduate Studies and Scientific Research Sector at Cairo University. From 2010-2021, he supervised two projects at Cairo University as a principal investigator entitled "Localization of a Decentralized Low-Cost Wastewater Treatment System in Egypt" and "Cairo University's Proposal for Education Development in Developing Countries Using Modelling Approach". In 2008 and 2015, he received the Appreciation and Excellence Awards from Cairo University in basic sciences and interdisciplinary and future studies. He founded the non-profit International Organization for Science and Technology.

Title: Project for Environmental Friendly Carbon Neutral and High-Value-Added System of Desalination Processes

M. A. Zaki Ewiss
Department of Physics, Faculty of Science, Cairo University, 12630 Giza, Egypt

Abstract:

In this project, we will develop, examine and implement the following: 1) Energy-less pretreatment and dilution process of saltwater using FO membrane combined with fine bubble technology, 2) Discharge highly condensed seawater and do not use any chemical agent for inhibition of fouling on the membrane, 3) Thermal transistor process supplying simultaneously hot/cold heat by AHP (Absorption Heat Pump), upgrading solar heat at a lower temperature than 80 °C, 4) The processes of seawater distillation and condensation of evaporated water, 5) Water quality improvement with refined bubble technique, 6) Evaluation of a bench-scale of the carbon neutral desalination system (approximate planned capacity: order of 102 kg/day), 7) Optimum total system design for scale-up of F-T desalination system, 8) Economic and environmental evaluation of the F-T desalination system, and 9) Education on seawater desalination for public acceptance.

Keywords: Thermal Transistor, Membrane Technology, Bubble Technology, Desalination System

Presenting Author
Prof. Chedly Tizaoui

Short Biography
Chedly Tizaoui, FIChemE, is a full Professor in Chemical Engineering at Swansea University, UK. He has research interests in water and wastewater treatment with focus on advanced oxidation and separation processes. So far, Tizaoui has supervised over 30 PhD and Postdoc researchers to successful completion and has published over 130 papers in peer-reviewed journals and international conferences as well as authoring book chapters and technical reports for several organisations. He received research funding from major funding bodies and industry, and he sits on the editorial boards of several peer-reviewed scientific journals.

Title: Membrane And Ozone Advanced Technologies For Water And Wastewater Treatment

Chedly Tizaoui

Water and Resources Recovery Research Lab, Department of Chemical Engineering, Swansea University, Bay Campus, Fabian Way, Swansea, SA1 8EN, United Kingdom
c.tizaoui@swansea.ac.uk

Abstract:
The United Nations (UN) warns that by 2050, five billion people worldwide could suffer water shortages due to climate change, increased demand, and polluted supplies. Despite the progress made towards addressing the UN's Sustainable Development Goal on safe water and sanitation (SDG6), the unacceptable reality is that nearly 1 in 3 people around the world still use sources of contaminated water. Providing clean and affordable drinking water for all people on Earth has become one of the greatest challenges in this century. Commonly, water and wastewater treatment plants employ conventional technologies that are costly to run and suffer from degrading efficiencies over time while they require chemicals and energy to operate. This keynote will discuss innovative technologies based on ozone oxidation and membrane separation developed to address challenging water treatment questions. Enhancement of ozonation and membrane separation performances through integration of the two processes and the use of nanocatalysts and nanofillers will form a key aspect of this talk. The audience will learn about some of the challenges in the water sector and how advanced oxidation and separation technologies combined with nanotechnology address them.

Keywords: Membrane; Ozone; Nanotechnology; Water Challenges

Session [2]

Membrane Technology & Renewable Energy

Presenting Author
Frank Rögener

Short Biography
Since 2014 Frank Rögener has been working as Professor of Fluid Process Engineering at the Cologne University of Applied Sciences (TH Köln). His focus is on thermal process technology, including membrane and wastewater technology. He studied chemical engineering at the TU Clausthal. In 2000 he received his doctorate from the University of Saarland on the application of membrane processes. For more than 20 years, Dr. Rögener has been involved in the development of energy and resource-efficient processes, especially in the food industry, chemical industry and metal finishing industry.

Title: Electrodialysis And Electrodialysis Reversal For The Concentration Of Li Containing Solution

Frank Rogener, C. Manderscheid.

TH Köln University of Applied Sciences

Abstract:
Electrodialysis is a membrane process employed for the concentration and depletion of ions dissolved in aqueous solutions. For this, alternating anion and cation exchange membranes promote the transport of unevenly charged ions and prevent the transport of evenly charged ions, when a direct current is applied. In the following, the application of electrodialysis in the recovery and concentration of lithium is considered. The investigations on the lab scale focused on the concentration of different Li-containing solutions using conventional electrodialysis (ED) and electrodialysis reversal (EDR) which is characterized by a change of electric and hydraulic flows. This allows the minimization of scaling effects on the membrane surface. A possible application is an application in lithium recovery from spent lithium-ion batteries.

Keywords: Resources; Li recovery; brine treatment, ED, EDR

Presenting Author
Prof. Heba Abdallah

Short Biography:
She is a professor in the Chemical Engineering Department, Engineering and renewable energy Research Institute at National Research Centre. She is a consultant engineer in the field of research of designing and manufacturing special membranes for water treatment processes in the Egyptian Engineering Syndicate. She has 89 international publication articles; 14 granted patents in the Egyptian Academy of Science & Technology in membrane fabrication and technology. Also, many projects in RO membrane preparation.

Title: Low-Cost Polymeric Membranes: Manufacturing Steps and Economic Study
Extracted from Chinese /Egyptian Cooperation Project STDF 30431

Heba Abdallah, Marwa Shalaby, Sahar Saad, Rania Sabry, Eman Sobhy, Hanaa Ali, Hanaa Gadallah, Ayman El-Gendi, Ahmed Shaban

[1]Chemical Engineering Department, Engineering and Renewable Energy Research Institute
, National Research Centre, Centre. 33 El-Bohouth St. (Former El-Tahrir St.), Dokki, Giza, Egypt, PO box 12622.
Affiliation ID: 60014618, Tel: 202 33335494, Fax: 202 33370931

Abstract:
Chinese and Egyptian teams cooperate to produce low-cost novel membrane products. Production of ultrafiltration (UF) membranes was carried out using PVC and $Mn(acac)_3$ nanoparticles. The best UF membrane was enlarged and fabricated as a spiral wound module and then tested in the Zenien sewage wastewater treatment plant in Giza. Production of nanofiltration (NF) APVC membranes was done and was applied on divalent and trivalent separation also they were tested in some drugs separation. The best NF membrane was enlarged, then rolled in the shape of NF spiral wound module, and was tested on wastewater from pharmaceutical industries. RO membranes were prepared by the Egyptian team and tested in high concentrations of the salty solution to get the optimum membrane used in seawater desalination. A spiral wound 4" RO module was fabricated and tested on real seawater samples. The economic study for UF, NF, and RO membranes production was investigated and indicated the lowest price compared with imported modules.

Keywords: Ultrafiltration; Nanofiltration.; Reverse Osmosis; Economic Study

Presenting Author
Dr. Zahia Tigrine

Short Biography

Dr. Zahia Tigrine is currently Senior Researcher at Solar Equipment Development Unit (UDES), Renewable Energy Development Center (CDER). She is the head of the Distillation and Desalination of Brackish Water and Seawater Team DDESM, CDER. She is also a member of the African Membrane Society. Dr.Tigrine has a very strong research interest in the field of solar desalination and membrane technology for water applications. She has been involved as a manager or a participant in several national and international projects, as well in international collaborations. She has published more than 30 international papers in peer-reviewed journals, and 3 patents and has approximately 100 international oral communications.

Title: Membrane Desalination by Renewable Energy in Arid Regions to Mitigate Climate Change: Application and Case Study

Zahia Tigrine
Unité De Développement Des Equipements Solaires, Route Nationale N°11, BP386, Bou-Ismail, 42415, Wilaya de Tipaza, Algeria.

Abstract:

Desalination techniques are essential for addressing water scarcity and resolving the energy-water-environment nexus. In general, the two main types of desalination technologies are membrane processes (mainly reverse osmosis) and thermal processes (multi-effect distillation (MED) and multi-stage flash (MSF)). Moreover, forward osmosis (FO), membrane distillation (MD), capacitive deionization (CDI), humidification dehumidification (HDH) are some of the emerging desalination technologies that are still largely in the research and development stages. The desalination industry is now able to build the largest desalination facilities in the world to generate drinking water because to advancements in reverse osmosis (RO) membrane technology. Production of drinking water is now a major challenge for many nations, particularly in the Middle East and North Africa region which is the world's most water-scarce region. Indeed, reverse osmosis is a widespread technique that has been installed in large scales configurations, due to its reliability and lowers energy consumption (3–4 kWh/m^3), compared to MSF (20–27 kWh/m^3) and MED (15–22kWh/m^3). Renewable energy is an endless source of power that also offers cost-saving advantages and clean energy production. The use of renewable energy for seawater desalination is appealing, especially when there is no electricity network. The use of renewable energy for seawater desalination can have a positive impact and a reliable source of drinking water production when fresh water and grid power connections are not available.

Keywords: Desalination; Membrane; Reverse osmosis; Seawater; Renewable energy

Presenting Author
Prof. Dr. Mohamed Hassen Elkiki

Short Biography
Prof. Dr. Mohamed Elkiki is a professor in the Civil Engineering Department, Head of the Civil Engineering department, Higher Institute for Engineering and Technology, New Damietta, Ministry of Higher Education, 34517, Egypt. Member of the arbitrators' committees in the permanent scientific committee to examine scientific production for the positions of professors and assistant professors – the 14th session 2022-2025 (water resources). REVIEWER TO: International Journal of Plant Breeding and Crop Science, PORT SAID ENGINEERING RESEARCH JOURNAL, Egyptian International Journal of Engineering Science and Technology (EIJEST), Journal of Engineering Sciences, Faculty of Engineering, Assiut University, American Journal of Water Science and Engineering and Journal of Water Science, National Water Research Center.

Title: Joint Effect of Sediment Transport and Floodplain Divergence on Flow Pattern in Compound Channels

Hesham, M.[1], Elkiki, M.[1,2], Selim, T.[1] and Elsakka, M.[3]
[1] Civil Engineering Department, Faculty of Engineering, Port Said University, Port Said 42523, Egypt.
[2] Civil Engineering Department, Higher Institute for Engineering and Technology, New Damietta, Ministry of Higher Education, 34517, Egypt
[3] Mechanical Engineering Department, Faculty of Engineering, Port Said University, Port Said 42523, Egypt.

Abstract:
Sediment transport in open channels is considered as one of the most complex processes in hydraulic engineering .In this study, a numerical investigation of the joint effect between the floodplain divergence angle and the size of suspended sediment particles on sediment transport and flow depth-averaged velocity (DAV) in non-prismatic diverging compound channels was conducted. The analysis was implemented using the Computational Fluid Dynamics (CFD) software ANSYS-Fluent. Results revealed that the span-wise relative depth-averaged velocity (RDAV) gradient between the main channel and floodplain at the middle and the end sections of the divergence reach is much larger in the case of higher divergence angle. Based on the results, it can be concluded that the span-wise DAV gradient was greatly affected by the floodplain divergence angle and sediment particle size.

Keywords: Suspended sediment particles, Divergence Angle, Compound Channels, CFD.

Presenting Author
Ekram Said Hassan Abdelghani

Short Biography

Preliminary Master of Environmental Sciences and Industrial Development - Faculty of Graduate Studies, Beni Suef University- Postgraduate Diploma in Chemical Engineering, Faculty of Engineering / Cairo University - Bachelor of Chemical and Nuclear Engineering, Faculty of Engineering / Cairo University. Consulting engineer for quality management - Head of the Environmental Performance Unit Of The Egyptian General Organization for Standardization and Quality and Senior chemical specifications specialist - Secretary of multiple committees in the authority, including (sustainable development - various chemicals - paints - building materials - water treatment chemicals) .

Title: The Role Of The Egyptian Organization For Standards and Quality Towards Sustainability And Green Transformation

Ekram Said Abdelghani
Egyptian organization standards and quality (EOS)

Abstract:

Egyptian organization standards and quality (EOS).EOS is the only national & competent body in Egypt affiliated with undertaking all the relevant activities of preparing and issuing Egyptian standards, as well as the different activities in the field of quality assurance and conformity assessment for the relevant products, testing & industrial measurements, aiming at increasing the quality of the Egyptian products to be competitive in the international and local markets along with consumer's protection and environment. In line with the global requirements and recommendations at the present time, as well as the sustainable development goals submitted by the United Nations, which adopt the principle of reducing harmful emissions affecting public health as well as climate change, and based on the vision of EGYPT plan 2030, which reflects the long-term strategic plan of the state to achieve the principles and goals of sustainable development in all fields. Where the state seeks to preserve development and the environment together through the rational use of resources in a way that preserves the rights of future generations in a more secure future by facing the effects of climate changes and enhancing the adaptability of environmental systems and the ability to face risks and natural disasters and increase reliance on renewable energy and adopt sustainable consumption and production patterns.

Keywords: EOS; Standards; Environmental; Quality.

Session [3]

Ceramic Membranes

Presenting Author
Prof. Dr. Miriam Sartor

Short Biography
Prof. Dr.-Ing. Miriam Sartor is professor for Environmental Process Engineering and Technology at Cologne University of Applied Science (TH Köln), Germany. She has more than 15 years of experience in industrial liquid media treatment, filtration and membrane filtration and material technology. Her research at TH Köln is focused on industrial process water and liquid effluent treatment by hybrid processes with membranes or biological treatment processes, especially with algae. Before, she was COO at "CERAFILTEC Germany GmbH" a technology provider for ceramic flat sheet membranes and Head of the Department Surface Technology at "VDEh-Betriebsforschungsinstitut", applied research institute for steel and process industry.

Title: Enhanced removal of micro-pollutants by hybrid processes combining flocculation or adsorption with ceramic flat sheet membrane filtration

Pascal Erdmann (1), Fin Florack (1), Martin Kaschek (1), and Miriam Sartor (2)

(1) CERAFILTEC Germany GmbH Blue Filtration, Quellenstraße 14, 66121 Saarbrücken, Germany
(2) Cologne University of Applied Science (TH Köln), Faculty of Computer Science and Engineering Science, :metabolon Institute, Gustav-Heinemann-Ufer 54, 50968 Cologne, Germany

Abstract:
Different approaches to remove micro-pollutants - especially persistent organics as well as phosphate residues - by hybrid processes consisting of ceramic flat sheet membrane filtration combined with flocculation or adsorption were investigated. The target of the studies was to improve the quality of treated sewage effluent (TSE) to protect the ecosystems from micro-pollutants and allow a reuse of water. Therefore, ceramic flat sheet membrane filtration was combined with a flocculation process (cake layer filtration) to remove dissolved and colloidal organics from treated sewage effluent and to co-precipitate phosphate. By combining ceramic flat sheet membranes with powdered activated carbon adsorption (active cake layer filtration) persistent trace organics were efficiently removed from surface water.

Keywords: ceramic membranes; hybrid processes; cake layer filtration, micropollutants

Presenting Author
Ass. Prof. Noelia Alonso Morales

Short Biography
Associate Professor of Chemical Engineering at Autónoma University of Madrid with more than 20 years of experience teaching and research on Chemical Engineering. During this period her research has been centered on the design, preparation, characterization and application of membranes prepared with carbon materials, particularly graphene oxide. The applications are focused on water phase separation, especially emerging pollutants. She belongs to a research group with expertise on carbon materials, water treatments, catalyst preparation, etc. She has been working in more than 20 projects with different funding sources and has been collaborating with international teams (Pennstate University, UCV Chile, e.g.).

Title: Membranes Based On Graphene Oxide With Tunable Properties For Improvement Of Water Filtration

Noelia Alonso-Morales, Raúl Pla, Jose Alberto Baeza, Luisa Calvo, Miguel Angel Gilarranz

Autónoma University of Madrid

Abstract:
Graphene oxide (GO) materials have attracted huge interest to prepare membranes because of their unique and modulated properties, which make possible to combine excellent water permeation and rejection of solutes in water treatment and desalination. GO membranes have a particular structure formed by laminated structure of GO nanosheets. The interlayer spacing and the chemical surface composition (oxygen functional groups: epoxy, hydroxyl, and carboxyl) are two of the key properties directly affecting to transport properties during water filtration and desalination. The conditions used during membrane formation, such as GO initial suspension concentration and GO load particularly influence the compaction of GO nanosheets, which controls the rejection and flux. The GO membranes properties can be improved by chemical modification, e.g., oxidation/reduction treatment, and by intercalation of amines. The reduction treatment of the formed GO membranes by UV modifies the oxygen surface groups, modulating the molecular weight cut-off due to changes in the interlayer spacing and chemical composition. Membranes modified by intercalation of amines led to a significant increase in flux while keeping a high solute rejection. The filtration behavior was studied with different pollutants and salts: phenol, pyridine, naphthol, dyes and emerging contaminants, such as PFOA and pharmaceuticals, in a cross-flow system.

Keywords: Graphene oxide membranes; water filtration; emerging pollutant.

Presenting Author
Prof. Shereen Kamel Amin

Short Biography

Research Professor – at National Research Centre (NRC). Also, Consultant engineer certified by the Egyptian Syndicate of Engineers in the field of research and development of the solid waste management industry. She participates as a technical expert and assessor, in Egyptian Accreditation Council (EGAC). She participates as a member of the National Egyptian Standards Technical Committee for Ceramic Products and Refractories. She has many Scientific Awards, one of them is an international award from India. She participates in many applied research projects. She participates as a reviewer and editorial board membership in several international journals. She published many research articles and books in international journals and conferences. She Supervised several Ph.D and M.Sc Thesis. She participates in the teaching of undergraduate students in chemical engineering in the faculties of engineering in various Egyptian universities.

Title: Synthesis and Application of Ceramic Membranes in Water Purification in Egypt

Shereen Kamel Amin
Chemical Engineering and Pilot Plant Department, Engineering Research and Renewable Energy Institute, National Research Centre (NRC)

Abstract:

Membrane technology is one of the most effective technologies available for water treatment. Water filtration using membrane technology is characterized by several features such as small footprint, low sludge production, ease of operation, low operating temperature, and high removal efficiency. According to the material of construction, the main types of membranes are polymer and ceramic membranes. These latter are fabricated from inorganic materials. Ceramic membranes are usually more costly than polymer types because their starting materials are more expensive besides the complexity of their fabrication. However, ceramic membranes are characterized by long term durability, high mechanical strength, resistance to chemicals and solvents and thermal stability.

This work presents a number of studies about synthesis and application of ceramic membranes in water treatment, which is produced by Egyptian team. Where, the team was fabricated flat sheet, tubular ceramic membranes, and composite polymeric/ceramic membranes.

Keywords: Ceramic membrane, Water treatment, Low-cost raw materials.

Presenting Author
Prof. Raja Ben Amar

Short Biography

Raja Ben Amar is currently working as full Professor in the chemical department of the Faculty of Science of Sfax, University of Sfax (Tunisia) and leading the research unit ' Advanced technologies for Environment and Smart Cities'. She is currently the President of African Membrane Society (AMSIC). Her main research interests are water treatment, development of ceramic membranes from low cost materials for various applications. She has published more than 120 papers In Indexed Journals and 4 patents.

Title: Development of Low Cost Ceramic Membranes for Waste Water Treatment and Reuse

Raja Ben Amar
Research unit "Advanced Technologies for Environment and Smart cities", Chemistry Department, Faculty of Science of Sfax, University of Sfax, Tunisia

Abstract:

Typically, the asymmetric ceramic membranes are manufactured from metal oxides materials such as pure or mixed alumina, zirconia titania and silica oxides. However, inspite of that, their use is still limited due to high cost of commercially available ceramic membranes manufactured using pure oxides which require high sintering temperature, increasing the manufacturing cost. A major cost reduction can be expected by replacing the synthetic precursor materials by natural minerals or industrial waste. In recent years, many attempts are made to develop porous ceramic membrane materials based on low cost materials such as clay, kaolin, zeolite, fly ash, etc. which can be prepared at lower temperatures than those needed for high purity metal oxides. Therefore, one of the challenges for future development of the ceramic membranes is to manufacture low-cost membranes with high flux performance to treat large volumes of liquid effluent. The performance of these low cost membranes will be mainly governed by the raw material composition, level of impurities, selection of appropriate binders and pore-formers and sintering temperature, as well as their application.

Keywords: low cost material, ceramic membrane, sintering temperature, wastewater treatment

Presenting Author
Dalia Rasha Tawakol

Short Biography

I am an assistant lecturer at Horus University Egypt, a Ph.D. candidate, and have a master's degree in Chemical Engineering, Faculty of Engineering, Alexandria University. Published two papers in water treatment using low-cost ceramic membranes. I Contributed as a presenting author at the 3rd. International Conference for Membrane Technology and its Applications andwas awarded as one of the best presenters

Title: Hydrophobic Ceramic Membranes for Membrane Distillation Processes

Dalia Rashad Tawakol Gaafar
Basic Science Department, Faculty of Engineering, Horus University Egypt

Abstract:

The MD process refers to a thermally driven transport of vapors through a non-wettable porous hydrophobic membrane, with the driving force being the vapor pressure difference between the two sides of the membrane pores. The non-wetted porous hydrophobic membranes are required for an efficient process realization.

In the term of membrane materials, the most commonly used membranes for wastewater treatment are made of polymeric material, such as polyvinylidene fluoride (PVDF), polypropylene (PP), and polytetrafluoroethylene (PTFE). However, for the uses in MD, these membranes need good mechanical strength and chemical/thermal stability, and their surface should be highly hydrophobic. Ceramic membranes represent another class of separators and are famous for their high mechanical strength, chemical and thermal stabilities, and high flux.

However, conventional ceramic membranes exhibit hydrophilic character because of the presence of hydroxyl groups (- OH) on the membrane surface and thus require hydrophobic modification for application in MD. To address this issue, grafting is frequently practiced due to its high performance, convenient operation, and easy adjustability.

MD presents several significant benefits compared to other separation processes, such as multistage flash distillation (MFD), reverse osmosis (RO), nanofiltration (NF), ultrafiltration (UF), and microfiltration (MF), for example, lower operating temperatures than in distillation process and lower hydrostatic pressures than in pressure-driven processes. Moreover, the possibility of using waste heat or alternative energy sources, such as solar and geothermal energies, enables MD to be combined with other processes into integrated systems, representing more promising separation techniques for industrial applications. There are various MD modes utilized, for example, sweep gas membrane distillation (SGMD), direct contact membrane distillation (DCMD), air gap membrane distillation (AGMD), and vacuum membrane distillation (VMD).

Keywords: Membrane Distillation; desalination ; Ceramic Membranes ; Hydrophobicity

Presenting Author
KESRI Fatma

Short Biography
KESRI Fatma, PhD student in process engineering, she works on the development of green and economical ceramic membranes for seawater pretreatment

Title: Elaboration and Characterization of ceramic membranes: application for the pretreatment of Mediterranean Seawater

Fatma. Kesri(1),Djilali.Tassalit (2), Zahia. Tigrine (2) and Nadia.Aicha.Laoufi(1)

(1) Laboratory of transfer phenomena (LPDT), Faculty of mechanical and process engineering, University of Houari Boumediene (USTHB), B.P32 El Alia, 16111 Bab Ezzouar, Algiers, Algeria.
(2) Unité de Développement des Equipements Solaires, UDES/Centre de Développement des Energies Renouvelables, CDER, Bou-Ismail 42415, W. Tipaza, Algeria.
*Email: kesri.fatma@gmail.com

Abstract:
Flat ceramic support was prepared from the clay, by mixing different mass compositions of the raw material ranging from 65% to 95% with a pore former to improve the porosity of the support. The support was prepared and sintered in a muffle furnace at different temperatures, ranging from 1000°C to 1250°C. In this study, the preparation of ceramic membranes, for the Mediterranean seawater pretreatment in the Algerian coastal region (Bouismail Town), using local and inexpensive raw materials will be presented. In addition, we study the influence of various parameters such as the raw material composition and sintering temperature on the membrane performance. The membrane performance was evaluated by measuring the membrane porosity and permeability. Sodium chloride solutions were filtered with the aim of reducing their turbidity, Salt Density Index (SDI), and Total Organic Carbon (TOC).

Keywords: Ceramic support- membrane performance-seawater pretreatment-water pretreatment.

Session [4]

Separation Processes

Presenting Author
Ass. Prof. Fatma H. A. Mustafa

Short Biography

Dr. Fatma Hussein Ali Mustafa is an Assistant Professor of Marine Chemistry, Marine Environment Division, National Institute of Oceanography and Fisheries (NIOF), Suez, Egypt.
She had her Ph.D. in Organic Chemistry. Department of Chemistry, Faculty of Sciences, Suez, Egypt. Thesis title: A Study of the Effect of Marine Paints Containing Some Thiadiazole and Triazole Derivatives on Marine Fouling Organisms. She got 8 project grants (national and international) and supervised 3 PhD and 5 MSc students. Grant: ASRT-APPLE 3 No. 9528 Role: Principle Investigator. Such as “Economic prototype for aquaculture effluents utilization using novel chitosan hydrogels nanocomposite”, 2022-2023. Grant: NIOF No. NIOF (Eg)-ENV-19-22. Novel Smart Ionic Chitosan Derivatives and Their Applications as Marine Antibiofoulants. 2021-2022. Grant: STDF-DAAD GE-SEED-6879. Grant: NIOF No. NIOF (Eg)-ENV-17-22 : Assessment of biodiversity, fish stocks, and pollution levels along the coasts of the Gulf of Suez (the current situation and future requirements). 2021-2022. Grant: NIOF No. NIOF (Eg)-ENV-18-22 Role: Researcher. Title: Preparation of environmentally friendly nano-biocomposite to remove some organic pollutants. Duration: 12 months, 2021-2022.

Title: Cost-effective removal of nitrogenous compounds from aquaculture wastewater by magnetic chitosan-seagrass hydrogels

Fatma H.A. Mustafa , Heba M. Ezzeldin, Ghada Y. Zaghloul, Zaki Z. Sharawy

National Institute of Oceanography and Fisheries (NIOF), Cairo, Egypt

Abstract:

Magnetic Chitosan-seagrass hydrogels were synthesized by gelation of chitosan with the non-toxic crosslinker glutaraldehyde for the purpose of removing ammonia from aquaculture wastewater. The hydrogels were identified using spectroscopic and morphological approaches. The effects of adsorbent dosage, pH, contact time, temperature, and initial ammonia concentrations were examined by batch technique. For Chitosan- seagrass hydrogel, the ideal conditions were: adsorbent dosage 0.3 g, pH 1, contact time 25 min, and temperature 25 ^{o}C; for Magnetic Chitosan sea grass hydrogel.
The ideal conditions were: adsorbent dosage 0.4 g, pH 1, contact time 25 min, and temperature 40 ^{o}C. The adsorption potential of newly developed hydrogels was compared. For the adsorption of ammonia, both adsorbents fitted a pseudo-second-order kinetic model. Low values of ΔS_o suggested a low degree of freedom with ordered ammonia molecules on hydrogel surfaces. The negative ΔH_o indicated that the ammonia adsorption process was exothermic. The negative ΔG_o confirmed that the ammonia adsorption process was spontaneous.

Keywords: chitosan hydrogel; magnetite; ammonia; Adsorption isotherm, Kinetics and Thermodynamics

Presenting Author
Mohamed Elsayed Gabr

Short Biography
Dr. Mohamed Gabr is an Associated Professor in the Civil Engineering Department, Higher Institute for Engineering and Technology, New Damietta, Ministry of Higher Education, 34517, Egypt. He was published more than 34 papers in the field of water resources management, climate changes, wastewater treatment, constructed wetlands, crop irrigation requirements, rainwater harvesting, water quality, soil salinity, groundwater quality, irrigation and drainage, and the environmental hydrology

Title: Approach to designing a vertical sub-surface flow constructed wetland for wastewater treatment in arid climates

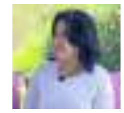
Mohamed Elsayed Gab[r1], and Osami Saied Rageh[2]
[1] Civil Engineering Department, Higher Institute for Engineering and Technology, New Damietta, Ministry of Higher Education, 34517, Egypt
[2] Professor of Harbor Engineering, Dean of the Higher Institute for Engineering and technology new Damietta.

*Corresponding author's mail: mohamed.gabr@ndeti.edu.eg

Abstract:
In this study, a wastewater treatment system is proposed, designed, and cost estimated. The system is serviced 3000 capita and has a wastewater discharge of 400 m^3/day in the developing arid region in West Minya new reclaimed area in western desert of Egypt. The system includes a primary sedimentation tank, a vertical sub-surface flow constructed wetland (VSSF-CW), and a storage tank. The relaxed tanks in series model based on areal loading rates and background pollutants concentrations (P-K-C*) was utilized to size the VSSF-CW. The influent wastewater pollutants for biological oxygen demand (BOD), total Phosphors (TP), and facale coliforms (FC) are 350 mg/L, 11 mg/L, and 1.4 × 1000000 MPN/100mL. After the primary sedimentation, the influent wastewater pollutants that enter the VSSF-CW are 250 mg/L, 7 mg/L, and 1000000 MPN/100mL for BOD, TP, and FC respectively. The results indicated that utilizing Phragmites australis and Papyrus for the biological treatment, VSSF-CW design treatment surface area was 2840 m2. The hydraulic surface loading rate (HSL) and hydraulic retention time (HRT) are 0.2 m/d and 1.14 day respectively. The expected overall cumulative removal efficiencies were 95, 73, and 99.9% for BOD, TP, and FC respectively. The proposed wastewater treatment system can be used to meet the Egyptian treated wastewater regulation at a cheaper cost and contribute additional non-conventional water sources for irrigation uses.

Keywords: Constructed wetlands; Surface hydraulic loading rate; water resources management; Biological oxygen demand; wastewater treatment; Aird regions.

Presenting Author
Dr. Hala El Manakhly



Short Biography

Climate Ambassador, Environmental Compliance Consultant, Granted Master Degree at Solar Energy field - 2000, Granted PhD Degree at Environment Science field -waste water treatment 2010, Certified Lecturer; at HSE field (Occupational Health/Safety/Environment and 20 + years of experience in the field of occupational safety, health and the environment in Oil & Gas Sector. She was honored on International Women's Day 2022 for her efforts in spreading the culture of safety in oil sites, whether on land or sea sites. She has several participations for Energy, Climate Change and Wastewater Treatment Seminars.

Title: Performance of Agro- Fibers Material Using as A filter for Industrial Wastewater Treatment Reclamation and reuse for irrigation”

,H. El-Manakhly[a], A.M. Shaaban [b]

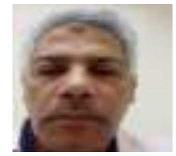
[a] Climate Ambassador, Environmental Compliance Consultant
[b] National Research Centre

Abstract:
The world works through the axis of sustainable development in the circular economy, whether solid, liquid or gaseous waste, to reduce carbon emissions and combat climate change. Use the environmentally friendly materials at waste treatment process. The process of wastewater treatment to make it fit for re-use is still a major problem and represents a great challenge for economic factors.

In this wastewater treatment; a different environmental friendly agro-fiber such as rice straw, luffa, sawdust, palm hemp and mixture of rice straw and luffa were used in trickling filter system as a filter media. The overall objective of this study was evaluation of final effluent quality achieved by using different agro-fibers.Removing of oil and grease and wastewater impurities are the main target of this work to reuse the effluent for irrigation un-fruitful trees purpose.

The results shows that the highest reduction in BOD (95.33%), COD (89.79%), TSS (96.6%), TDS (95%) and Oi/ grease (99%)) were recorded using the mixture of rice straw & luffa beds. The BOD(mg/l), COD(mg/l), TSS(mg/l), TDS(g/l) and oil/grease(mg/l) of the final effluent were 21,84.8,17,0.15(mg/l).

Keywords: agro-fiber, industrial wastewater.



Presenting Author
Dr.Yasser Mohamed Tawfic Ali

Short Biography
1- B. Sc. degree, July 1990, very good. M.T.C. Department of Chemical and nuclear Engineer, Cairo, Egypt.
2- M. Sc. degree, June 2003 Faculty of Eng. Department of Chemical Engineer, Cairo University, Cairo, Egypt.
5- Ph. D degree (Effects of metal oxide nanoparticles on EPDM properties) 2016 Faculty of Eng. Department of Chemical Engineer, Cairo University, Cairo, Egypt.

Title: Synthesis of Zinc Oxide Nanoparticles by co-precipitation Methods and their activity against bacteria

Yasser Mohamed Tawfic Ali
Higher institute Of Engineering & Technology in New Damietta

Abstract:

For ZnO NPs using co-precipitation methods, they were made from Zn chloride and NaOH at a constant annealing temperature of 300°C. Fourier transform infrared (FTIR), X-ray diffraction (XRD), scanning electron microscopy (SEM), and UV-vis spectroscopy were used to analyze the produced ZnO NPs. From the FT-IR result, ZnO NPs were observed in the region of 400-600 cm-1. Wurtzite hexagonal structure of ZnO NPs with the average crystal size 32 ± 49 nm was observed from XRD results. Evolution of the antibacterial activity against various bacteria including Staphylococcus aureus and Escherichia coli was studied.

Keywords: Zinc Oxide Nanoparticles; Co-precipitation methods; Activity against bacteria.]

Presenting Author
Marwa H. Gaber

Short Biography
Chemist at national research centre since 2014, Chemical Engineering Department and Ph. D degree in Chemistry 2022.

Title: Pectin /quaternary ammonium salt as highly selective cation nanofiltration membranes for application in desalination

M.S.Shalaby, Marwa H. Gaber

Chemical Engineering and Pilot Plant Department
National Research Centre - El Buhouth St., Dokki, Giza, Egypt

Abstract:
Nanofiltration membrane-based separation technologies have attracted an important interest from various industries owing to their high process efficiency. However, the wider applications of conventional polyamide (PA) thin-film composite (TFC) membranes are very popular although they are limited by their poor pH stability and low cation selectivity, demanding the development of membranes with advanced chemistries. Herein, an extreme cost effective, pH-resistant, highly cation-selective membrane is fabricated by synthesizing a poly(quaternary ammonium) (PQA) selective layer with pectin as green polymer via electospinning. The membrane produced a thin, densely crosslinked, and positively charged PQA permselective layer without hydrolysis-prone functional groups. Moreover, the PQA membrane exhibits remarkably high rejection and selectivity for divalent cations owing to the exceptionally strong positive charge imparted by its abundant cationic QA groups. More importantly, the PQA membrane displays ultrahigh pH stability under both extremely acidic (1.5 m H2SO4) and alkaline (5 m NaOH) conditions. The prepared fibers were subjected to full chemical analysis and were evaluated for removal of divalent from seawater.

Keywords: Nanofiltration , pectin, quaternery ammonium, salt, electrospinning, divalent, cations

Presenting Author
Dr. Sara Mamdoh Moatmed

Short Biography

Research Assistant, Deputy director of quality management and sampling manager at potable water and sanitation company in Beni Sueif, Member at the Egyptian Society For Membrane Technology& its Application.

Title: "Sustainable Electrospun Nanofiber Membrane for Enhanced Oil/Water Separation: Eco-friendly and Reusable Approach"

Sara M. Moatmed [a,b], M.H. Khedr [a], S. I. El-dek [a], Ahmed G. El-Deen [c]
[a] Materials Science and Nanotechnology Department, Faculty of Postgraduate Studies for Advanced Sciences (PSAS), Beni-Suef University, Beni-Suef 62511, Egypt
[b] Environmental Affairs and Quality Sector, Quality Department of Central Laboratory of Beni Suef Water and Sanitation Company of The Holding Company for Water Drinking, Egypt
[c] Renewable Energy Science and Engineering Department, Faculty of Postgraduate Studies for Advanced Sciences (PSAS), Beni-Suef University, Beni-Suef 62511, Egypt

Abstract:

The increasing occurrence of oil spills and organic pollution in marine environments has necessitated the development of a cost-effective and efficient oil/water separation process. This study introduces a novel approach using standalone, environmentally friendly polystyrene composite nanofibers as hybrid membranes for rapid oil/water separation without external pressure. Electrospinning created a superhydrophobic/super-oleophilic membrane by incorporating metal oxide intercalated polystyrene nanofibers with multifunctional coverage. Characterization techniques such as field emission scanning electron microscopy (FE-SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD), and contact angle measurements were employed to investigate the morphology, crystal structure, and surface wettability properties of the membranes. The optimization of nanofiber membrane functionalization was explored to achieve the highest separation performance. The results demonstrate that the integration of nanoparticles into the membranes significantly affects their superhydrophobic properties and separation efficiency for both light and heavy oils. Among various formulations, the fabricated polystyrene nanocomposite membrane exhibited exceptional characteristics, including ultra-high flux, remarkable separation efficiency, outstanding superhydrophobicity, and excellent recyclability for over 50 consecutive cycles. Remarkably, the proposed hybrid coated nanofiber membrane showcased the switch ability to superhydrophilic/superhydrophobic behavior, enabling efficient separation of diverse oil types. Overall, this study provides a cost-effective and straightforward method to enhance membrane performance for long-term oil/water separation processes. Using green and reusable electrospun nanofiber membranes offers a promising solution to address the challenges of oil spills and organic pollution in marine environments.

Keywords: superhydrophilic/superoleophobswitch able nanofiber membrane oil separation

Session [5]

Membrane Applications and Energy Saving

Presenting Author
Asso. Prof Emad Alhseinat

Short Biography

Dr. Alhseinat is currently an associate professor in the Chemical Engineering Department at Khalifa University in Abu Dhabi. Dr. Alhseinat is a co-founding member of the Center for Membrane and Advanced Water Technology in Khalifa University. Dr. Alhseinat has filed five patents and published one book chapter and 55 scientific journal papers in high impact Journals. His research efforts are focused toward contributing to solve the problem of freshwater shortage in arid region through improving the efficiency of water desalination and treatment processes and creating innovative and sustainable solutions.

Title: Innovative Approach for Enhancing the Efficiency of Membrane Desalination Processes through Electromagnetic Treatment

Emad Alhseinat*, Pham Le Phuong Tu, Ahmad Al Masri Alwan, Salha Bahayan
Department of Chemical Engineering, Khalifa University of Science and Technology, Abu Dhabi, P.O. Box 127788, United Arab Emirates.
Center for Membranes and Advanced Water Technology, Khalifa University of Science and Technology, Abu Dhabi, P.O. Box 127788, United Arab Emirates

Abstract:

Comparison to conventional thermal desalination membrane desalination, particularly reverse osmosis (RO) and membrane distillation (MD) is preferred due to its higher efficacy and lower energy consumption. However, contamination continues to be a significant issue in membrane desalination. Scaling, which is caused by the precipitation of inorganic salts is the most persistent fouling problem for RO and MD regardless of the pretreatment method. Electromagnetic field (EMF) has been evaluated as a solution for membrane scaling issues. The experiments investigated the effect of electromagnetic fields on the formation of $CaCO_3$ during RO and MD desalination. The results of the MD experiment demonstrated that EMF increases the efficiency of water evaporation and the crystallization of $CaCO_3$ in bulk. In the absence of EMF effect, a mixture of calcite, aragonite, and vaterite formed, but aragonite was observed to be the predominant morphology of $CaCO_3$ in the experiment with EMF. In contrast, the results of a RO experiment with a high level of supersaturation revealed that EMF has an effect on the dissolution of $CaCO_3$ when it is formed prior to the passage of EMF. For further membrane desalination industrial applications, it is crucial to gain a comprehensive understanding of the effects of electromagnetic fields.

Keywords: membrane desalination; reverse osmosis; membrane distillation; Electromagnetic field

Presenting Author
Ass. Prof. Mohamed Elsayed Gabr

Short Biography

Dr. Mohamed Gabr is an associated professor in the Civil Engineering Department, Higher Institute for Engineering and Technology, New Damietta, Ministry of Higher Education, 34517, Egypt. He was published more than 30 papers in the field of water resources management, climate changes, constructed wetlands, crop irrigation requirements, rainwater harvesting, water quality, soil salinity, groundwater quality, irrigation and drainage, and hydrology

Title: Management and Treatment of Brine Solutions: A Review

Nawaf S. Alhajeri[1], Fahad M. Al-Fadhli[2], Salem Al Jabri[3], and Mohamed Elsayed Gabr[4]
[1] Department of Environmental Technology Management, College of Life Sciences, Kuwait University, Safat 13060, Kuwait
[2] Department of Chemical Engineering. College of Engineering and Petroleum, Kuwait University, Safat 13060, Kuwait Management and treatment
[3] Department of Soils, Water, and Agricultural Engineering, Sultan Qaboos University, Muscat, Oman
[4] Civil Engineering Department, Higher Institute for Engineering and Technology, New Damietta, Ministry of Higher Education, 34517, Egypt
*Corresponding author's mail: alhajeri.n@ku.edu.kw

Abstract:

Extremely concentrated saline water used for desalination, brine contains a variety of salts, minerals, heavy metals, organic pollutants, and microbiological contaminants. Desalination brine's toxic and salinity levels are raised by conventional disposal, which has detrimental effects on natural and marine ecosystems. The creation of brine management technology that can result in zero liquid discharge is necessary to address these problems. By implementing financially viable approaches, brine management can be productive and allow for the recovery of priceless resources including freshwater, minerals, and energy. This review focuses on the most recent improvements in brine management employing various membrane/thermal-based technologies and their application in recovering energy, minerals, and water while weighing the benefits and downsides of each. The information analyzed and the prognosis provided in this analysis might undoubtedly aid in the creation of future policies for sustainable brine management that are economically feasible.

Keywords: Brine solution; Brine treatment; Management; Sustainability

Presenting Author
Dr. Eman S. Mansor

Short Biography

Dr Eman is a researcher at water pollution research department in National Research Centre. Her research work in the field of water /wastewater treatment using advanced technologies especially advanced oxidation processes (AOPs) and membrane technology. She has good expertise in preparation, characterization of different materials (nano-micro) that used in photocatalysis, adsorption or others application. She has good expertise in ultrafiltration (UF), Nanofiltration (NF) Reverse Osmosis (RO) membranes fabrication, application and characterization. Also preparation of thin film composite membranes (TFC) by interfacial polymerization. She has participated in several projects deal with the most advanced techniques for water/wastewater treatment (10 projects). She has attended various training courses, international conferences and workshops. She has many international publications.

Title: Development of polymeric membranes for wastewater treatment

Eman S.Mansor, Heba Abdallah, Ahmed Shaban
Water pollution Research Department, Environment Research and climate change Institute, National Research Centre, Dokki, Cairo, Egypt, 1,3.
Chemical Engineering Department, Engineering and Renewable Energy Research Institute, National Research Centre, 33 El-Bohouth St. (Former El-Tahrir St.), Dokki, Cairo, Egypt,2

Abstract:

In the framework of the Sustainable Development Goals issued by the United Nations, there has been considerable discussion about equal access to clean water and sanitary facilities. Due to the greatest population and significant economic development, demands on water and purification have significantly risen.

Classical wastewater treatment procedures have made some progress over the years in purifying effluents for disposal, but they fall lacking in the way they deeply control emerging harmful substances. The potential to reuse treated wastewater for home, agricultural, and industrial needs depends on breakthroughs in purifying technologies. One of the most recent breakthroughs to be implemented effectively is membrane technology. Nanofiltration, microfiltration, reverse osmosis, ultrafiltration, and membrane bioreactors are examples of widely utilized membrane processes depending on features such as size or charge. Over traditional treatment, membrane technology offers various benefits. This review article discusses a number of membrane-related topics, including membrane categorizing, integration of filtration membrane for wastewater treatment and application in various fields.

Furthermore offer an outlook of the filtering membranes that will be used in the future. Smart membranes have gained interest because of their selectivity, and tunable characteristics. Modified interfacial polymerizations approaches have been investigated in addition to adsorptive ultrafiltration mixed matrix membranes.

Keywords: membrane technology; membrane classification ;Application ;wastewater

Presenting Author

Ahmed Abdelnaby Kabeel

Short Biography

Dr Ahmed received a BSc degree in electronics and communication engineering from the higher institute of Engineering and technology in 2012 and received his M.Sc. in 2015 from Mansoura University and Ph.D. in 2019 from AL Menia University, His M.Sc. dedicated to UWBA design for ground penetrating radar for environmental exploration, the Ph.D. is devoted to introduce a new spectrum sensing algorithm based on antenna array for cognitive radio application also has introduce an enhancement using beamforming algorithm, Ahmed also is IEEE Member AP-S Society

Title: Solar Panel Optimization Based on Graphene-Silicon-Droplet Integration

Nada A. Abd Elshafy, Abdelrahman E. Hamouda, Arwa E. Abozaher, Haneen M. Siyaam, Ahmed A. Kabeel

Department of Communication and Electronics.

Higher institute Of Engineering & Technology in New Damietta

Abstract:

Solar panels are an essential component of renewable energy systems. However, the efficiency and cost-effectiveness of traditional solar panels have been a limitation in widespread adoption. In recent years, there has been significant researches and development in improving solar panel technologies. One promising advancement is the integration of graphene-silicon-droplet materials into solar panels. This paper presents a novel approach that combines graphene, silicon, and droplet panel integration to enhance solar energy harvesting capabilities, making it an ideal candidate for improving solar panels. The new solar cell can be excited by incident light on sunny days and raindrops on rainy days, yielding an optimal solar-to-electric conversion efficiency of 6.53 % under AM 1.5 irradiation and current over micro amps as well as a voltage of hundreds of microvolts by simulated raindrops. The combined use of graphene, silicon, and the droplet panel demonstrates promising advancements in solar panel technology. The synergy between these materials results in a highly efficient, cost-effective, and scalable solar panel design. This new design holds significant potential for revolutionizing the renewable energy landscape, paving the way for sustainable and eco-friendly power generation.

Keywords: Graphene-silicon solar cells, Droplet panel, Solar Pannel, Transparent Antenna, Renewable energy

Presenting Author
Esraa Khaled Mohamed Hefny

Short Biography

Esraa Khaled Mohamed. – Post Graduate: November 2020, Master degree, Faculty of Engineering, Chemical Engineer department, Cairo University, (Solar Desalination using solar collector). Aspen-plus simulation program is used to solve flow sheet and economic study is done to know the cost of fresh water. – Assistant Researcher at National Research Center from 2018-2020. 2 years' experience in industry of Flat Sheet membrane, desalination and waste water treatment, - Assistant Teacher at Canal Higher Institute for engineering and technology from 2021 till now. – Speaker in Frist, Second & Third International Conference for Membranes Technology and Its Application (2019), (2021), (2022).

Title: Uses of the polymeric membrane in medical application

Esraa Khaled Mohamed Hefny
Canal High Institute of Engineering and Technology, Ministry of High Education, Suez, Egypt

Abstract:

Membrane technology is applied in many applications as desalination, water treatment, oil/ water separation, and medical fields. In medical fields, membranes are used in hemodialysis and wound dressing. The hemodialysis technique is permeability for substances smaller than albumin and the request to prevent the passage of impurities of the dialysate into the blood, membranes used are composed of a hydrophobic base material and hydrophilic components, The hydrophilic component in the membrane is the pore-forming agent and improves blood compatibility and antifouling properties, the efficiency of a membrane depends on low membrane thickness, effective pore size and binding capacity for uremic substances. Wound dressing is one of the most frequently used applications for hydrogel membranes. Hydrogel membranes used in wound dressing processes must be hydrophilic polymers, Hydrogels can absorb and retain the wound exudates, which promote fibroblast proliferation and keratinocyte migration. The advantages of hydrogel membranes in wound dressing are easily removed from the wound, accelerate healing, reduce pain, and have low cost. But its disadvantages are semi-permeable to gases and water vapor, and poor bacterial barrier.

Keywords: hydrogel membrane; wound dressing; Hemodialysis; hydrophilic; hydrophobic

Presenting Author
Dina Mohamed Ahmed Ibrahim

Short Biography

- Demonstrator of chemical engineering, faculty of engineering, Minia university.
- Master degree & specification: In oily waste water treatment, separation techniques.
- Getting TOEFL certification from Minya university, getting ICDL certification, getting endnote and Spss certification, getting presentation skills and effective communication skills certification from Minya university, getting scientific research ethics certification, getting Quality standard certification

Title: Improvement of Oil / Water Treatment Using Advanced Technique

Dina M. Sorour*[1], Eman A. Ashour[1], Marwa Shalaby[2]

[1] Department of Chemical Engineering, Faculty of Engineering, Minia University, 61516 Minia, Egypt.
[2] Department of Chemical Engineering, Engineering research & Renewable Energy Institute, National Research Centre, 33El-buhouth street, Dokki, Egypt

Abstract:
Nowadays large amounts of oily wastewater have been produced from many sources. The main important challenge of oily wastewater treatment is separate the stable emulsified oil particles from water, generally, because of the easy of advanced separation processing and low cost, as well as their high flexibility, polymeric membranes are critical in these processes. Many types of additives are added to a based polymer to increase it is hydrophilicity and increase it is properties as enhancing pure water flux (PWF). This paper illustrates the preparation of PVC membrane by phase inversion method using N, N-Dimethyl-formamide (DMF). In order to achieve both higher permeation flux and fouling resistance, modification of PVC has been done by adding polymeric additives such as polyvinylpyrrolidone (PVP), also in this paper, we compare lab chemical membrane and commercial chemical membrane on the hand of their fluxes, rejection and characterization. the enhanced PVC/PVP membranes were characterized and evaluated by Mechanical strength, porosity, scanning electron microscopy (SEM), Fourier Transform Infrared (FTIR), and water contact angle measurement. Finally, the membranes were evaluated in a lab-scale cross-flow system with synthetic oily wastewater as feed.

Keywords: Oil/water separation, UF membranes, Membrane modification

Presenting Author

Sherif Mohammed El Sherbini

Short Biography

A PHD Researcher in the Faculty of Engineering chemical Engineering Department Minia University, I work as a Process Department Manager in Middle East Oil Refinery (MIDOR) for Acid Gas Treating units like SRU/ TGT/ARU/SWS and Hydrotreating Units like DHT/KHT at Technical and Development department with 15^{+} years' experience in oil, gas and petrochemical Sector.

Title:"Stripped sour water reuse at an Oil Refinery''. Case Study and an Economical Evaluation.

Sherif M. Elsherbini[1], Marwa S. Shalaby[2], Ebrahiem E. Ebrahim[3], Hassan A.Farrag[4]

Chemical Engineering Department, Faculty of Engineering, Minia University[1]
Chemical Engineering Department Engineering Research and Renewable Energy Institute, National Research Center, El Bouhouth Street [2],
Chemical Engineering Department, Faculty of Engineering, Minia University[3]
Chemical Engineering Department, Faculty of Engineering, Alexandria University[4]

Abstract:

Many opportunities are studied to decrease the overall water balance to achieve sustainability and water management of the petroleum sector by applying modern methods of conservation/reuse and recycling. Various sources of wastewater are generated in the petroleum oil refineries and contaminates are the restricting factor of water reuse . Oil refineries generate large volumes of sour water, which contains high concentrations of contaminants suchas oil, grease, ammonia, hydrogen sulfide, and dissolved solids. Traditionally, this water is treated and then discharged to the surface water bodies causing negative environmental impacts. Contaminants in sour water can be treated to make it reusable in a valuable process.as washing water for air coolers instead of condensate water due to the high cost and availability of condensate. This study explores the feasibility of using refinery-treated sour water as a supplement source for condensate water in the (REAC) wash. The goal is to evaluate the technical and economic viability of this approach, as well as its potential environmental benefits. The results of this study show that using refinery-treated sour water is a viable option for air cooler wash water. The treated sour water meets the required quality standards for this application, and its availability is not affected by the process requirements that limit the availability of condensate water. Moreover, using treated sour water can reduce water consumption and wastewater discharge, resulting in cost savings and environmental benefits.

Keywords: Stripped Sour Water- Water reuse- REAC (Reactor Effluent Air Cooler) Condensate water Wash-Water Management-Treated water-Environmental Regulations-Economical evaluation

Presenting Author
Gaweł Sołowski

Short Biography
Gaweł Sołowski completed his Master’s Degree at the Silesian University of Technology at Gliwice in 2014. He is a Ph.D. student at the Institute of Fluid Machinery of the Polish Academy of Science since 2014. He has been serving as an assistant editor in Open Chemistry in de Gruyter Open and published 31 publications including 26 in reputed journals. From 2022 he works as a specialist at Bingol University in Turkey. He is a specialist in dark fermentation and polymer membranes. He is also interested in phytomedicine.

Title: Biofuels From Algaes And Microrganism

Gawel Solowski

Department of Molecular Biology and Genetics, Faculty of Science and Art, Bingol University, Bingol, 1200, Türkiye, gawelsolowski@gmail.com

Abstract:
European sustainability plan for 2050 assumes conversion from fossil fuels into renewable sources. Therefore many countries besides Europe published many plans of using microbial and algae as relevant parts, also. Both methods often combine themself for optimization. Butanol and ethanol can be obtained by acetone-butanol-ethanol bacteria but more solutions are from algae, while hydrogen is from dark fermentation. Algaes are lipid-rich plants and after biophotolysis and biosorption can be then fed for dark fermentation. In dark fermentation, the rest are partially converted by anaerobic bacteria into hydrogen and unconverted for biodiesel.

Keywords: hydrogen, ;…butanol..;…acetone;…ethanol..

Session [6]

Membranes For Desalination

Presenting Author
Martin Hubrich

Short Biography
Until 04/2000: Study of process engineering at Technical University of Clausthal, Germany - main subjects: chemical and mechanical process engineering Since 04/2000: Project/research manager at VDEh-Betriebsforschungsinstitut GmbH, Germany (companyfocus: applied research in national and international projects for iron and steel industry). And Main focus of performed projects: water recovery from cooling and wastewaters of iron and steel industry e.g. by desalting with membrane based capacitive deionisation,development of a magnetic separator form lab scale up to 50 m³/h plant for removal of suspended solids from cooling waters and cold rolling emulsions And treatment of oil and heavy metal containing waste waters by membrane filtration.

Title: Desalination Of Wastewater To Ensure Fresh Water Supply

Martin Hubrich, Matthias Kozariszczuk

VDEh-Betriebsforschungsinstitut GmbH, Sohnstrasse 69, 40237 Düsseldorf, Germany

Abstract:
Water is one of the most important media in iron and steel industry, being mandatory for machine and product cooling, gas washing and material conditioning with a total freshwater demand of over 2 billion m³ per year in EU27. Due to climate change, water stress, effecting the water availably and quality, a sufficient and reliable water supply is becoming more important in whole Europe. As a result, novel technologies are required for opening new water sources such as e.g. waste waters of central and decentral wastewater treatment plants.For this purpose, the use of membrane-based capacitive deionization, already been successfully tested for cooling water treatment, is considered more in detail together with other technologies. Current BFI work is focusing on the treatment of organic and solid-containing wastewaters from chemical-physical or biological treatment plants for the treatment of degreasing baths and old emulsions or for a central treatment plant before discharge. Another focus is the determination of potential impurities and their removal to ensure reliable wastewater desalination. Further, the production of mono-concentrates as raw material for the electrochemical production of a chlorine-based biocide for direct use in cooling circuits by using nanofiltration in combination mixed concentrates from desalting, is being investigated.

Keywords: wastewater, internal treatment, water supply, desalting, recovery, nanofiltration, membrane based capacitive deionization, iron and steel production, concentrate handling

Presenting Author
Sahar S. Ali

Short Biography

Prof. Chem. Eng. Dept. NRC Egypt, has an experience in membrane fabrication and applications through participating in many projects, taking training courses; in HF membrane production and permeability test May 2011 & 2013, and in Spiral wound membrane fabrication, NRC 2017. I have an MSc and Ph.D. in the treatment of industrial effluents using biotechnology for microorganism selection. I have 30 international articles; on membrane preparation, and water treatment applications. In addition, she has four gained patents from ASTR Egypt, in membranes preparation (Production of RO membrane, fabrication of different types of cellulosic membranes NF , FO, and preparation draw solutes compound used for water desalination via FO and HF membrane production. Moreover submission 4 patents for the FO process and one for fuel cell membrane fabrication.

Title: Development of Forward osmosis process for different water treatment applications

Sahar S. Ali, *Rania Sabry; Hanaa Gamal; Hanaa Ali*

Chem. Eng. Dept., Flat sheet membrane group, NRC Egypt

Abstract:

Forward osmosis (FO) is a process that may be able to desalinate water sources at a notably reduced cost. The development of the FO process can govern by two major factors; the development of high-osmotic draw solutions and highly efficient FO membrane. The main objective of this study is to investigate different natural types of draw solutes which can generate highly osmotic pressure by using highly efficient FO membranes prepared for different applications. Also, the effect of different FO membranes prepared was investigated. A high FO performance in terms of high water flux of > 100 LMH with no reverse solute flux was obtained at the optimum condition. It was found that the development of the FO process is mandatory to apply for different water treatments.

Keywords: Forward osmosis, Draw solutes, membrane preparation, application, water treatment

Presenting Author
Li-Feng FANG

Short Biography

Associate research fellow/ post-doctor at Zhejiang University. He obtained his doctoral degree from Zhejiang University in 2015, and conducted postdoctoral research at Kobe University in Japan and Zhejiang University from 2016 until now. His main research interests include the design and synthesis of amphiphilic polymers for membranes, the development and high-performance of polymer separation membranes, as well as antibacterial and antifouling separation membranes and biomedical materials. He published more than 80 papers, applied 19 invention patents (16 patents have been granted), and served as PI for 5 projects, including the National Natural Science Foundation Youth Fund project of China.

Title: Novel nanofiltration membrane prepared from amphiphilic copolymer-based nanoparticles packing for molecular separation

Li-Feng Fang[1], Wen-Han Yu[1], Ming-Yong Zhou[1], Yu-Jie Shen[1], Bao-Ku Zhu[1]
[1] Department of Polymer Science and Engineering, ERC of Membrane and Water Treatment (MOE), Zhejiang University, Hangzhou 310027, China

Abstract:

Nanofiltration (NF) as a promising candidate is widely used in molecular separation, due to its proper pore size and charge property. In this report, we will introduce the novel NF membrane prepared from amphiphilic copolymer-based nanoparticles packing, which will be used for biomolecules (water phase) and dye separation (organic solvent phase). The amphiphilic copolymer-based nanoparticle emulsion was firstly prepared by soap-free emulsion polymerization, and then directly depositing onto porous substrate to form nanochannel selective layer of NF membrane, followed by the proper post treatment. The optimal NF membrane shows a desirable rejection of basic amino acids and biopeptides (i.e., ~95%) and allows neutral or acidic ones with similar molecule weight to permeate through. Moreover, by replacing the organic solvent resistant substrate membrane, the resultant membrane shows excellent retention for dyes with specific molecular weights, with a molecular weight cut-off (MWCO) of 825 Da. In particular, the rejection rates of Coomassie brilliant blue (BB) and Bengal rose red (RB) were 96.6% and 97.9%, respectively. This work provides the novel membrane material and facile operation process for NF membranes, which have the great potential in biomolecular separation and the field of organic solvent nanofiltration (OSN).

Keywords: Amphiphilic copolymer; Nanoparticle packing; Nanofiltration (NF); Molecular separation

Presenting Author
Prof. Ayman El-Gendi

Short Biography

Prof. Ayman Elgendi is a professor in Engineering Research Institute, National Research Centre (NRC), Egypt and also in Canal High Institute of Engineering and Technology, Ministry of High Education, Suez, Egypt. He has an experience in the membrane fabrication and application through projects and training in which he participated in a good number of projects. He has 41 international publication articles from 2007 to 2023 in desalination, membrane technology and membrane preparation. He has 8 granted patents from Egyptian Academy of Science & Technology. He has published a book entitled: Ternary phase diagram construction and membrane morphology evaluation, LAB LAMBERT academic publishing, Germany ISBN: 978-3-659-57611-9 (2014). Furthermore, He has published a Chapter 3 in Desalination Updates book, ISBN 978-953-51-2189-3, edited by Robert Y. Ning chapter entitled "Phase Diagram and Membrane Desalination".

Title: Development of Performance of RO Desalination Membrane.

Ayman El-Gendi [a,b*]
a, Canal High Institute of Engineering and Technology, Ministry of High Education, Suez, Egypt
b, Chemical Engineering Department, Engineering Research Institute, National Research Centre, 33 El-Bohouth St, Dokki, Giza, Egypt, Post Code 12622, Tel: +20233335494, Fax: +20233370931, corresponding author: aymantaha2010@yahoo.com

Abstract:

Shortage of water is a serious global problem owing to the increase of industrial activities as well as dramatic population growth. The limited fresh water resources make it necessary to produce fresh water from brackish or seawater by desalination technology. The current and future growing need for clean water puts a great pressure on the development of highly efficient and low-cost water purification systems as well as the exploration of unconventional or untraditional water sources such as the use of purified municipal wastewater. Membrane based processes are recognized as energy efficient solutions for many separation tasks, including water purification. Reverse osmosis (RO) technique is used for desalination of seawater by applying high pressure to overcome the osmotic pressure of the seawater. Fabrication of antifouling separation membranes is of significant interest for water treatment. However, fabrication of membrane with antifouling properties associated with improved performances is a great challenge particularly in the field of materials. This proposed work will cover the development of considerable fundamentals and know-how involved in the improvement of Reverse Osmosis (RO) antifouling membranes for water desalination.

Keywords: Water shrinkage, Membrane; Desalination; Nanomaterial; Fouling; Characterization

Presenting Author
Zhuofan Gao

Short Biography

I obtained my Ph.D. degree in Chemical Engineering from National University of Singapore in 2021. My research areas was membrane and its application. Currently, I am working in Changjiang River Scientific Research Institute of Changjiang Water Resources Commission. My major research focuses on membranes science & sustainable technology for clean water, clean energy, organic waste-resource utilization, water environment protect and rehabilitation, biofuel, solvent separation and carbon capture, utilization, and storage (CCUS) etc.

Title:Desalination Performance Enhanced By In-situ Growing ZIF-8 Nanoparticles Into Thin-film Composite Reverse Osmosis Membranes For Unconventional Water Purification

Zhuo Fan Gao1,3, Xia Chen1, Xian Zhou1, Zeyu Fan1, Shanshan Deng1, Jiazheng Li1, Qi Lu1, Wei Han1, Gang Chen2*,Tai Shung Chung3,4*

1 Changjiang River Scientific Research Institute, Research Center of Water Engineering Safety and Disaster Prevention of Ministry of Water Resources, Wuhan 430010, China . 2 College of Environmental Science and Engineering, Donghua University, Shanghai 201620, China. 3 Department of Chemical and Biomolecular Engineering, National University of Singapore, Singapore 117585. 4 Graduate Institute of Applied Science and Technology,
National Taiwan University of Science and Technology, Taipei, Taiwan 106335

Abstract:

Thin-film nanocomposite (TFN) membranes have outstanding performance in desalination from wastewater, seawater and brackish water. ZIF-8, a type of metal-organic frameworks, were induced into the polyamide-based TFN reverse osmosis membranes. The inherent porous structure, suitable triangular aperture size, and high chemical and water stability of ZIF-8 offer the TFN membranes with lower cross-linking and extra passageways for water molecules across the polyamide skin layers. A new methodology to produce TFN membranes is displayed by layer-by-layer (LBL) in-situ growth of ZIF-8 nanoparticles under mild environment onto an ultrafiltration support, followed by a thin film polyamide layer coating via interface polymerization. By tuning the ZIF-8 in-situ growing procedure times, a water flux of 56.6 LMH with a salt removal rate of 99.1 % is gained for the optimal TFN membrane. Compared to the pristine membrane, the water permeance is enhanced by 78 % without scarifying the salt rejection in brackish water desalination tests. Meanwhile, in high-concentrated seawater desalination tests, the newly developed TFN membranes still present a better water flux and salt rejection than the pristine membrane for 7 days. This simple and mild method promotes a new effective strategy to fabricate TFN membranes for unconventional water treatment and reuse.

Keywords: Thin-film nanocomposite (TFN), desalination, ZIF-8 nanoparticles, layer-by-layer (LBL)

Presenting Author
F.Z.YAHIAOUI

Short Biography : Student in Unité de Développement des Equipements Solaires, UDES/Centre de Développement des Energies Renouvelables,, Algeria

Title: Membrane autopsy study to characterize the type of fouling of the reverse osmosis membrane used in a seawater desalination plant in Algeria

F.Z.YAHIAOUI, Z.TIGRINE[1], C.TORKI[1]
[1]Unité de Développement des Equipements Solaires, UDES/Centre de Développement des Energies Renouvelables, CDER, Bou-Ismail, 42415, W. Tipaza, Alegria.
[1]*Email: ayadiyahiaoui.fatmazohra@yahoo.com

Abstract:
The desalination of sea water is the most recommended solution to overcome the thirst that threatens humanity due to contemporary climate change. Algeria is one of the countries most affected by drought. Faced with the shortage of drinking water, the Algerian government has launched several seawater desalination stations along the Mediterranean coast. Reverse osmosis processes are becoming the most widely used technology for seawater desalination. Although one of the major obstacles to reverse osmosis processes is the clogging of the membranes. The performance of the membranes is altered and their lifespan is considerably reduced. The project aims to identify and characterize the different agents clogging the used membrane. In the present work, we present an experimental study of spiral-wound reverse osmosis membrane fouling to determine the nature and origin of the fouling matter. The sample was collected from a large-scale reverse osmosis water desalination plant from the seawater desalination station of El-Maqutaa in the west of Oran City (West of Algeria). The clogged membrane was unwrapped and opened, and all membrane sheets of each module were visually examined. Different RO membrane specimens were cut from the membrane for autopsy. The membrane samples were characterized by an infra-rouge spectroscopy in order to identify the elements in the foulants and sealants. In addition, the crystalline deposits structure of the membrane surface was analysed by X-ray diffraction (XRD).External inspection of the membrane revealed the presence of a thick, green\brown deposit on some surfaces of the membrane sheets. One of feed spacers was removed. Integrity tests with methylene blue and rhodamine show damage to the membrane. According to the test of weight loss with heating, the rate of mineral matter is significantly high with 94%. Therefore, the type of clogging tends towards mineral clogging. The spectra drawn by Fourier Transform Infrared Spectroscopy (FTIR) confirm the results obtained by the fire weight loss test. Absorbance is minimal in the regions of double and triple bonds that characterize organic compounds. The XRD spectrum of this membrane contains only the crystalline phase of SiO_2, which means that this membrane is completely covered by clays. Microbiological analyzes of the membrane reveal the presence of the following bacteria: Staphylococcus aureus, Flavimonas oryzihabitans, Burkholderia cepacia.

Keywords: Membrane fouling, Reverse Osmosis, Seawater Desalination, RO membrane Autopsy, Fouling Characterization.

Session [7]

Environmental Science & Technology

Presenting Author
Assoc. Prof. Ramadan Abd-Alghany Ali Elkateb

Short Biography

Assoc. Prof. of physical chemistry, Basic science and Engineering Eepartment, High Institute Engineering and Technology, New Damietta.Consultant in Environmental Impact Assessment, Ministry of Environment. He published 20 papers in the field of wastewater treatment by adsorption technology.

Title: Residual Soil as Low-cost natural adsorbent for adsorption of cationic dye from aqueous solutions

R.A. Mansour
Department of Basic Science and Engineering, High Institute Engineering and Technology, New Damietta
Coresponding author:
R.A.Mansour
drramadanelkatep@yahoo.com

Abstract:

A single-stage batch adsorber was designed for adsorption of MB by andesite rocks based on optimum isotherm. Experimental work was carried out by studying contact time (5-60 min), adsorbent dosage (0.5-1.3g), temperature (25-55℃) and pH (2 – 11). The maximum adsorption capacity of MB was found to be 4.24 mg/g using the Temkin isotherm model which is the best-fitted model for the process. The values of the free energy (ΔG), enthalpy (ΔH), and entropy (ΔS) were -5.19 kJ/mol, -42.2 kJ/mol and -0.13 kJ/mol K, respectively. The kinetics of MB dye adsorption was analyzed using pseudo-first-order and pseudo-second-order models, and it was found that the pseudo-second-order model was suitable for the behavior of the MB dye at R^2 = 0.999. The changes in functional groups, surface morphology, and chemical composition of andesite before and after adsorption were identified by Fourier transform infrared spectroscopy, scanning electron microscope, energy-dispersive X-ray spectroscopy, respectively. The specific surface area of andesite was found to be 35.12 m^2/g using Brunauer– Emmett–Teller analysis

Keywords: Adsorption, Andesite, Dye removal, Kinetic, Thermodynamic.

Presenting Author
Ass. Prof. Fatma H. A. Mustafa

Short Biography

Dr. Fatma Hussein Ali Mustafa is an Assistant Professor of Marine Chemistry, Marine Environment Division, National Institute of Oceanography and Fisheries (NIOF), Suez, Egypt.
She had her Ph.D. in Organic Chemistry. Department of Chemistry, Faculty of Sciences, Suez, Egypt. Thesis title: A Study of the Effect of Marine Paints Containing Some Thiadiazole and Triazole Derivatives on Marine Fouling Organisms. She got 8 project grants (national and international) and supervised 3 PhD and 5 MSc students. Grant: ASRT-APPLE 3 No. 9528 Role: Principle Investigator. Such as “Economic prototype for aquaculture effluents utilization using novel chitosan hydrogels nanocomposite”, 2022-2023. Grant: NIOF No. NIOF (Eg)-ENV-19-22. Novel Smart Ionic Chitosan Derivatives and Their Applications as Marine Antibiofoulants. 2021-2022. Grant: STDF-DAAD GE-SEED-6879. Grant: NIOF No. NIOF (Eg)-ENV-17-22 : Assessment of biodiversity, fish stocks, and pollution levels along the coasts of the Gulf of Suez (the current situation and future requirements). 2021-2022. Grant: NIOF No. NIOF (Eg)-ENV-18-22 Role: Researcher. Title: Preparation of environmentally friendly nano-biocomposite to remove some organic pollutants. Duration: 12 months, 2021-2022.

Title: Rice Straw Extracted Cellulose Incorporated Sulfonated Polyethersulfone for Petrochemical Wastewater Treatment

Fatma H.A. Mustafa (1), Hanan A.E.-A. Attia (2)

(1) National Institute of Oceanography and Fisheries (NIOF), Cairo, Egypt
(2) Quality Control Department, Oriental Petrochemicals Company Ninth Industrial Zone Northwest Gulf of Suez Ain Sokhna, Suez, Egypt

Abstract:

cellulose (CE) and its composite with sulfonated polyethersulfone (CE-SPES) were created from their respective supplies, rice wastes, and polyethersulfone (PES). The successful creation of novel materials and the functionalization of their surfaces with OH and SO_3H groups were both validated by the characterization techniques. To optimize the parameters for the batch experiment, the effects of sorbent dose (SD), equilibrium contact time (CT), pH, temperature (T), and initial Zn^{2+} concentration were investigated. The following conditions were determined to be optimal: pH = 5; CT = 5 min for CE and 30 min for SPES, SD = 0.2 g for CE and 0.02 g for SPES, T = 25 °C for CE and 30 °C for SPES; and Zn^{2+} concentration = 2 ppm. Zn^{2+} adsorption on CE and CE-SPES followed Langmuir (R_2 = 0.956 and 0.968, respectively) with a minor contribution of the Freundlich model (R_2 = 0.809–0.859). Both biosorbents exhibited pseudo-second-order kinetics for Zn2+ adsorption (R_2 = 0.974–0.992). The negative ΔH° and ΔS° values indicated that the Zn2+ adsorption was exothermic and Zn2+ ions are more orderly spread over the adsorbent surface.

Keywords: Cellulose; Sulfonated polyethersulfone; composite; Zn^{2+} removal; Adsorption Kinetics and Thermodynamics

Presenting Author

Ass. Prof. Mohamed Elsayed Gabr

Short Biography:

Dr. Mohamed Gabr is an Associated Professor in the Civil Engineering Department, Higher Institute for Engineering and Technology, New Damietta, Ministry of Higher Education, 34517, Egypt. He was published more than 34 papers in the field of water resources management, climate changes, wastewater treatment, constructed wetlands, crop irrigation requirements, rainwater harvesting, water quality, soil salinity, groundwater quality, irrigation and drainage, and the environmental hydrology

Title: Technologies for wastewater treatment in aquaponics and their sustainability: A review

Mohamed Elsayed Gabr[1], Nawaf S. Alhajeri[2], Fahad M. Al-Fadhli[3], and Salem Al Jabri[4]

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Abstract:

The globe is dealing with a number of major issues, the most significant of which include climate change, population growth, water scarcity, soil erosion, and food security. These issues might be addressed by aquaponics, a closed-loop system that combines hydroponics with aquaculture components. The main components of aquaculture wastewater that can have an adverse effect on fish growth and the environment include dissolved and particulate organic matter, total dissolved solids, and nutrients including phosphorus and nitrogen. In this study, different wastewater treatment methods used in aquaculture are compared along with how effective they are at achieving sustainability. For small scale aquaponics commercial reverse osmosis filtration system that provides outstanding water quality control is an effective solution to eliminate dangerous chemicals from water. Constructed wetland systems have demonstrated excellent efficacy in the treatment of wastewater containing nitrogen compounds, with removal efficiencies for NH_4-N up to 98% and NO_2-N exceeding 98%. Since just 10% of the entire volume of water is replenished daily, recirculation systems are shown to be more sustainable and effective in managing the volume of effluent in aquaculture units. The use of this technology in a business setting will be especially beneficial to arid regions experiencing water stress.

Keywords: Aquaponics; Water scarcity; Recirculating aquaculture systems; Wetland treatment system; RO system

Presenting Author

Sohier Mohamed. Abobakr

Short Biography

Dr. Sohier Currently, working as a Corrosion consultant and faculty member in , New Demiatta Higher Institute of Engineering, Egypt after long experience in the Corrosion and Materials Selection consultancies in a multinational oil and gas firm in the Middle East representing the golden mortar between the oil and gas hands on experience and the fine grade academia, She has over fifteen years of experience,Dr. Sohier is considered one of the pioneers on materials selection and corrosion applications . She has a Bachelor, Master's and PhD degree in Chemical Engineering .Dr. Sohier is a professional trainer "TOT" certified, has extensive hands-on experience in oil and gas as a professional instructor. She trained more than fifty of courses in Chemical engineering, Materials selection and Corrosion Application related topics.

Title: Magnetite-Cellulose Core Shell Nano Structure in Polymer Composite Materials for Storage Energy Applications

Sohier Mohamed. Abobakr [1], A.M. Abdelghany [2.]

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Abstract:

The rise of innovation in the electronic industry is driven by the controlled design of new materials. The hybrid materials based on magnetite/cellulose nano structure are highly interesting due to their various applications in electromagnetic interference shielding, medicine, biomedical sensing, solar cell and electronics devices, etc.Magnetite-Cellulose Core Shell nanocomposites or nanoparticles embedded in polymer matrices have attracted a great deal of attention because of their multifunctional nature and ease of integration with existing manufacturing processes.

In this work, we have successfully synthesized a new kind of (polyvinyl alcohol– polyphenyle phenol) composite membranes with different concentrations of magnetite/cellulose nano structure core shell. The real part of the dielectric constant $\acute{\varepsilon}$, dielectric loss factor (ε'') and the ac conductivity σac for all the samples are measured as a function of frequenciesfrom 50 Hz -5 MHz with a 0.1-V applied voltage using HIOKI 3532-50 LCR Hi tester . The optical properties of the thin membranes were determined using UV-Visible spectrum. It was found that these composite membranes can be used in electronic devices because of their good dielectric behavior. The effect of magnetite/cellulose nano structure loading on the crystal structure of synthesized composites membranes was investigated by XRD and FTIR methods.

Keywords: Magnetite-Cellulose Core Shell, polymer composites, Electrical properties, optical properties

Presenting Author
Ahmed Abdelnaby Kabeel

Short Biography

Dr Ahmed received a BSc degree in electronics and communication engineering from higher institute of engineering and technology in 2012 and received his M.Sc. in 2015 from Mansoura university and Ph.D. in 2019 from AL Menia university, His M.Sc. dedicated to UWBA design for ground penetrating radar for environmental exploration, the Ph.D. is devoted to introduce a new spectrum sensing algorithm based on antenna array for cognitive radio application also has introduce an enhancement using beamforming algorithm, Ahmed also is IEEE Member AP-S Society

Title: Energy harvesting System based on transparent microstrip patch antenna combined with solar sill system for environmental application

Ahmed A. Kabeel
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Higher institute Of Engineering & Technology in New Damietta

Abstract:

Energy harvesting technology has gained significant attention due to the widespread use of wireless devices. It has become a highly researched topic globally, as it plays a crucial role in providing convenient and cost-free energy for inaccessible applications. Energy harvesting involves capturing energy from various sources such as solar, light, thermal, wind, and kinetic energy. This technology supports applications with specific quality-of-service requirements. This paper provides an overview of a multi-source energy system that utilizes both radio frequency and solar energy for computing purposes. The radio frequency collection technique relies on a transparent antenna that can be applied on top of solar cells, allowing light to pass through the antenna and reach the cell, this proposed energy harvesting system will provide a dependable source of renewable electrical power that can be used for various applications

Keywords: Radio frequency Energy Harvesting, Microstrip Patch antenna, solar Pannel, transparent Antenna, Nano material

Session [8]

Water Treatment Technologies

Presenting Author
Prof. Mohamed Gamal El-Din

Short Biography

Dr. Mohamed Gamal El-Din is a Professor in the Department of Civil and Environmental Engineering at the University of Alberta. His research focuses on the fundamentals of advanced and innovative treatment approaches for water and wastewater (municipal and industrial such as oil and gas). Since 2011, he holds an NSERC Senior Industrial Research Chair (IRC) in Oil Sands Tailings Water Treatment. Because of his contributions in the area of oil sands process water treatment, in 2017, Dr. Gamal El-Din received the Alberta Science and Technology Leadership (ASTech) Foundation Award for Innovation in Oil Sands Research.

Title: Effectiveness of Forward Osmosis to Treat Industrial Process Water Using On-Site Basal Depressurization Water as Draw Solution

Mohamed Gamal El-Din, Ph.D., P. Eng., FCSCE, FASCE
Department of Civil and Environmental Engineering, University of Alberta, Edmonton, Alberta, Canada, T6G 1H9

Abstract:

Because of the increasing scarcity of fresh water supplies, many industries that intensively rely on the use of water for their operations have adopted several practices for water conservation and reuse. In particular, the oil sands industry in Alberta, Canada, depends upon the reuse of oil sands process water (OSPW), water generated after the extraction process, to support other production processes. In this study, forward osmosis (FO) was used to treat OSPW, using on-site waste basal depressurization water (BDW) as draw solution. The results indicated that the rejection efficiencies of naphthenic acids, one of the important contributors of organic carbon in OSPW, were 98.3%. The experimental results also showed that the volume of OSPW was reduced for more than 40% in an experimental period of 24-h using 1 L of BDW as draw solution. The decline of the water flux due to membrane fouling was 30% without any pre-treatment. The findings of this study show that forward osmosis is an effective method to treat OSPW, has less and reversible membrane fouling, and allows the reuse of diluted BDW.

Keywords: Forward osmosis; industrial process water; basal depressurization water

Presenting Author
Dr. Ali M. Abdullah

Short Biography
Dr. Ali M Abdullah is Senior chemist/Senior QA/QC in Holding Company for water and wastewater, he is Specializing in preparing calibration and testing activities for accreditation to ISO/IEC17025, Sharing in establishing Quality management system and he published many articles in different conferences

Title : Evaluation of an Ultrafiltration Membrane for Drinking Water Production in Comparison to the Traditional Methods, Alexandria, Egypt

Ali M. Abdullah
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Abstract:
In most developing nations, it has long been difficult to meet the public's need for clean, drinkable water for a variety of reasons. Over the past 20 years, numerous developed nations have demonstrated the effectiveness of large-scale membrane water treatment systems. This opens the door for underdeveloped nations to research the viability of using membrane technology for water treatment and to adopt it. There are still many obstacles to be solved, particularly with regard to the membrane technology's significantly higher capital and operating costs as compared to the traditional water treatment method. In order to generate drinking water, waterborne bacteria, and viruses are successfully removed from surface water using ultrafiltration (UF) membranes. In this study, the effectiveness of the UF membrane for the removal of waterborne pathogens and water pollution was assessed in comparison to the conventional technology used for the manufacture of drinking water. According to the study, UF technology produces water with high water quality indices (WQI 99.8), whereas conventional techniques create water with indices that vary from 98.2 to 98.8. The study revealed numerous obstacles to using UF technology in the production of drinking water, and its operating costs are higher than those of conventional techniques.

Keywords: UF membrane, Conventional technique, drinking water treatment.

Presenting Author
Sahar Ahmed Mobarak Mousa

Short Biography

She is a graduate of the University of Aswan holding a BSc degree in physics 2007. employed as a teacher in physics at STEM high school, and she is holding a master's degree in physics from Cairo University titled "Reduction of Recombination Processes in Nano Green Synthesized Metal Oxides Photocatalyst". She is interested in nanotechnology and its applications, the Preparation of many Nano-metal oxides using different methods and green technologyy and membrane technology, and its application in water treatment especially photocatalytic membranes.

Title: Enhanced Photocatalytic TiO_2 Heterostructures Incorporated PVC Membranes for Effective Removal of Organic Compound from Wastewater under Sunlight.

Sahar. A. Mousa[1]*, Heba Abdallah[2]
[1] Physics department, faculty of science, Cairo University, Giza,12613, Egypt
[2] Chemical Engineering and Pilot Plant Department, Engineering Research Division, National Research Centre, 33 El-Bohouth St. (Former El-Tahrir St.), Dokki, Giza, PO Box 12622, Egypt

Abstract:

In this study, a highly efficient photocatalytic membranes process is demonstrated for water purification using sunlight. The process relies on the development of TiO_2 heterostructures membranes and their incorporation into an innovative water purification device that combines membrane filtration with semiconductor photocatalysis. green synthesized TiO_2, ZnO, MnO_2, nanoparticles (NPs), and GO nanosheet were fabricated to use in the composite membranes' fabrication with a Phase inversion method. and photogenerated charge separation resulting from the hetero-structure TiO_2/ZnO, TiO_2/GO, TiO_2/MnO_2, composite photocatalytic membranes. Different devices were used to examine the properties of nanocomposite membranes. The contact angle was used to examine the hydrophilicity, although the crystal structure and chemical bonding of the membrane surface were investigated using Raman, and Fourier transform infrared spectroscopy (FT-IR). The modified membrane's hydrophilicity was significantly improved. Furthermore, the integrated process showed much better efficiencies, and water flux of humic acid. This work gives insight to the effective application of solar energy for the improvement of membrane separation in water treatment.

Keywords: Photocatalytic Membrane, PVC membrane, heterostructure, TiO_2, Green synthesized, TiO_2/ZnO, TiO_2/GO, TiO_2/MnO_2, and nanocomposite.

Presenting Author
Rania Ramadan Abou El-ellaa Abou El-maati

Short Biography

She is assistant researcher (PhD student) in pilot plant and Chemical Engineering department, Institute of Engineering Research, Energy & Renewable Energy in National Research Centre. She worked in the production of chemical compounds from sea bittern and wastewater. Also she has experienced in the field of nano-materials fabrication, chemical treatment in brackish water treatment, and membrane applications, she has participated in international cooperation projects. She has 9 publication articles.

Title: Recent Advances in Iron, Manganese and Ammonia Removal from Brackish Ground Water Using Membranes

M.S. Shalaby [1], El Rafie, Sh[1]., R., Ramadan[1], Moustapha S. Mansour[2], Ibrahim Ismail Ibrahim[3]
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Abstract:

In the coming decades, there will be a significant issue with the availability of drinkable water as a result of population growth, present consumption patterns and climate change. This issue will have a similar social impact to rising energy prices. By far the most prevalent and easily accessible source of freshwater is groundwater, which is then followed by lakes, reservoirs, rivers, and wetlands. But it contains low concentrations of chemical or microbial contaminants. Simultaneously; Ferrous iron (Fe^{2+}), manganese (Mn^{2+}), and ammonia (NH^{4+}) are always present at the same time in the majority of anaerobic groundwater sources, due to natural processes and anthropogenic activities, posing a serious threat to the safety of drinking water supplies. Excessive levels of Fe^{2+} and Mn^{2+} in water supplies lead to problems, such as undesirable taste, brown colour, pipeline clogs, and a risk to the public's health owing to possible nervous system damage. Consuming high levels of NH^{4+} is also linked to major health hazards for people, including ionic balance disruption in cells that could cause convulsions. Additionally, the transformation of NH^{4+} into cancer-causing trihalomethanes and organochlorines is possible. in order to solve these issues, Various techniques have been developed to remove Fe^{2+}, Mn^{2+}, and NH^{4+} from drinking water sources. This study focuses on the use of an ultrafiltration membrane as a pretreatment for a reverse osmosis membrane to treat brackish groundwater. High colloidal and suspended particles are present in brackish water sources, which can cause fouling load of RO membranes and reduce their effectiveness.

Keywords: Brackish water; UF pretreatment; Iron-manganese removal; ammonia removal

Session [9]

Membranes and Artificial Intelligence

Presenting Author
Prof. Dr. Mohamed Hassen Elkiki

Short Biography
Prof. Dr. Mohamed Elkiki is a professor in the Civil Engineering Department, Head of the Civil Engineering Department, Higher Institute for Engineering and Technology, New Damietta, Ministry of Higher Education, 34517, Egypt. Member of the arbitrators' committees in the permanent scientific committee to examine scientific production for the positions of professors and assistant professors – the 14th session 2022-2025 (water resources). REVIEWER TO: International Journal of Plant Breeding and Crop Science, PORT SAID ENGINEERING RESEARCH JOURNAL, Egyptian International Journal of Engineering Science and Technology (EIJEST), Journal of Engineering Sciences, Faculty of Engineering, Assiut University, American Journal of Water Science and Engineering and Journal of Water Science, National Water Research Center.

Title: Predicting Seepage Losses from Cracked Lined Canals Using ANN and GEP Models

Elshaarawy, M.[1], Elkiki, M.[2,3], Selim, T.[2] and Eltarabily, M.[2]
[1]Civil Engineering Department, Faculty of Engineering, Horus University-Egypt, New Damietta 34517, Egypt.
[2] Civil Engineering Department, Faculty of Engineering, Port Said University, Port Said 42523, Egypt.
[3] Civil Engineering Department, Higher Institute for Engineering and Technology, New Damietta, Ministry of Higher Education, 34517, Egypt

Abstract:
In this study, artificial neural network (ANN) and gene expression programming (GEP) models were utilized to predict the seepage losses from lined canals in the presence of cracks. In order to develop the ANN and GEP models, sixty simulations were performed using the SEEP/W numerical model to estimate the seepage losses considering combinations of non-dimensional parameters Results showed that the ANN and GEP models had higher correlation values and lower error values in both stages. Therefore, engineers and researchers are advised to use these models as precise, reliable, and quick tools that are provided in mathematical expressions and script codes to predict seepage losses from cracked lined canals. It was found that the seepage losses were increased by increasing the crack's width and number of cracks by 230–460% and 66–88% for single and multiple cracks in the liner, respectively. Regardless of the canal berm width, the crack's location was found to have a minor effect on the seepage losses under the canal's bed, while the maximum seepage losses occurred when the crack was at the center of the canal..

Keywords: Artificial neural network; crack; lining; seepage losses; gene expression programming

Presenting Author
Rabab Reda Mohamed Ibrahim

Short Biography

Dr Rabab received a BSc degree in electrical engineering from Faculty of Engineering - Mansoura University in 2004 and received his M.Sc. in 2009 from Faculty of Engineering - Mansoura University and Ph.D. in 2019 from Faculty of Engineering - Mansoura University, His M.Sc. dedicated to Restoring the electrical system to its pre-fault condition using modern methods the Ph.D. is intelligent improvement of the electrical system using smart methods

Title: Stability, Analysis and Control of Power System Using Artificial Intelligence.

Dr. Amira. A .Elsonbaty, Dr. Rabab Reda Mohamed Ibrahim
Department of Communication and Electronics.
Higher institute Of Engineering & Technology in New Damietta

Abstract:

Increasing use of renewable energy sources, liberalized energy markets and most importantly, the integrations of various monitoring, measuring and communication infrastructures into modern power system network offer the opportunity to build a resilient and efficient grid. This review paper presents an overview of the utilization of AI in the stability, analysis, and control of power systems. AI-based methods, such as machine learning and optimization algorithms, have been employed to enhance the monitoring, prediction, and control capabilities of power systems. These techniques leverage vast amounts of data collected from various sensors, historical records, and real-time measurements to develop accurate models and intelligent decision-making systems. A brief review of reinforcement learning (RL) and deep reinforcement learning (DRL) approaches to transient stability assessment is also presented. Finally, we highlighted some challenges and directions for future studies.

Keywords: Artificial Intelligence, Power Framework Stabilizers, power system, deep reinforcement learning, reinforcement learning

Presenting Author
Salma O. Elshabrawy

Short Biography:
Salma Osama Elshabrawy, chemical engineer, graduated from Chemical Engineering Department, Alexandria University, Egypt in 2021 with overall grade excellent with honors. Worked afterwards as a teaching assistant in the Chemical Engineering Department, Alexandria University from fall 2021 till current teaching number of courses including water treatment. Won a scholarship from the center of excellence of water funded by the USAID to conduct the masters in water resources management from Alexandria University.

Title: Integrative Modeling and Optimization of Methylene Blue Dye Removal from Aqueous Solutions via Statistical Experimental Design and Artificial Intelligence

Salma O. Elshabrawy [1,2], Mohammad Mansour [3], Lobna A. Said [3], Manal G.Eloffy [4], Shaaban. Nosier [1], Mahmoud M. Taha [1,5] , Mohamed Bassyouni [5,6] , Abdelaziz H. Konsowa [1], Ahmed G.Radwan [3,7] , Irene S. Fahim [2]

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[6] Chemical Engineering Department, Port Said University, Port Said, Egypt,
[7] Engineering Mathematics and Physics Dept., Faculty of Engineering, Cairo University, Giza, 12613, Egypt

Abstract:
This study explores the efficient removal of methylene blue through adsorption by employing statistical experimental design techniques. The adsorption process parameters, including adsorbent dose, temperature, and stirring time, were systematically varied, and the response was measured. Artificial neural network (ANN) and response surface methodology (RSM) models were used to develop predictive models, capturing the complex relationships between process variables. Agricultural waste-derived carbonaceous material served as the adsorbent and was characterized using FTIR and SEM. The ANN and RSM models achieved high R^2 values of 0.963 and 0.956, respectively, indicating their effectiveness in modelling the adsorption process. Optimal conditions for maximum removal efficiency were determined as a dose of 10 g/L, temperature of 42.26 °C, and contact time of 7.92 min, confirmed by both ANN aided genetic algorithm and RSM techniques. Under these conditions, a remarkable removal efficiency of 98.29% ± 0.68% was achieved. This study highlights the potential of statistical experimental design and ANN modelling for efficient methylene blue removal through adsorption.

Keywords: Adsorption; ANN; Methylene blue; RSM

Presenting Author
Amira Reda Badr

Short Biography

Amira is a senior student in the chemical engineering department, Port Said university. She is an active young researcher that is keen on learning new skills and exploring opportunities. She has participated in different research competitions and in organizing conferences. She is currently the team leader in a competition held by the innovators support fund, the project subject is on water treatment and photodegradation.

Title: Recycling Reverse Osmosis Membranes: Addressing the Challenges of Non-Biodegradability and Waste Generation

Amira Reda, Amr Mansi [a,b], Heba Abdallah [c], Fang LiFeng [d], Chuan-Jie Fang [d], Xin-Yu Zhang [e], Yasser Elhenawy [f], Monzer Ashraf [a], Rawya Rizk [a], Mohamed Bassyouni [a,b]

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[d] Department of Polymer Science and Engineering, ERC of Membrane and Water Treatment (MOC), Key Laboratory of Macromolecular Synthesis and Functionalization (MOE), Zhejiang University, Hangzhou 310027, China
[e] School of Civil and Environmental Engineering, Shandong Jianzhu University, Jinan250101, PR China.

Abstract:

Reverse osmosis (RO) technology has emerged as a vital process for desalination. One of the major drawbacks of modern desalination plants is the massive quantities of reverse osmosis (RO) membranes solid waste. This review paper explores the problem of non-biodegradable membranes and the growing concern surrounding the massive accumulation of RO membrane waste. Furthermore, it investigates the feasibility and potential benefits of recycling and reusing RO membranes as a sustainable solution. Reverse osmosis membranes have a limited life span of between five to seven years. Tons of non-biodegradable RO membranes are disposed of annually in landfills which poses severe environmental concerns. Several challenges hinder the widespread adoption of recycling RO membranes, including the presence of irreversible fouling, the diverse composition of membranes, and the need for cost-effective and energy-efficient recycling methods. However, recent advances in membrane treatment techniques, characterization, and material science provide possibilities for overcoming these complications. By embracing recycling and reuse strategies for RO membranes, the water treatment industry can transition towards a more sustainable and environmentally responsible approach. Therefore, recycling RO membranes can offer large economic and environmental benefits.

Keywords: Membrane recycle; Desalination; Reverse osmosis; Sustainability.

Articles

Enhanced removal of micro-pollutants by hybrid processes combining flocculation or adsorption with ceramic flat sheet membrane filtration

Pascal Erdmann (1), Fin Florack (1), Martin Kaschek (1), Miriam Sartor (2)

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(2) Cologne University of Applied Science (TH Köln), Faculty of Computer Science and Engineering Science, :metabolon Institute, Gustav-Heinemann-Ufer 54, 50968 Cologne, Germany

Abstract:
Different approaches to remove micro-pollutants - especially persistent organics as well as phosphate residues - by hybrid processes consisting of ceramic flat sheet membrane filtration combined with flocculation or adsorption were investigated. The target of the studies was to improve the quality of treated sewage effluent (TSE) to protect the ecosystems from micro-pollutants and allow a reuse of water. Therefore, ceramic flat sheet membrane filtration was combined with a flocculation process (cake layer filtration) to remove dissolved and colloidal organics from treated sewage effluent and to co-precipitate phosphate. By combining ceramic flat sheet membranes with powdered activated carbon adsorption (active cake layer filtration) persistent trace organics were efficiently removed from surface water.

Keywords: ceramic membranes; hybrid processes; cake layer filtration, micropollutants

1. Introduction

Growing awareness for environmental pollution, the poor quality of water bodies and the impairment of the environment as well as contaminations caused by anthropogenic substances are becoming focus of society. This increasing awareness is also driven by the constant improvement of chemical analysis technology: stepwise it is possible to detect and measure even the smallest amounts of chemical substances quantitatively and qualitatively. Due to the continuous improvement of analytical methods, the extent of pollution is becoming drastically clear. The synthesis of various persistent substances, which are released into ecosystems, causes continuously greater problems, e.g. sterilization of fish or the accumulation of harmful substances in food. Microplastics, organic trace substances like drug residues or their metabolites as well as phosphates are proven to accumulate in rivers and deteriorate the quality of the water. To prevent chronic diseases of humans or animals and to avoid the destruction of entire ecosystems these persistent, hazardous, toxic, and often bioaccumulating pollutants need to be removed from the water. Often trace substances were emitted in the past, where they were released carelessly and partly without knowledge of their environmental hazard. The list of detected dangerous (micro-) pollutants that should not be released into nature or need to be removed thereof is growing continuously. In particular, ingredients used in pharmacy as well as microplastics and even phosphates enter ecosystems through the sewage and the treated sewage effluent as the conventional sewage treatment plants cannot retain or decompose these contaminants. Conventional wastewater treatment plants work with three purification stages:
- Mechanical treatment for the removal of coarse particles and oil,
- Biological treatment for degradation of organic carbons and nitrogen compounds,
- Chemical treatment for phosphate elimination.

The removal of many of the undesired substances from wastewater is currently not completely possible with the three mentioned conventional clarification stages 0, 0. The different kinds of micropollutant cause severe problems for ecosystem and human health: Although phosphate removal technologies were installed in sewage treatment plants decades ago, they cannot eliminate phosphate fully 0 and up to 1.0 µg/l are released into the rivers. On average in the years 2012 to 2016 about 22 kilotons of phosphorus per year were discharged into the German water bodies: The share from sewage treatment plants was around 30 % 0 and has hardly decreased in recent years. However, especially in combination with nitrogen compounds the residual phosphate promotes eutrophication in the receiving water bodies leading especially during summer time to a collapse of the entire ecosystem 0. Persistent organics like e.g. drugs and their metabolites harm the growth of duckweed, lead to sterilization of fishes or have toxic effects on aquatic organisms while other persistent organics like e.g. PFAS are suspicious to cause cancer or other diseases in human 0. More than 100 medical active substances or their metabolites were detected in German sewage treatment plants. In surface waters approx. 130 pharmaceuticals or their metabolites were found. Isolated concentrations above 1.0 µg/L were measured 0. Further, microplastics accumulate in rivers and surface waters, which can have far-reaching consequences for organisms 0. Laboratory studies have shown, for example, that exposure to microplastics reduces the fertility of copepods 0. Further studies showed that microplastics accumulate in the digestive tracts of mussels and fish and can lead to inflammation 0.

1.1 Overcoming Challenges in Water Supply by Micro-Pollutants

In order to relieve receiving water bodies from the above-mentioned substances and to avoid further pollution of drinking water sources and impairment of ecosystems, the installation of a fourth purification stage for sewage treatment plants is discussed in Germany since years 0, 0. However, the optimum treatment in terms of effectiveness and (resource) efficiency is still under investigation. Traditional activated carbon adsorption 0 including fine-powder activated carbon processes 0 or other adsorbents 0 are considered. To increase the removal efficiency of the residual organics also ultra- or nanofiltration steps 0, 0 are investigated. However, the mentioned processes are limited either due to efficiency, material costs (e.g. adsorbents, membranes) or energy consumption and there is a demand to develop treatment processes facing these objections. In the study presented different approaches to remove micro-pollutants, especially persistent organics as well as phosphate residues, were studied. The approach is the utilization of hybrid processes consisting of ceramic flat sheet membrane filtration in combination with flocculation or adsorption. The target of the investigations was to find approaches to improve the quality of treated sewage effluent to protect the ecosystems from micro-pollutants and surface water for drinking water production. This research is in line with the discussion in membrane science claiming that for breakthrough implementation of membranes especially in environmental science new processes need to be investigated rather than new materials to be developed.

1.2 Membrane Filtration and Ceramic Flat Sheet Membranes

In membrane filtration at low pressure (microfiltration and ultrafiltration) there are two options for filtration direction through the membrane 0. For inside-out-filtration the water is pressed from inside the membrane module through the membrane layer itself to the outer side, while for outside-in-filtration the water flows from the outer side of the membrane module to the inside. In general, both variants offer procedural advantages and disadvantages and their selection is a decisive step for the projection of membrane processes and system integration. As the core difference lies in the direction of the water flow through the membrane and thus the place of accumulation of the separated substances, outside-in-filtration is the relevant filtration direction for the hybrid processes. Furthermore, the driving force as pressure difference for water transport through the membrane can be realized in two ways 0. Pressure-driven membrane filtration (tubular membranes) apply a pressure on the membrane module while for systems with submerged membranes (hollow fibres, flat sheet membranes) the driving force is a suction pressure. Pressure-driven membrane filtration processes lead to the formation of a relatively dense filter cake. Thus, a high resistance for the water passage lead to an increase of the energy required to continue the filtration. To allow continuous filtration energy consuming cross-flow water stream is used to minimize the cake-layer formation. 0 The operation of membranes as a submerged system with a suction pressure allows the formation an almost non-compressed filter cake leading to a low energy consumption. For the hybrid processes ceramic flat sheet membranes in the filtration direction outside-in-filtration were selected as submerged system (Figure 1). Thus, the rejected particles in standard filtration for particle removal, flocculants or the adsorbents (active material in case of the hybrid process) form a cake layer on the surface of the membrane. Thus, the water is forced to contact first the flocculation or adsorption before passing the membrane. This specific type of membrane was first produced and patented at the beginning of the 1990s in Germany 0. Commercial applications with ceramic flat sheet membranes in wastewater treatment (membrane bioreactors, MBR) 0 and demonstrations in fresh water treatment from surface water 0 were realized around 2005. During the last decades several processes and applications for difficult-to-treat effluents were developed, e.g. 0, 0, 0. The advantages of ceramic flat sheet membranes compared to polymeric membranes are predominant especially in harsh environments like extreme pH values, aggressive chemicals or high temperature applications as well as for the filtration of abrasive particles. 0

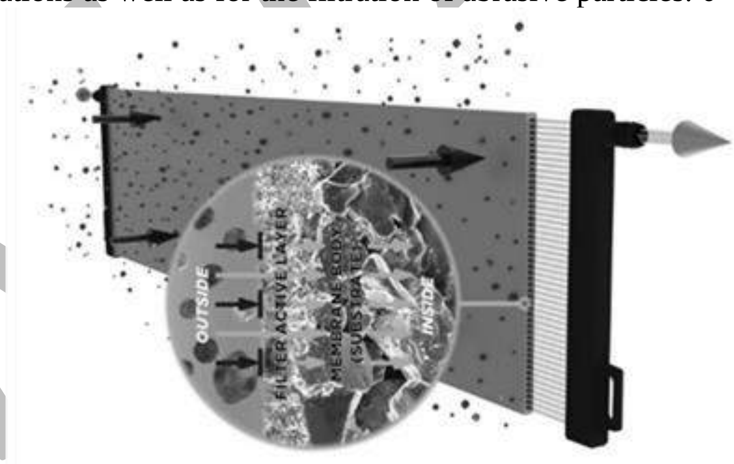

Figure 1 Schematic drawing of submerged filtration with ceramic flat sheet membranes (outside-in filtration) (Source: CERAFILTEC®)

As the technology has been significantly improved in terms of membrane production capacity, the availability of various membrane materials, module development and process stability it has very good prospects for the future 0. Especially for applications with fluxes above 400 LMH or under harsh conditions ceramic membranes - which are significantly more expensive than polymer membranes - are now competitive 0, 0. Especially for drinking water treatment from deep groundwater sources where fluxes of 700 LMH are realized ceramic flat sheet membranes seem to have advantages. Their utilization is especially interesting considering hybrid processes where the material properties of high mechanical strengths and chemical stability are relevant.

2. Hybrid Processes with Ceramic Flat Sheet Membranes

Surface water as well as treated sewage effluent contains organic particles like microorganisms but also degraded organic material as dissolved or colloidal organics or micro-pollutants which are separated insufficiently. While the particles have a density at approx. 1,000 kg/m³ which makes sedimentation uneconomically due to long residence times or size of the sedimentation basin dissolved organics as well as colloids will not settle at all.

Filtration processes in the range of sieving or microfiltration are often inefficient as these particles are very small and pass the filter. In addition, the strong surface charge of the particles also promotes their stabilization in the water. Nanofiltration allows the removal of dissolved organics but suffers from fouling, e.g. 0. Supportive technologies, especially oxidation processes like e.g. pre-ozonation which are intended to avoid fouling on the membranes 0 need further energy and increase TOC level in the treated water. Especially for the treatment of water with organic micro-pollutants ozonation can be regarded as a critical technology as ozone destroys the organic compounds and forms smaller molecules which are hard to remove from the water and have unknown toxicity.

Typically, fixed bed adsorber with granular activated carbon are applied to remove trace or persistent organic from water sources. Especially for trace substances the effort to remove those substances from water is high as the diffusion path of the molecules into the granular activated carbon grain is comparably long. Thus, the utilization of powdered activated carbon (PAC) is of high interest as the specific surface is maximized and the pathways for the adsorption are comparable short. However, as the small powdered activated carbon particles (D50 < 100 µm) are hard to reject the removal of the PAC after loading limits its effectiveness. Conventional filter materials block due to the fine particles and polymeric membranes suffer from surface impairments by abrasion.

By combining unit operations like flocculation, precipitation, adsorption or ion exchange with micro- or ultrafiltration the disadvantages of the single unit operation are solved. The new hybrid processes improve water treatment for micro-pollutant removal and reuse of treated water.

2.1 Cake Layer Filtration (CLF)

Flocculation of organic material allows the conversion of suspended and colloidal contaminants, into larger, separable particles. In combination with a filtration step with ceramic flat sheet membranes an economic approach is chosen as a formation of small flocs is acceptable to form a particle layer on the membrane's surface. Further, dissolved organics can be adsorpt in the flocs during the filtration process. This hybrid process allows the removal of the residual organic material from treated sewage effluent and is called "cake layer filtration" (CLF): The flocculation is done in a separate tank followed by the membrane filtration step (ref. Figure 2). As iron or aluminum salts are used for the flocculation step of the colloidal and dissolved organic substances a co-precipitation of phosphates is possible. Polymeric flocculants should be avoided for the treatment of the treated sewage effluent for reuse as they may increase the organic load of the water when not removed completely.

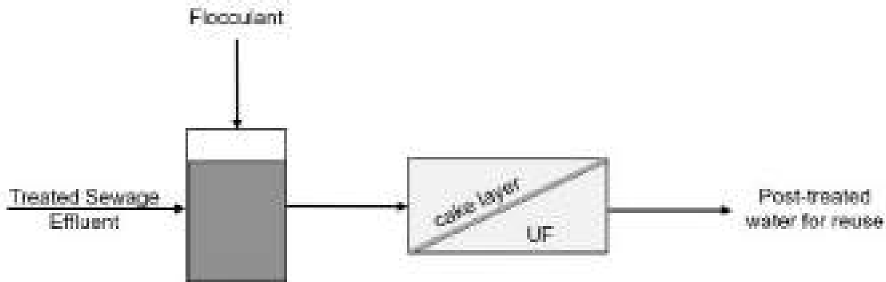

Figure 2 Block diagram of cake layer filtration for quality enhancement of treated sewage effluent

2.2 Active Cake Layer Filtration

The combination of the adsorption step with ceramic flat sheet membrane filtration into a hybrid process is called “active cake layer filtration” (ACLF): The ceramic flat sheet membrane is a carrier of a packed bed of “active” material, like e.g. a fine powdered activated carbon as adsorbent (Figure 3). The submerged out-to-in filtration allows a comparable loose powdered activated carbon bed without compression and therefore a high-flux and low-pressure membrane operation (step 1). The formed adsorbent bed layer allows a perfect contact area for adsorption or ion exchange (step 2) and a quick removal of trace pollutants from the water 0, 0.

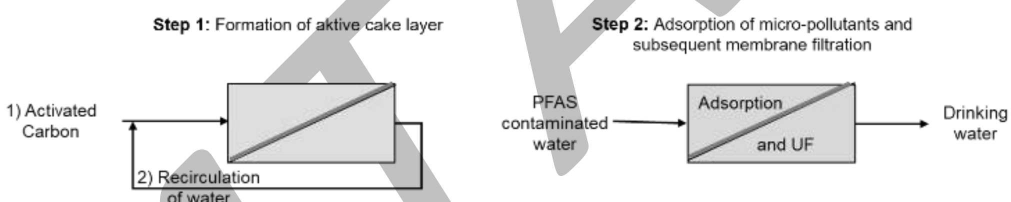

Figure 3 Block diagram of active cake layer filtration for quality enhancement of drinking water: step 1 is the formation of the active cake layer and during step 2 the PAC is rejected by UF and organic trace molecules are adsorbed

3. Experimental

The investigations for the two hybrid processes were done in lab scale and followed by technical scale investigations. Selected membranes were ceramic flat sheet membranes. The flocculant applied was ferric chloride for the lab experiments and aluminum chloride for the technical scale experiments. As adsorbate different powdered activated carbons (PAC) were used. Experiments were done in lab units as well as technical scale units which were designed and constructed by the company CERAFILTEC®.

3.1 Material and Methods

Ceramic flat sheet membranes. The membranes applied for the tests were supplied by CERAFILTEC®. The membranes were ultrafiltration membranes with a pore size of 0.1 µm made of two different materials: Silicon Carbide (SiC) and Alumina Oxide (Al2O3). The characteristics are displayed in Table 1.

Table 1 Characteristics of the applied ceramic flat sheet membranes

Type	SiC-1	Al2O3-7
Material	Silicon Carbide	Alumina Oxide
Nominal Pore Size [µm]	0.1	0.1
Porosity [%]	42	34
Clean water permeability [l/m²hbar]	7,500	1,800

Flocculants. The flocculation was realized with chlorides. During laboratory study iron chloride and for the technical scale trials aluminum chloride was used.

Powder activated carbon (PAC). Different PAC were investigated as adsorbents, Table 2.

Table 2 Characteristics of the applied powder activated carbon

Type	H1AK1 (Lab)	H2AK2 (Lab)	Cabot Darco S-51 (Technical)
D50 [µm]	20	20	30-42
Iod number [mg/g]	950	n/a	n/a
Methylenblue adsorption [g/100 g]	28	20	n/a
BET [m²/g]	1050	950	650

Analysis. The analysis of the water was done were pH, turbidity, SAK254, Orthophosphate, COD and Extinction. The analysis equipment displayed in Table 3 was used.

Table 3 Laboratory analysis methods applied

Parameter	Equipment	Comments
pH [-]	Parallel analyzer SL 1000, Hach Lange	
Turbidity [NTU]	Turbidimeter 2100 P, Hach Lange	
SAK254 [m-1]	Real UV 254, Realtech Incorporation	
COD [mg/l]	Spectrophotometer DR 2800, Hach Lange	Range for COD measurement: 0.0 – 150 mg/l as O2
PO43- [mg/l]	Parallel analyzer SL 1000, Hach Lange	Range for orthophosphates: 0.2 – 4.00 mg/l as PO43-
Fe total [mg/l]	Spectrophotometer DR 2800, Hach Lange	Range for Fe total: 0.2 – 6.0 mg/l

Fe^{2+} [mg/l]	Spectrophotometer DR 2800, Hach Lange	
Fe^{3+} [mg/l]	Spectrophotometer DR 2800, Hach Lange	
Extinction [nm]	Spectrophotometer DR 2800, Hach Lange	Maximum of adsorption for brilliant blue: 629 nm (628-630 nm, detection limit: 5 µg/l according to 0) For the calibration a concentration series was prepared.

3.2 Inlet Water for Investigations

Depending on the investigation target for the CLF filtration and the ACLF different approaches and polluted water were used.

3.2.1 Water for cake layer filtration (CLF)

For the laboratory investigations to remove organics and trace phosphates from sewage effluent, effluent from the municipal sewage treatment plant in Saarbruecken, Germany was used. This is a municipal sewage treatment plant with a daily inlet water of 60,000 m³ of wastewater from households with almost no industrial wastewater 0. The water for the laboratory investigations was taken after the settling tank prior to discharge the effluent into river Saar. The water is clear with a slightly yellowish color and contains some particles. Table 4 shows the results of the inlet water analysis for the cake layer filtration experiments.

Table 4 Average concentrations of specific water parameter of the feed for the CLF laboratory experiments

Parameter	Unit	Average value of treated sewage effluent
pH	[-]	7.14
Turbidity	[NTU]	1.56
SAK254	[m-1]	0.198
COD	[mg/l]	22.1
PO_4^{3-}	[mg/l]	1.13
Fe total	[mg/l]	0.246
Fe^{2+}	[mg/l]	0.055
Fe^{3+}	[mg/l]	1.191

The technical scale experiments were done with treated sewage effluent of an industrial sewage treatment water plant in Thailand with a COD of approx. 70 mg/l.

3.2.2 Water for active cake layer filtration (ACLF)

Laboratory investigations were done with a model organic (dye - brilliant blue FCF, E133, 0) which allows a quick characterization of the process due to short analysis times. This approach was selected as analysis of trace organic contaminants takes several days and is not allowing a quick change of process parameter during the process development. Brilliant blue was selected as it is easy to handle, not harmful and has a high solubility in water. Due to the solubility the dye is not rejected by the ultrafiltration membrane and need to be adsorbed on the activated carbon for removal from the water. Thus, it is a good model for trace, persistent organics. Experiments were done with a concentration of brilliant blue of 1 mg/l. This concentration is in the typical trace concentrations of persistent organic at contaminated sites which normally show concentrations in the same range of several µg/l. Surface water concentrations are lower and found in the range of several ng/l. However, it was expected, that these experiments will give a first indication and proof of functionality of this process.

The technical scale experiments were done with a groundwater contaminated with 1.3 ng/l PFAS as trace organic micropollutant. The water was from a drinking water plant in the City of Rome, USA.

3.3 Lab Filtration Systems

For the filtration tests a lab filtration unit was used consisting of a filtration tank, a pump for filtration and backwash, a blower and a data log unit 0. The flux is set by the pump speed and the pressure is detected by a pressure sensor (Figure 4). The filtration tank of the laboratory system is designed in correspondence to the dimensions of a ceramic flat sheet filtration module. The membrane of 0.01 m² is mounted in a membrane adapter and stands upright in the filtration tank for batch filtration tests (volume of 5 litres). The distance between the membrane and the wall corresponds to that of two mounted membranes (5 mm) in a filtration module.

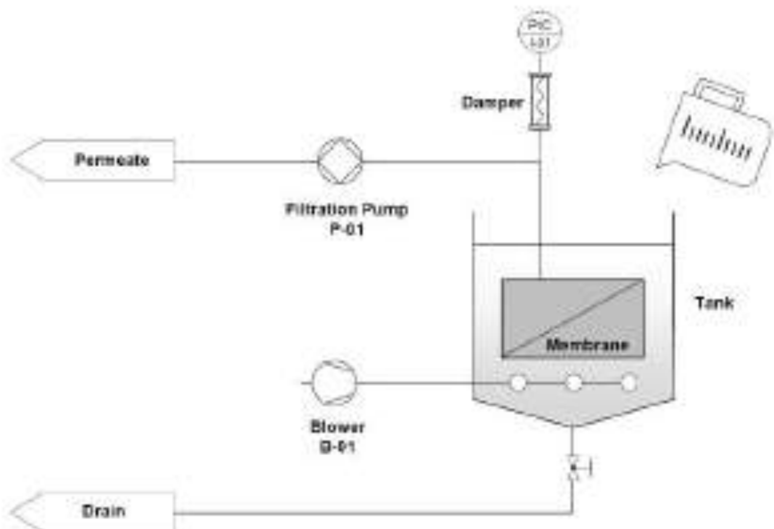

Figure 4 P&ID of the laboratory unit (Source CERAFILTEC®)

For continuous operation a pressure vessel was connected to the filtration tank as a storage tank in order to continuously convey feed water into the filtration tank. A level sensor controlled the feeding. As a result, the hydrodynamic pressure as an error variable for long-term measurements can be omitted.

3.4 Plants for Technical Scale Experiments

The technical scale experiments were done in full-scale technical units with full membrane modules. The modularized plant for the technical scale ACLF experiments was installed inside a 40-feet-sea-container (Figure 5) while the technical scale plant for CLF was fixed onsite. Both plants have a control unit for data storage (flux, pressure, pH, conductivity) including remote control 0. For the mixture of powder activated carbon into the water as well as the addition of the flocculants separate tanks were applied.

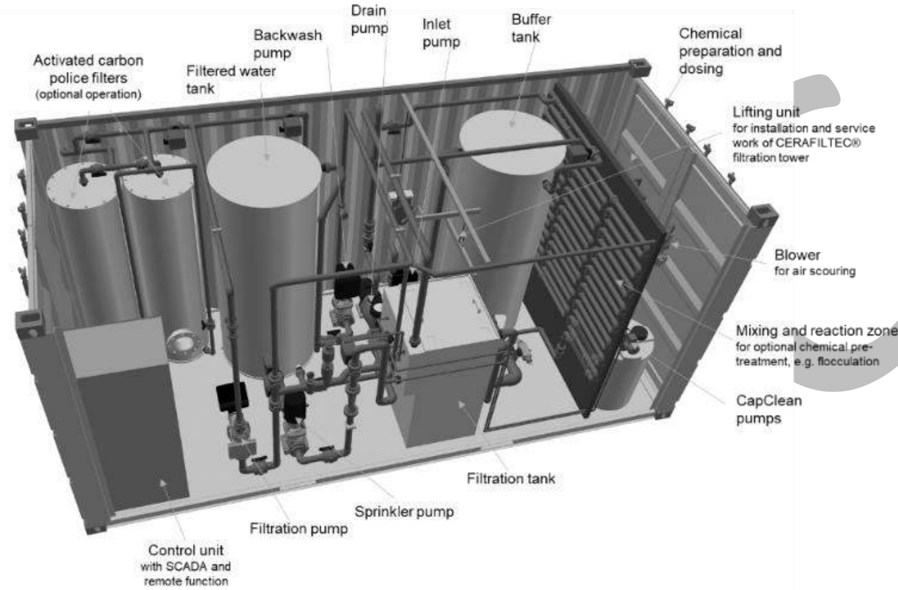

Figure 5: 3D-drawing of a mobile, containerized unit (right) (Source CERAFILTEC®)

4. Results

The results are presented separately for cake layer filtration (CLF) and active cake layer filtration (ACLF).

4.1 Cake Layer Filtration (CLF)

Targets of the cake layer filtration experiments were to improve the quality of the treated water from the sewage treatment plant in terms of removal of residual organic material by flocculation and to remove residual phosphates by co-precipitation.

As known from basic literature the application of flocculants leads to three sub-processes 0:
- First during the coagulation: the electrostatic rejection of the suspended and colloidal organic substances is overcome and agglomerates are formed.
- Second during flocculation: the flakes formed adsorb further organic material and even the removal of dissolved organic substances is possible.
- Third: ferric chloride leads to a precipitation as the ferric and the orthophosphates form sparingly soluble ferric phosphate (eq. 1).

$[PO_4]^{3-} + FeCl_3 \rightarrow FePO_4 \downarrow + 3\, Cl^-$ (eq.1)

Aluminum containing salts like used for the technical scale experiments lead to the formation of sparingly soluble aluminum phosphates (eq. 2).

$[PO_4]^{3-} + AlCl_3 \cdot 6\, H_2O \rightarrow FePO_4 \downarrow + 3\, HCl + 3\, OH^-$ (eq.2)

4.1.1 Lab results CLF

The experiments were divided in two different steps. In a first step the optimum concentration of the flocculant in terms of organic removal (measured as SAK254) and phosphate precipitation were determined. In a second step the combined process of flocculation and ultrafiltration was investigated. Figure 6 shows the results of the determination of the optimum flocculant concentration.

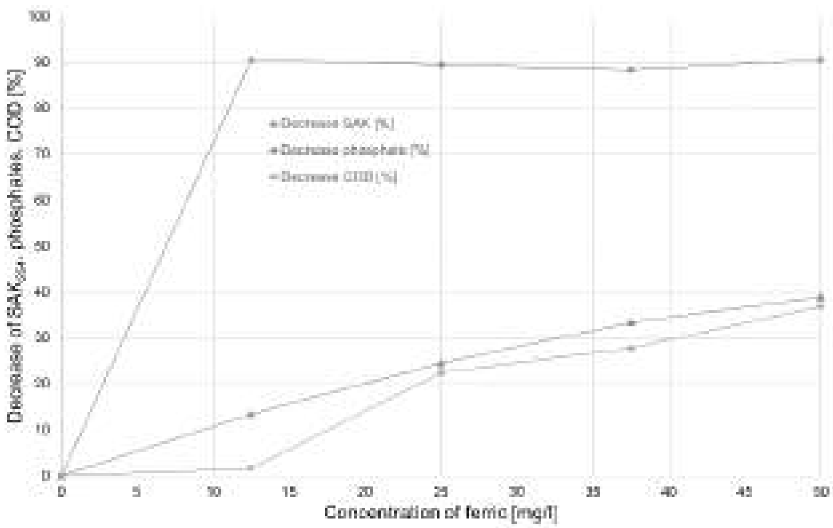

Figure 6 Decrease of organics and phosphate concentration by addition of ferric chloride depending on the concentration

The investigations showed, that the maximum phosphate concentration is already achieved with a ferric concentration of 25 % while the organic removal can be improved with rising concentrations of the flocculant.

The filtration experiments were done in order to evaluate the interrelations of the flocculant with the membrane and – which is most important – to determine the improvement of water clarification by this combined process. The flocculant is added with a concentration of 0.075 ml/l to the flocculation tank with a stirring velocity of 4.7 m/min which is applied for 30 seconds, after for 15 minutes the pre-treated water is stirred with a velocity of 0,3 m/min. The filtration flux applied was 200 LMH while the backwash flux was 700 LMH. The filtration cycle was 45 minutes followed by a 30 second backwash which was enhanced by shear forces due to aeration. Total filtration time was 1.5 h (two cycles). During filtration the tank volume was kept constant. The results of the filtration experiments in terms of permeability of both investigated membrane types is shown in Figure 7.

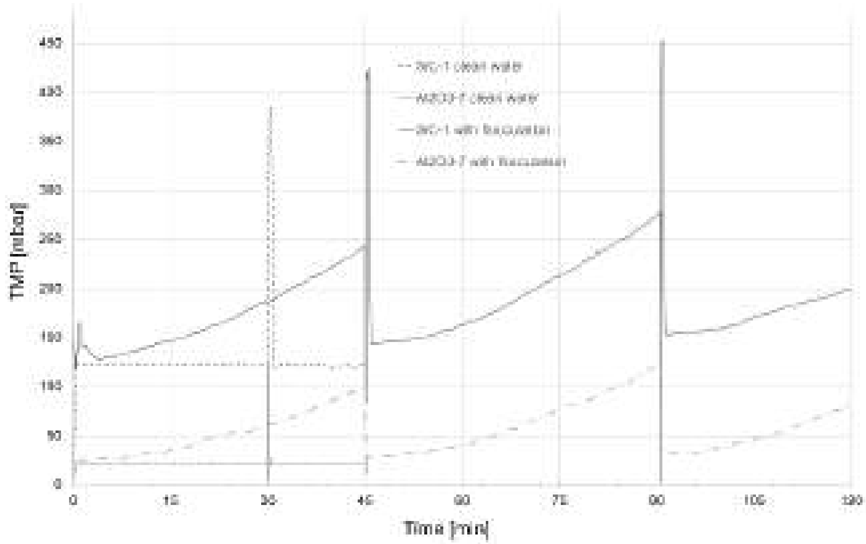

Figure 7 Permeability of the investigated membranes with flocculation (ferric chloride) in comparison with clean water flux

The investigations showed, that ferric chloride causes only a low decrease of permeability. However, the membrane is not recovering fully during backwash which indicates a slight fouling. The effect on the membranes is comparable although the permeability of the SiC-1 membrane is significantly higher than the Al2O3-7 membrane. No severe difference could be determined for the filtered water quality between the two different membrane types, Table 5. However, due to the higher permeability the efficiency of the SiC-1 membrane is significantly higher.

Table 5 Decrease of organic and phosphate concentration in treated sewage effluent

Parameter	Decrease [%]	
	SiC-1	Al2O3-7
Turbidity	88.4	86.2
SAK254	39.3	38.4
PO43-	91.1	89.6
COD	58.5	60.0

During a long-term filtration test of 24 h a volume 60 l of treated sewage effluent was post-treated. The results achieved during the 2 h filtration tests were confirmed. Phosphate concentration was reduced below 0.2 mg/l and organic concentration below 15 mg/l (as COD) or below 0.065 m-1 (as SAK254).

4.1.2 Technical scale results CLF

A technical scale plant was realized at a soy bean production plant in Prachinburi, Thailand. As state-of-the-art the water was collected in open ponds. However, the residual nitrogen and carbon concentration as well as the oily residues increases the eutrophication resulting in bloom of algae. Recovery of the water for reuse is challenging as it leads to strong membrane fouling. Cake layer filtration allowed to overcome this challenge and allows a recovery of the water.

For the flocculation and cake formation an aluminum-based flocculant is used. The filtration is operated with a flux of 215 LMH. The plant treats a water volume of 15.5 m³/h. After the filtration time of 1.93 h a backwash is done to remove the cake layer. The backwash including a short chemical cleaning takes 3 min/h. The water parameter turbidity, total suspended solids (TSS) and oil are reduced below detection limits allowing a reuse of the treated water in chillers (Table 6). The plant is constantly in operation since December 2019.

Table 6 Water quality before (feed water) and after (filtrate) treatment with CLF, data extracted from 0

Parameter	Unit	Feed water	Filtrate
Turbidity	[NTU]	11.2	< 0.5
COD	[mg/l]	68	30
TSS	[mg/l]	18	< 1 (nil)
Oil	[mg/l]	7.2	< 0.2

4.2 Results Active Cake Layer Filtration (ACLF)

Persistent organic trace material can be removed by adsorption on activated carbon 0. Especially per- and polyfluorinated alkyl substances (PFAS) have recently received increasing attention in connection with contamination of the soil and groundwater and the associated risk of contamination of drinking water. The group of PFAS are artificial, industrial chemicals that comprise about 4,700 substances. They are persistent, toxic and accumulate in the food chain. Worldwide, contaminated drinking water is one of the main sources of adverse effects on humans caused by PFAS; among other things, PFAS is suspected of being carcinogenic and toxic in reproduction. 0, 0, 0

For the lab experiments suspension with a concentration of 2.5 g/l of PAC was mixed in a beaker and the suspension was given into the lab unit. The PAC layer was formed by high filtration speed of 1,000 LMH. After the layer was formed uniformly to avoid local breakthrough, the filtration started at lower filtration flux. With the filtration flow as the driving force, the activated carbon adheres to the membrane surface. Nevertheless, approx. 15 % of PAC is lost during this process and not fixed on the membrane's surface. The thickness of the PAC layer was measured by light microscopy in a cross section of the coated membrane. The average thickness is between 178 up to 155 µm (Figure 8).

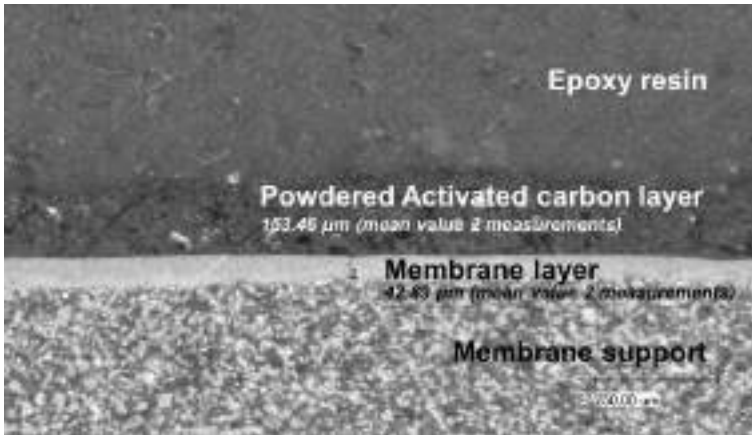

Figure 8 Cross-section of ceramic flat sheet membrane and PAC

4.2.1 Lab results ACLF

Comparable to the experiments with the flocculation first experiments were done for adsorption of the organics in stirred beakers. The residual concentration of the dye brilliant blue was measured after 24 h and 48 h. The results showed, that after 24 h 99.98 % and after 48 h 100 % of the dye was removed by both activated carbons.

The idea of active cake layer filtration is to increase the adsorption time drastically by applying a cake layer formed by PAC on the surface of the membrane. The fine particles are rejected by the membrane and the polluted water is forced to move through this thin packed bed layer. The investigated aspects were the pressure drop caused by the PAC layer on the membrane and the adsorption ability of the thin PAC layer for the trace organic.

The membrane applied was SiC1 and the PAC layer was formed from with 400 ml suspension with 2.5 mg/l PAC with a flux of 1,000 LMH. The filtration velocity (flux) was varied between 400 up to 1,000 LMH to find the optimum operation parameter. The formation time for the PAC layer (precoating time) was 2 minutes.

Regarding permeability or pressure drop respectively it was found that there is almost no influence on the membrane filtration caused by the PAC. However, for finer particle grains a slight increase of filtration pressure is found as the transport distance through the layer (tortuosity) arises. The contact time within the PAC layer was calculated by the flow through the porous bed (eq. 3). This was done

as empty tube velocity $t = \frac{h*A}{\dot{V}}$ (eq. 3)

with

t = contact time [s]

h = thickness of powdered activated carbon bed [m]

A = surface area of activated carbon bed [m²]

$\dot{V}$ = Volume flow [m³/s]

with correction factors of porosity ε [%] and tortuosity τ. Porosity was estimated based on basic literature to ε = 0.4 and for the tortuosity values of τ = 2 and τ = 4 were selected 0.

The calculation shows, that the contact time in the thin fixed bed is less than 2 seconds, Table 7.

Table 7 Calculation of contact time in the thin fixed bed at different filtration fluxes

Flux [LMH]	Average layer thickness [µm]	Contact time [s]			
		without ε and τ	with ε	with ε and τ=2	with ε and τ=4
700	193.63	0.98	0.39	0.79	1.57
800	177.77	0.79	0.32	0.63	1.26
900	147.25	0.58	0.23	0.47	0.93
1,000	239.25	0.85	0.34	0.68	1.36

Both investigated activated carbons were able to retain the dye at a concentration of 1 mg/L and a flux of 1,000 LMH completely over a period of 5 h. After 5 h, the retention decreased to 99.7% for the H1AK1 and to 99.5% for the H1AK2 (Table 8). Due to the very slow surface diffusion, the activated carbon in the precoat layers is only partially loaded. The adsorption experiments with contact times between 24 h to 48 h showed that 150 mg/l dye could be adsorbed on the PAC while only 65 g/l were adsorbed with a filtration speed of 1,000 LMH. However, the tank volume and retention time is lower and therefore the process is interesting for the treatment of high-volume water streams like e.g. removal of persistent organic from drinking water.

Table 8 Retention of brilliant blue by ACLF

Filtration time [h]	Retention [%]	
	H1AK1	H1AK2
1	100,0	100,0
2	100,0	100,0
3	100,0	100,0
4	100,0	100,0
5	100,0	100,0
5.5	99,7	99,5

4.2.2 Technical scale results ACLF

The technical scale experiments were done in a period of three months with a containerized unit in the City of Rome, Georgia, USA. The city's drinking water supply is affected by a contamination of PFAS in the range of 1.3 ng/l. The turbidity of the influent water was 0.1 to 0.3 NTU. A full-scale membrane module of CERAFILTEC® with 6 m² of membrane area was covered by a thin powdered activated carbon layer. After covering the membranes with powdered activated carbon (PAC), the filtration was operated with a flux of approx. 200 LMH. The plant treated a water volume of 1.2 m³/h. After the filtration time of 23.75 h a backwash was done to remove the loaded PAC and a new cycle started.

Four different water sources were tested during the technical scale trials. Water samples were taken and analyzed by the laboratory of the City of Rome almost every week. The results are displayed in Table 9.

Table 9 Mean values in the different months of technical scale trials, data extracted from 0

Water Source	PFAS [ng/l] before treatment	PFAS [ng/l] after treatment	Removal [%]
1	0.85	0.06	93.1
2	0.74	0.00	99.3
3	0.34	0.00	99.5
4	0.05	0.00	99.7

The results show that a removal of PFAS was achieved for three of the four sources for 99 to 100 %. The results from water source 1 were poorer as it was the first attempt for the formation of the PAC layer. After PAC layer formation was optimized, the PFAS was removed from the water to detection limit.

5. Discussion of the results

The laboratory experiments showed, that the hybrid process of flocculation with co-precipitation followed by ceramic flat sheet membrane (cake layer filtration, CLF) is suitable to remove dissolved and colloidal organics from treated sewage effluent and to reduce the phosphate concentration in this water. It should be noted that the performance of filtration varies greatly due to the type of membrane, flocculant and inlet surface water. Overdosing flocculants might lead to membrane fouling. Therefore, the interactions of flocculants with membrane surfaces need further investigation. The hybrid process with precoated powdered activated carbon on the ceramic flat sheet membrane (ACLF) for adsorption of trace organic material showed high removal efficiencies. For this process the selection of the suitable activated carbon is a crucial step for the removal of the targeted organics. Additionally, the mechanisms of the adsorption process need to be studied in detail as it cannot be explained by exiting fixed bed models.

The technical scale trials proved that the hybrid processes developed in laboratory scale improve the treatment of water with residual and trace organics:
combination of flocculation and ceramic flat sheet membrane filtration (CLF) reduces membrane fouling caused by organic residuals and allows a reuse of treated sewage effluent while reaching fluxes of 215 LMH,
combination of adsorption and membrane filtration (ACLF) allows the efficient removal of trace organic components from drinking water. The technical scale trials showed that ACLF can remove hazardous micro-pollutants like PFAS constantly > 99 % and the suitable operation flux is 200 LMH. Further experiments with the hybrid process of an active cake layer formed by PAC on the ceramic flat sheet membrane is perspective to remove trace organic components from surface water. This process is interesting as due to the high surface area of the PAC compared to granular activated carbon it is more efficient than typical fixed bed adsorber and the ultrafiltration process itself is more energy efficient than nanofiltration / reverse osmosis processes currently applied for trace organic removal. PAC layer avoids also membrane fouling.

6. Conclusions and Perspectives

Within the scope of this work, it could be shown that hybrid processes combining ceramic flat sheet membrane ultrafiltration with a flocculation or adsorption process is valuable for the treatment of surface water contaminated with micro-pollutants. The combination of activated carbon adsorption and ceramic flat membrane is suitable for removing trace organic substances from the treated effluent and by combination of ceramic flat sheet membrane with flocculation, colloidally dissolved and finest suspended organic water constituents are converted into separable flakes which allow a high-flux membrane filtration. Part of the latter process is a co-precipitation of phosphate. The combination of flocculants and ceramic flat sheet membranes contribute to a good post-treatment of treated sewage effluent by removing organics and phosphates. This will on the one hand protect the ecosystems from eutrophication and on the other hand allow a reuse of the treated sewage effluent as rinsing water, for gardening or agricultural irrigation. The hybrid process of ACLF showed a high-potential for trace organic removal from surface water. This contributes especially to the improvement of drinking water security. The biggest advantage of using the hybrid processes with ceramic flat sheet membranes is the modularity of the process. Existing sewage and drinking water treatment plants can be equipped with a very low degree of upgrade to improve water quality. This is particularly interesting when the concentration of the pollutants in the feed is subject to strong seasonal fluctuations, which means that the need for flocculation / co-precipitation or adsorption is not always present. Such fluctuations can occur in surface waters due to heavy rain or supplied meltwater and introduce significant amounts of pollutant into the water. In an application for industrial wastewater, such fluctuations are also conceivable, for example due to large time intervals between individual batches of problematic products. Existing constrains are poor knowledge on the details of the interactions of flocculants with the membranes and the adsorption mechanism during the short contact time. These aspects will be part of future research to improve the hybrid processes constantly in order to contribute to water reuse and cleaner water resources.

7. Conflicts of interest

There are no conflicts to declare.

8. Acknowledgements

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Abbreviations

ACLF	Active cake layer filtration
A	Surface area of PAC layer [m²]
BET	Surface area (Brunauer, Emmet, Teller)
CLF	Cake layer filtration
COD	Chemical oxygen demand
D50	Average particle size (50 %)
E	Porosity [%]
Fe	Iron
Fe2+	Iron (II)
Fe3+	Iron (III), Ferric
Fe3PO4	Ferric phosphate

$FeCl_3$	Ferric chloride
H	Thickness of PAC layer [m]
l/m²hbar	Permeability – liters per square meter of membrane area, hour and pressure
LMH	Flux – liters per square meter of membrane area and hour
MBR	Membrane bioreactor
NTU	Nephelometric turbidity units
PAC	Powdered activated carbon
PFAS	per- and polyfluorinated alkyl substances
PO_4^{3-}	Orthophosphate
SAK254	Specific adsorption coefficient at 254 nm
TSE	Treated sewage effluent
TSS	Total suspended solids
T	Contact time [s]
T	Tortuosity
$\dot{V}$	Volume flow [m³/s]

References

[1] German Federal Ministry of the Environment: Umweltbewusstsein in Deutschland (Report on Environmental Awareness in Germany), https://www.bmuv.de/fileadmin/Daten_BMU/Pools/Broschueren/umweltbewusstsein_2020_bf.pdf , (accessed 28 March 2022)
[2] J. G. Gesamp, Sources, fate and effects of microplastics in the marine environment: Part two of a global Assessment, London, 2016
[3] P. E. Stackelberg, E. T. Furlong, M. T. Meyer, S. D. Zaugg, A. K. Henderson, D. B. Reissman, Persistence of pharmaceutical compounds and other organic wastewater contaminants in a conventional drinking-water-treatment plant, Sci. Total Environ, 2004, 329 (1–3), 99-113. https://doi.org/10.1016/j.scitotenv.2004.03.015
[4] B. Klauer, Pharmaceutical residues in drinking water and water bodies, TAB-Fokus, 2019, 22, 183, ISSN: 2364-2645
[5] J. C. Crittenden, J. R. Trussel, D. W. Hand, et.al., MHW's Water Treatment, New Jersey, 2012
[6] D. L. Correll, The Role of Phosphorous in the Eutrophication of Receiving Waters: A Review, J. Environ. Qual., 1998, 27, 261-266, https://doi.org/10.2134/jeq1998.00472425002700020004x
[7] German Federal Ministry of the Environment: Einträge von Nähr- und Schadstoffen in die Oberflächengewässer (Nutrients in surface water) https://www.umweltbundesamt.de/daten/wasser/fliessgewaesser/eintraege-von-naehr-schadstoffen-in-die#nahrstoffeintrage-sinken-wieder-langsam (accessed 17 November 2021)
[8] A. J. P. Smolders, E.C.H.E.T. Lucassen, R. Bobbink, How nitrate leaching from agricultural lands provokes phosphate eutrophication in groundwater fed wetlands: the sulphur bridge, Biogeochemistry, 2010, 98, 1-7, DOI 10.1007/s10533-009-9387-8
[9] A. Chohan, H. Petaway, V. Rivera-Diaz, A. l. Day, O. Colaianni , M. Keramati, Per and polyfluoroalkyl substances scientific literature review: water exposure, impact on human health,

and implications for regulatory reform, Rev. Environ. Health, 2021, 36 (2), pp. 235-259, https://doi.org/10.1515/reveh-2020-0049

[10] T. aus der Beek, F.-A. Weber, A. Bergmann, S. Hickmann, I. Ebert, A. Hein, A. Küster, Pharmaceuticals in the environment—Global occurrences and perspectives, Environ. Toxicol. Chem., 2016, 35 (4), 823–835. https://doi.org/10.1002/etc.3339

[11] M. Wagner, S. Lambert, (ed.), Freshwater Microplastics – Emerging Environmental Contaminants?, Cham, 2018, DOI 10.1007/978-3-319-61615-5

[12] E. Worch, E., Adsorption technology in water treatment – Fundamentals, Processes, and Modelling, Berlin, Boston, 2012 https://doi.org/10.1515/9783110240238

[13] Y. Matsui, H. Hasegawa, K. Ohno, T. Matsushita, S. Mima, Y. Kawase, T. Aizawa, Effects of super-powdered activated carbon pretreatment on coagulation and trans-membrane pressure buildup during microfiltration, Wat. Res., 2009, 43 (20), 5160 – 5170. DOI: 10.1016/j.watres.2009.08.021

[14] R. Awual, Efficient phosphate removal from water for controlling eutrophication using novel composite adsorbent, J. Cleaner Prod., 2019, 228, 1311-1319. https://doi.org/10.1016/j.jclepro.2019.04.325

[15] J. Radjenović, M. Petrović, F. Ventura, D. Barceló, Rejection of pharmaceuticals in nanofiltration and reverse osmosis membrane drinking water treatment, Wat. Res., 2008, 42 (14), 3601-3610. https://doi.org/10.1016/j.watres.2008.05.020

[16] B. van der Bruggen, C. Vandecasteele, Removal of pollutants from surface water and groundwater by nanofiltration: overview of possible applications in the drinking water industry, Environ. Poll., 2003, 122 (3), 435-445, https://doi.org/10.1016/S0269-7491(02)00308-1

[17] U. Beucher, E. J. Kappert, J. G. Wijmans, Membrane research beyond material science, J. Mem. Sci., 2022, 643, (1-5). https://doi.org/10.1016/j.memsci.2021.119902

[18] K. W. Böddeker, Liquid Separations with Membranes – An Introduction to Barrier Interference, Berlin, 2008

[19] H. Chmiel, Druckstabile anorganische Membranen (pressure resistent inorganic membranes), DE 4329473 C1, 1993 – expired

[20] C. Blöcher, Einsatz getauchter keramischer Mehrkanal-Flachmembranen in Bioreaktoren (utilization of submerged ceramic flat sheet membranes in bioreactors), upt-Schriftenreihe, volume 1, Saarbruecken, 2004

[21] M. Sartor, B. Schlichter, H. Gatjal, V. Mavrov, Demonstration of a new hybrid process for the decentralised drinking and service water production from surface water in Thailand, Des., 2008, 222, 539-551

[22] C. Gränitz, M. Kaschek, O. Binkle, Process for the separation of radioactive nuclides by ceramic filtermembranes, EP 2 754 158 B1

[23] C. Gränitz, K. G. Gabriel, Filter unit for treating water and other liquid media and process for producing the same, EP 2 310 115 B1

[24] M. W. Hakami, A. Alkhudhiri, S. Al-Batty, S., M.-P- Zacharof, J. Maddy, N. Hilal, Ceramic Microfiltration Membranes in Wastewater Treatment: Filtration behaviour, Fouling and prevention, Mem. 2020, 248 (10), 1-34. doi:10.3390/membranes10090248

[25] M. B. Asif, Z. Zhang, Ceramic membrane technology for water and wastewater treatment: A critical review of performance, full-scale applications, membrane fouling and prospects, Chem. Eng. J., 2021,, 418, 1-18. doi.org/10.1016/j.cej.2021.129481

[26] GWI -Global water Intelligence: Market Map – Ceramic membranes: high expectations for cracking the market, GWI, 2017, 6, 43-49

[27] Interview Keil, R.R., Hi-tech solutions are 'need of the hour', Gulf construction, 2018, 10, 87-89
[28] D. Liu, J. Cabrera, L. Zhong, W. Wang, D. Duan, X. Wang, S. Liu, Y. F. Xie, Using loose nanofiltration membrane for lake water treatment: A pilot study, Front. Environ. Sci. Eng. 2021, 15 (4):69, 1-11. DOI:10.1007/s11783-020-1362-6
[29] W. Yu, T. Liu, J. Crawshaw, T. Liu, N. Graham, Ultrafiltration and nanofiltration membrane fouling by natural organic matter: Mechanisms and mitigation by pre-ozonation and pH, Wat. Res., 2018, 139, 353-362. doi: 10.1016/j.watres.2018.04.025.
[30] M. Sartor, M. Kaschek, Membrane Filtration and Flat Sheet Membrane Technology, MTAIC, Cairo, Egypt, 15.-17.08.2021, Keynote Lecture on invitation of National Research Center, NRC Cairo, 2021
[31] M. Kaschek, M. Sartor, K. G. Gabriel, High Flux Operation of Ceramic Membrane System in Drinking Water Application, Industrial Water 2018, Frankfurt am Main, (2018)
[32] National Library of Medicine, Information on brilliant blue, https://pubchem.ncbi.nlm.nih.gov/compound/Brilliant-Blue-FCF, (accessed 23 May 2022)
[33] Entsorgungsverband Saar, Information on sewage treatment plants in Saarland, Germany, https://www.evs.de/evs/oeffentlichkeitsarbeit/infomaterial/abwasser , (accessed 23 May 2022)
[34] CERAFILTEC, Lab test units, https://www.cerafiltec.com/lab-test-units/ (accessed 23 May 2022)
[35] CERAFILTEC, Container pilot units, https://www.cerafiltec.com/container-pilot-unit/ (accessed 23 May 2022)
[36] C. E. Mortimer, U. Müller, Basiswissen Chemie (Chemistry - The basic knowledge of chemistry), Stuttgart 2001
[37] CERAFILTEC, Case Studies, https://www.cerafiltec.com/case-industrial-tse/ , (accessed 23 May 2022)
[38] S. Metzger, Einsatz von Pulveraktivkohle zur weitergehenden Reinigung von kommunalem Abwasser, Use of powdered activated carbon for advanced treatment of municipal wastewater, München, 2010
[39] OECD, Portal on Per and Poly Fluoinated Chemicals, http://www.oecd.org/chemicalsafety/portal-perfluorinated-chemicals/, (accessed 26 March 2021)
[40] US:AWWA Briefing on PFAS, Denver, Washington, 2019
[41] UBA: PFAS – gekommen um zu bleiben (PFAS – came to stay), Studies on PFAS in Germany, https://www.umweltbundesamt.de/sites/default/files/medien/2546/publikationen/uba_sp_pfas_web_0.pdf , (accessed 26 March 2021)
[42] M. Stieß, Mechanische Verfahrenstechnik - Partikeltechnologie 1 (mechanical process engineering, particle technology), 3rd ed., Berlin, 2009
[43] N.N. ravenvolt: Pilot Test Summary Report, City of Rome, Georgia, PFAS Mitigation Technologies, 2021, https://www.cerafiltec.com/pfas-report-2021/ (accessed 9 April 2022)
[44] N.N., PFAS treatment market concentrates on waste reduction and total destruction

Management and treatment of brine solutions: A review

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Abstract:
Utilization of unconventional resources is being encouraged by the growing scarcity of water for agricultural irrigation in arid and semiarid countries. In spite of the supply price being significantly higher than that of other conventional water sources, seawater desalination has steadily gained farmers acceptance. Extremely concentrated saline water used for desalination, brine contains a variety of salts, minerals, heavy metals, organic pollutants, and microbiological contaminants. Desalination brine's toxic and salinity levels are raised by conventional disposal, which has detrimental effects on natural and marine ecosystems. The creation of brine management technology that can result in zero liquid discharge is necessary to address these problems. By implementing financially viable approaches, brine management can be productive and allow for the recovery of priceless resources including freshwater, minerals, and energy. This review focuses on (i) the most recent improvements in brine management employing various membrane/thermal-based technologies and their application in recovering energy, minerals, and water while weighing the benefits and downsides of each, (ii) possibility of desalinating water for agriculture in the Arab World. The information analyzed may surely help in the development of future, economically viable desalination water for agriculture in the Arab World and brine management plans.
Keywords: Brine solution; Brine treatment; Management; Sustainability

1. Introduction

The most fundamental human need for health and well-being is access to clean water, proper sanitation, and hygiene. If development doesn't triple, billions of people will lack access to these essential services by 2030. Rapid population expansion, urbanization, and increased water requirements from the agricultural, industrial, and energy sectors are all contributing to an increase in demand for water (SDGs 2014). A clean drinking water service was available to 74% of the world's population in 2020, up from 70% in 2015. Even in 2020, two billion people will lack access to properly managed drinking water systems, including 1.2 billion who will not even have the most basic level of service. 1.6 billion people won't have access to properly managed drinking water, 2.8 billion won't have access to properly managed sanitation, and 1.9 billion won't have access to even the most basic hand hygiene facilities by 2030 if current rates of development continue (SDGs 2022).

Therefore, the utilization of unconventional resources is being encouraged by the growing scarcity of water for agricultural irrigation in arid and semiarid countries. In spite of the supply price being significantly higher than that of other conventional water sources, seawater desalination has steadily gained farmers' acceptance in Spain over the past ten years, solidifying its position as a source alternative to increase the supply for agricultural irrigation. Additionally acknowledged as a practical technological option to increase the water supply for irrigated agriculture in coastal areas is seawater desalination.

Desalinated seawater (DSW) primary advantages for agriculture irrigation have been underlined by early experiences (Aznar et al. 2017; Gao et al. 2017; Martínez-Alvarez et al. 2017; El-Rawy et al. 2023): (i) It is an endless source of agricultural water that also reduces the risk of drought; (ii) When used to replace low-quality water sources in areas with a lack of water, its low salinity can significantly boost crop yields in terms of quality and quantity; and (iii) The use of DSW in place of conventional water sources opens up new possibilities for water management and water regulations. The main issues are (i) the high energy consumption, which results in costs that are significantly higher than for other water supply options (Aznar et al. 2017); (ii) the boron concentration, which is above the threshold for sensitive crops, implying toxicity risks (Martínez-Alvarez et al. 2019); and (iii) the aggravation of the water-energy nexus in DSW production, i.e., high greenhouse gas emissions that fuel the processes of climate change (Gao et al. 2017).

Desalination of seawater and brackish water utilizing high-pressure membranes, such as reverse osmosis (RO) and nanofiltration (NF) technology, has recently emerged as an excellent solution to this problem because it results in water of exceptional quality (Korngold et al. 2009; Jiang et al. 2014; Suwaileh et al. 2020; Buzaina et al. 2022). It has been shown that these membranes are very efficient at filtering out a wide variety of organics from feed water, including micropollutants, hormones (Bello et al. 2021) different inorganic chemicals (and biological materials (viruses, bacteria, cell components) (Backer et al. 2022). Additionally, this has the benefits of a small footprint, simple maintenance, and expansion potential. Desalination converts separate feedwater into clean water and brine streams, which are concentrated streams. In seawater RO systems, the usual water recovery ranges from 40% to 50%. Plants for RO desalination of (Lee et al. 2016) and brackish water typically run at recoveries of 75% to 85% (Sethi et al. 2009). The varying sample parameters, trans-membrane pressure, and membrane type employed for the treatment all affect the amount of water recovered (Lu and Wang 2020). The majority of desalination facilities, however, have a severe environmental problem in properly managing and disposing of the brine because it contains extremely concentrated salts, organics, and other contaminants.

Surface water discharge, deep well injection, evaporation ponds, and land application are common methods of disposing of concentrate (Kim et al. 2017, Abdul Wahid et al. 2017). Membrane-based technologies are appropriate in this situation because they can extract these minerals from complicated solutions while also purifying the water. Kuwait has a very dry climate (Mohamed et al. 2007), little yearly precipitation, and a very small supply of freshwater. Since the 1950s, Kuwait has relied heavily on the pricey MSF process to transform seawater into freshwater (Hisham et al. 1998). Along the Gulf Coast, Kuwait has nine desalination facilities, seven of which use multistage flashing technology and the other four RO technology (Adel 1983). 3.7% of the desalination capacity in the Middle East and North Africa region is accounted for by Kuwait (Hanan et al. 2015). The experience recounted suggests that DSW might be an efficient way to alleviate water restrictions for irrigated agriculture in coastal locations that are experiencing ongoing water scarcity. Although its broad use is currently constrained by the high energy requirements and accompanying costs compared to other water sources, the complementing function of DSW supply for crop irrigation is helping to preserve food production in many irrigation regions in South East Spain (SE Spain). In fact, it is permitting the cultivation of high-yield crops for which highly efficient water use and farming methods have already been adopted, ensuring the socioeconomic prosperity of the surrounding area. This review's goals are to go over DSW in agriculture and the brine solution characteristics and give a quick rundown of available brine disposal methods. The standard technologies intended to lessen the environmental impact of the disposal of RO concentrates are also critically examined in this essay. In addition, the methods for brine treatment and disposal evaluation are discussed.

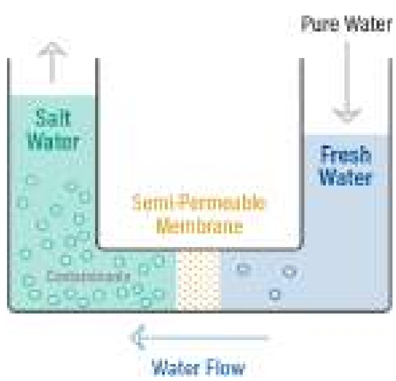
2. Reverse Osmosis membrane system for irrigation uses

The majority of our water resources are still used for agriculture, and the world continues to disregard the fact that water sources are running out. As a result, we have made tremendous progress in reducing the load on various industries, most notably agriculture, by building high-quality water treatment systems that can generate enormous amounts of freshwater from inappropriate sources such as rivers, lakes, wells, and so on (Jongmin et al. 2023). In arid regions, irrigation is the most typical usage of freshwater. The vast majority of this water is derived from scarce groundwater. Each year, aquifers are poisoned or depleted, making it harder to find enough fresh water for crops. Alternative methods are now being used by farms all over the world to conserve water and sustain this precious natural resource.

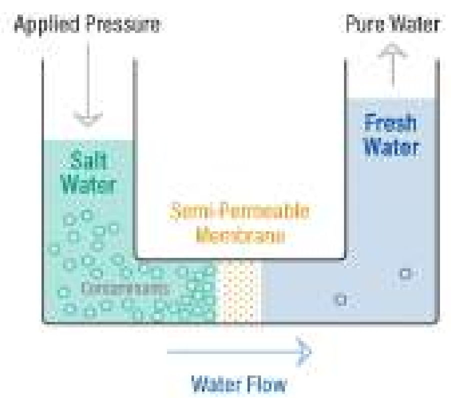
It is well knowledge that reverse osmosis water treatment systems are used in greenhouses and aquaculture facilities to cultivate the newest plants. These commercial agricultural water filters have been a mainstay of professional growers for many years. Reverse osmosis systems might be a wise investment for farms. Reverse osmosis (RO) filters, which are similar to carbonate filters, separate water molecules from other dissolved particles in the water. Carbonates, which serve as a buffer, can make maintaining pH more difficult. It is impossible to exaggerate the importance of water for agriculture because it is this resource that propels the growth of food (Nirenkumar et al. 2023; Shaheen et al. 2019).

Water is necessary for the growth of crops as well as the raising of livestock for meat production. The quantity of crops produced in the agricultural industry is directly correlated with the amount of water used (Samuel et al. 2015). Due to extensive subsidies in the agricultural industry and problems with efficiency, it is now more challenging to increase output while reducing water use. Some atoms or molecules can pass through a semi-permeable membrane, but not others. A screen door is an easy illustration. Pests and anything bigger than the screen door's perforations cannot travel through it; only air molecules can (Shanxue et al. 2017). Another illustration is the Gore-tex fabric used for clothing, which has a very thin plastic layer with countless tiny pores cut into it. The pores are both large enough to allow water vapor through and tiny enough to block the passage of liquid water (Figure 1 A). The reverse process of osmosis is known as reverse osmosis. Osmosis occurs naturally without the need for energy, but in order to reverse the process, energy must be added to the more saline solution. Reverse osmosis membranes are semi-permeable membranes that mostly block the passage of dissolved salts, organics, bacteria, and pyrogens. They enable the passage of water molecules.

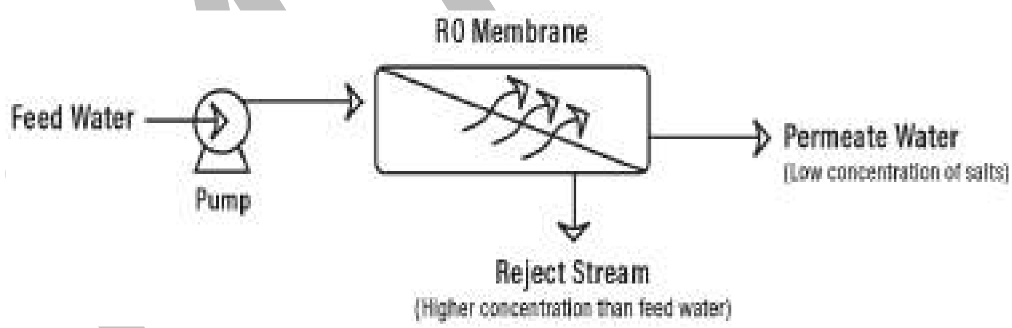
To desalinate (demineralize or deionize) water, you must, however, apply pressure that is greater than the naturally occurring osmotic pressure, which will 'push' the water through the reverse osmosis membrane while keeping most contaminants out (Figure 1B). Reverse osmosis works by employing a high-pressure pump to increase pressure on the salt side of the RO and drive the water past the semi-permeable RO membrane, leaving nearly all (about 95% to 99%) of the dissolved salts behind in the reject stream (Bijan et al. 2021). Depending on how much salt is in the supply water, different pressure levels are needed. Pressure is needed to overcome the osmotic pressure to a greater extent the more concentrated the feed water is (Figure 1C).



Osmosis



B. Reverse Osmosis (RO)



C. Reverse Osmosis (RO) unit

Figure 1. Membrane desalination A: Osmosis, B: Reverse Osmosis (RO), C. Reverse Osmosis (RO) unit

In recent years, a number of studies on agricultural desalination facilities have been carried out. In Australia, the Sundrop Greenhouse (Figure 2) is a well-known undertaking (Olga et al. 2015). They generate heat and electricity for their greenhouse using a concentrated solar power (CSP) system. In order to conduct a Multi-Effect

Distillation (MED) process for seawater desalination and agricultural irrigation, they additionally use heat from their CSP system. Desalination applications in agriculture have also been evaluated for viability in some published studies across the nation (Quist-Jensen et al. 2015; Samuel et al. 2015). In addition, in Spain, due to the fact that south east Spain's existing agricultural desalinated seawater (DSW) consumption is concentrated in coastal regions and the areas immediately surrounding them, any inland allocation of DSW must take the price of new water distribution systems into consideration. Due to its greater total cost in comparison to other conventional water sources, DSW is one of the key obstacles preventing it from being widely used for irrigation (Martínez-Alvarez et al. 2019).

Due to the enormous amounts of energy needed for manufacturing and distribution, DSW is expensive (ranging from 0.53 to 0.72 $/m^3$). About 70% of the total Specific energy consumption (SEC, kW/m^3), which ranges from 3.49 to 4.84 kWh/m^3, is used in the desalination processes, while the remaining 30% is primarily used for DSW allocation and distribution. Figure 2 illustrates the five stages of a typical DSW production and supply chain for agriculture in SE Spain, each with distinct SEC requirements: Pumping for the following processes: (1) seawater intake; (2) desalination; (3) pumping to an elevated reservoir for regulation; (4) gravity-driven conveyance to irrigation districts; and (5) pumping for water distribution within irrigation districts. Seven SWDPs in SE Spain have these stages (ACUAMED 2016, 2017). Figure 3 illustrates the variance range for each stage.

Figure 2. Sundrop Farms' greenhouse just outside of Port Augusta in South Australia, relies on sunlight and seawater to grow tomatoes. (Supplied: Sundrop Farms)

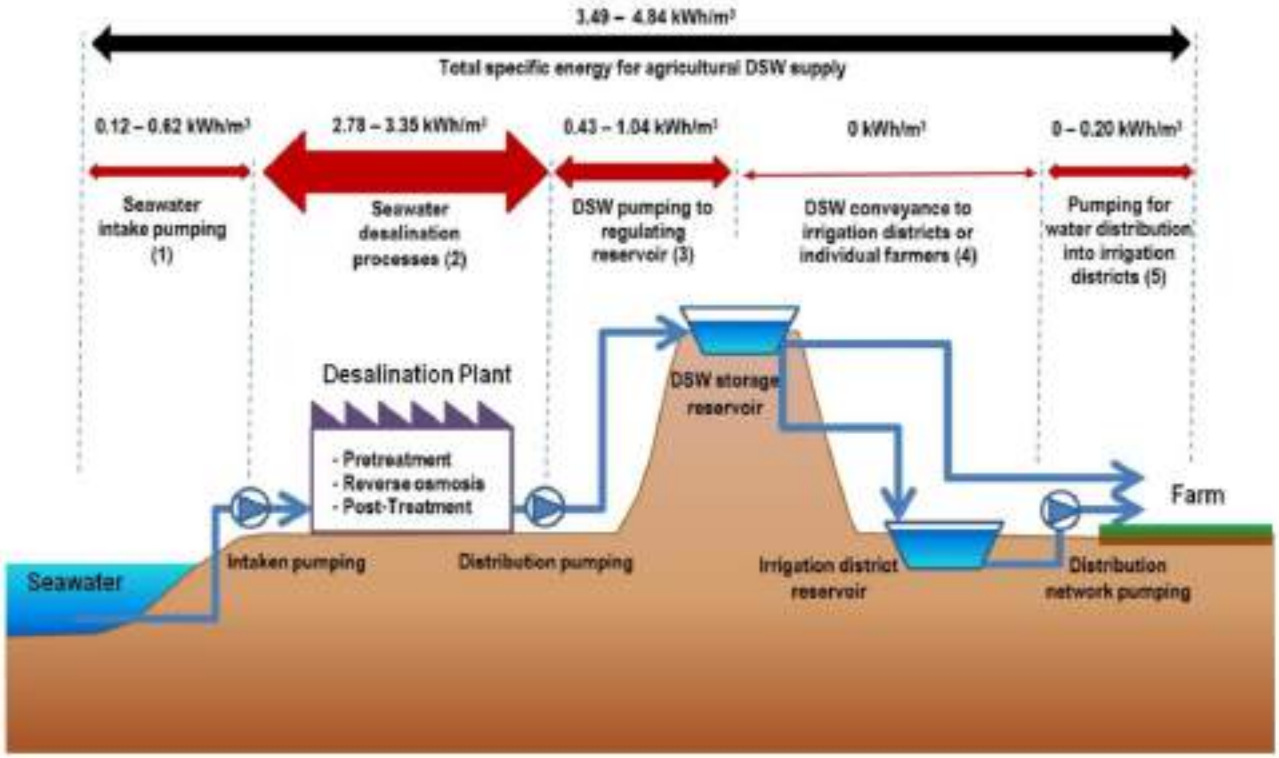


Figure 3. Specific energy consumption characteristics (kW/m3) for the various stages of DSW production and delivery for irrigation in SE Spain in 2017 (Martínez-Alvarez et al. 2019)

Desalination of agricultural drainage water with medium salinity and moderate pollution with organic and inorganic chemical pollutants was suggested by El Sayed et al. in 2022 as a possible solution to the problem of water scarcity in desert regions. The current work offers a potential ADW desalination system with zero liquid discharge that is suggested to treat 300,000 m^3/d. The method relies on staged reverse osmosis (RO) membrane pretreatment to eliminate contaminants that are hazardous to desalination. To recover more fresh water and salts with monetary value, the brine from the final RO stage is processed using thermal vapor compression and solar pond evaporation. They used software for water pretreatment, RO membrane, desalination, thermal desalination, and solar evaporation ponds (Figure 4) to estimate the technical and financial indicators of the proposed system's components. The system has a total recovery rate of about 98% with 294,000 m^3/d of total distilled water recovery and 245,000 t/y of recovered salts. The net cost of producing water is USD 0.46/m^3.

The main variables influencing the use of desalinated water for agriculture are the type of crop, the cultivation and irrigation techniques used, the salinity of the soil and water, the seasonal weather patterns, the environmental effects of the desalination processes, the accessibility of conventional water sources, and finally the cost of the water. High-value crops like pistachio are the only ones that can use desalinated water for agricultural reasons because it is more expensive than traditional freshwater resources. Due to the high cost of desalinated water, however, factors like effective irrigation techniques, soil salinity control measures, leaching needs, and the choice of suitable salt-tolerant crops should be taken into account as part of an integrated program (Welle et al. 2017; El Kharraz et al. 2023).

The use of desalination techniques for agricultural purposes differs from desalination for potable reasons in both technical and economic aspects. These desalination systems are substantially less expensive than those for drinking water since agricultural uses require lower water quality, which also results in lower energy consumption and running costs (Welle et al. 2017; El Kharraz et al. 2023). Additionally, because the permeate flow contains less calcium and magnesium than normal, it must be remineralizer by blending it with surface or groundwater resources, which can further lower overall expenses, especially when it is utilized for salt-tolerant crops like cotton and pistachio.

Desalinated water offers advantages and disadvantages when used for irrigation. The following are the primary benefits of inland brackish water desalination techniques for agriculture: (El Kharraz et al. 2023).

- Less water use because farmers adopt effective irrigation techniques due to the high cost of water;
- Less detrimental effects on soil, which, thanks to its high-water quality, can aid in the recovery of saline soils;
- Using high-quality, demineralized irrigation water to increase agricultural output and quality while reducing crop toxicity issues,
- Providing water that is reusable.
- Water is more expensive than traditional water sources.
- The potential for groundwater resources to evaporate quickly,
- The issue with brine discharge and the requirement for brine management,
- Ionically balanced is required everywhere,
- The desalination units consume a lot of electricity.

3. Brine Disposal in Inland Locations

Brine disposal is very important from an environmental and economic perspective, especially for inland communities. For instance, in Canberra, Australia, sustainable brine management continues to be a major economic and environmental hurdle for the RO-based advanced reclamation facility (Azerrad et al. 2019). Brine concentrate has been used more frequently lately as a source of water for irrigation and industry. According to studies, these waste streams contain a variety of rare and valuable metals and metalloids, including alkaline metals like lithium (Li), magnesium (Mg), and potassium (K), rare earth metals like cerium and scandium, precious metals like palladium, platinum, and rhodium, radioactive metals like radium, and precious metals like palladium, platinum, and rhodium (Pramanik et al. 2016; Quist-Jensen et al. 2016). Table 1 summarizes the typical properties of brine produced by seawater desalination plants.

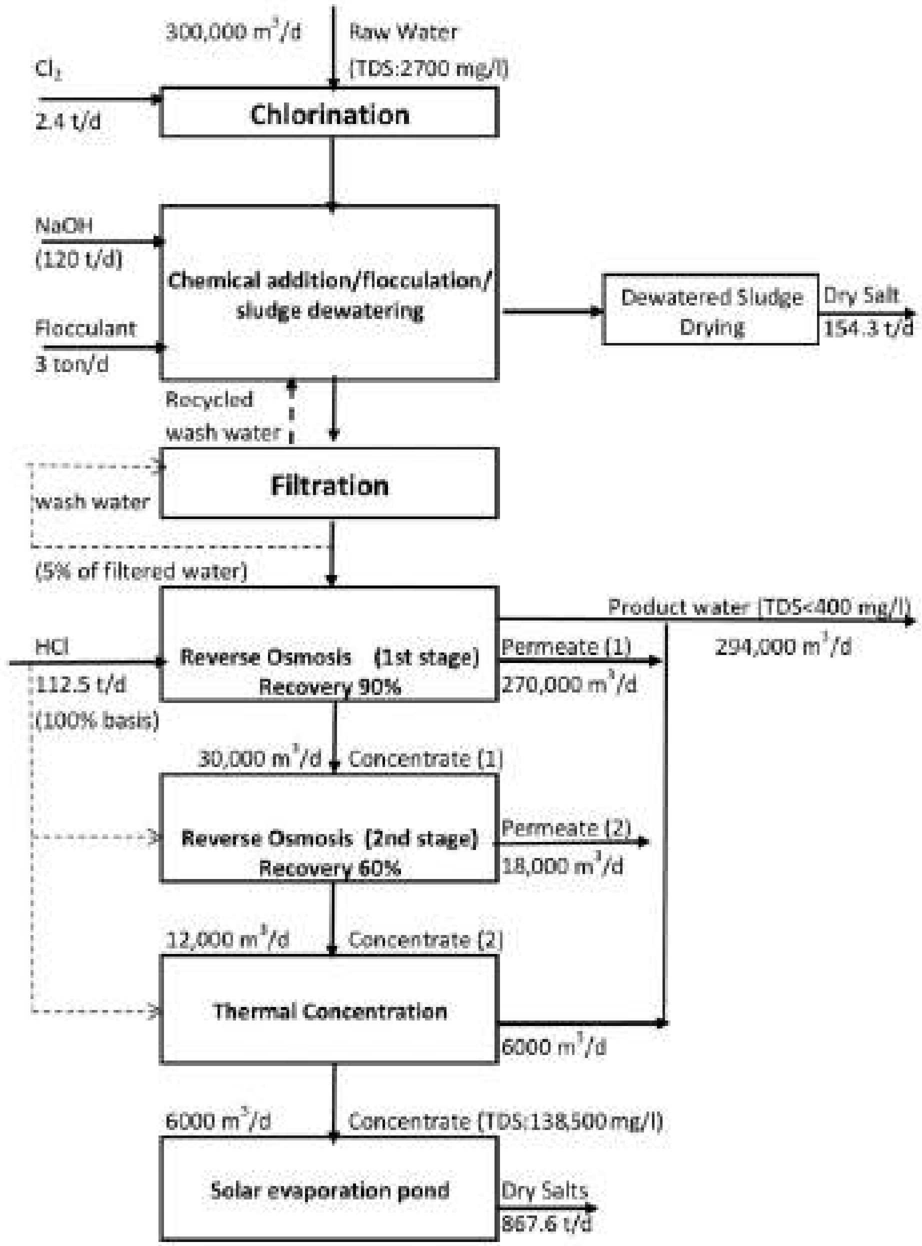


Figure 4. Depicts the proposed zero liquid discharge ZLD desalination system's process flow, major parts, and material balance (El Sayed et al. 2022)

Table 1. Typical properties of brine produced by seawater desalination plants (Kress et al. 2020; Ogunbiyi et al. 2021).

Parameter	Facts
Physical characteristics	Conductivity: 0.6 W/mK at 25 ^oC; temperature: ambient seawater; pH: 7-8; salinity: greater than 55,000 mg/L of TDS.
Inorganic salts	The principal components are sodium chloride (NaCl), magnesium chloride ($MgCl_2$), and calcium chloride ($CaCl_2$).
Nutrients	Nitrate, ammonia, and phosphorus.
Metals caused by corrosion	If a factory makes use of inferior stainless steel, brine may have high concentrations of iron, chromium, nickel, and molybdenum.
Halogenated organics	Trihalomethanes are common byproducts of chlorine addition (low content).
Pretreatment chemicals	Antiscale additive (ethylenediaminetetraacetic acid: EDTA, sodium hexameta phosphate). Biofouling control additives such as chlorine (small quantities)—coagulants
Cleaning chemicals	Acidic solutions used to adjust the pH of the seawater. Detergent such as EDTA, oxidants (sodium perborate) and biocides (formaldehyde) are used to clean the membrane.

However, for the advancement and spread of brine management, any management strategy should take into account sociopolitical and legal issues (Sanmartino et al. 2017; Al-Anzi et al. 2021). A multitude of frequently ignored socio-political elements have a significant negative impact on it. These important variables are divided into four groups: strengths, weaknesses, opportunities, and risks, and they play a significant role in the success or failure of numerous brine management initiatives around the world. The crucial societal needs of political stability, improved health, economic prosperity, and water security are all connected to brine management. Indeed, these substances are among the most priceless non-renewable resources for our contemporary society because they are essential to the electrical and electronic sectors.

As an illustration, effective brine management can lead to the commercialization of priceless resources such as water, minerals, and energy, which will reduce costs overall and present a business opportunity that unquestionably will ensure the economic, social, and environmental stability of nations. Additionally, due to their toxicity, these substances have the potential to harm the ecosystem severely if released improperly. Inland brackish groundwater has been used more and more lately for desalination. However, brine disposal is the desalination plant's limiting constraint. There are numerous disposal alternatives that are currently accepted by most people. The most of them are in use or being researched, although the accessibility of the disposal alternatives varies depending on the site. Therefore, it is necessary to analyze each disposal strategy according to its effects on the environment and economic viability. Table 2 summarizes advantages and disadvantages of common brine treatment and disposal methods.

Table 2: Advantages and disadvantages of common brine treatment and disposal methods

Disposal method	Advantages	Disadvantages
Evaporation ponds	• A viable option for inland plants in highly arid regions • Possible commercial salt exploitation • No marine impact expected • Low technological and managing efforts	• Expensive • High energy consumption • Production of dry solid waste – precipitates
Land applications	• Can be used to irrigate salt tolerant species • Viable for inland plants with small volumes of brine • No marine impact expected	• Requires large areas of land • Suitable for smaller discharge flows • Can affect the existing vegetation • Can increase the salinity of groundwater and underlying soil • Storage and distribution system needed
Direct surface water discharge	• Natural processes promote degradation • Can accommodate large volumes • Water body promotes dilution • Low cost • High dilution rates in the water body, possible dilution and blending with power plant discharge	• Dilution depends on local hydrodynamic conditions • Good knowledge, monitoring and planning programs of receiving waters are required • Limited natural assimilation capacities cause adverse impacts on marine environment if exceeded • Thermal pollution, reduction of dissolved oxygen in receiving waters, eutrophication, toxicity, pH increase, damage of biota
Deep well injection	• Viable for inland plants with small volumes of brine • No marine impact expected	• Cost efficient only for larger volumes • Needs a structurally isolated aquifer • Increases the salinity of

		groundwater
Discharge to a sewage treatment plant	• Lowers the BOD of the resulting effluent • Dilutes the brine concentrate • Uses existing infrastructure	• Can inhibit bacterial growth • Can hamper the use of the treated sewage for irrigation due to the increase in TDS and salinity of the effluent • Overload the existing capacity of the sewage treatment plant while diminish its usable hydraulic capacity
Mixing with the cooling water discharge	• Achieve dilution of both effluents prior to discharge • Combined outfall reduces the cost and environmental impacts of building two outfalls • Necessary to reduce salinity if disposing in fresh water bodies	• Dependent on the presence of a nearby thermal power plant
Mixing with the sewage treatment effluent	• Achieve dilution of brine effluent prior to discharge • Does not overload the operational capacity of sewage treatment plant • Use of existing infrastructure • Necessary to reduce salinity if disposing in fresh water bodies	• The brine could enhance the aggregation and sedimentation of sewage particulates that can impact benthic organisms and interfere with the passage of light in the receiving water body

4. Possibility of Desalinating Water for Agriculture in the Arab World

Desalination technology has advanced in recent years from being low-end in the world to being employed in some oil-rich nations where energy prices are low. Additionally, their use has expanded to include the agriculture industry due to advances in technology and decreased costs. Three criteria must be considered in determining the average cost of desalinated water: feedwater quality, desalination technology and energy requirements, and water quality products. According Jägerskog and Anders 2022, the majority of Golf

Cooperation Council (GCC) nations have a strong solar energy potential for irrigation and rural water delivery.

To create a favorable climate for crop growth, greenhouses are used. More than 50 nations around the world engage in covert commercial crop cultivation. According to Awaad et al. (2022), the primary crop demand within greenhouses is 3 L/m^2 for tomato, cucumber, pepper, and lettuce whereas it is 8 L/m^2 for flowers. The Mediterranean region currently has about 200,000 acres of conventional greenhouses. It is possible to manufacture fresh water from saltwater in greenhouses, which can be used for irrigation and replenishing groundwater (Awaad et al. 2022).

The Arab Region is one of the most water-scarce regions of the world. Moreover, 85% of the water in the Arab Region is used for irrigation. The region is the world's largest importer of grains. The attempt of Saudi Arabia to be self-sufficient in water-intensive crops, such as wheat, from the 1970s onward is a unique trail of self-sufficiency in water-intensive crops, such as wheat; it is a clear example of unsustainable development adopting the latest desalination technology (Jägerskog and Anders 2022). In 1984, Saudi Arabia became self-sufficient in wheat. However, such an agricultural strategy was environmentally unsustainable and depended mainly on subsidies from the government. Wheat output increased to over 2.6 million tons in 2006, albeit at a significant expense to non-renewable subsurface water resources (Sewilam and Nasr 2017). About 1.2 million m^3/day of desalinated water is used in Qatar. If farmers don't adopt the most effective water-saving methods, such as greenhouses, drip irrigation, and hydroponics, they will need to use up to an additional 3.5 million m^3/day of desalinated water to feed Qatar's 1.8 million people (Jägerskog and Anders 2022).

Hirich et al. (2015) demonstrated that a greenhouse farming method is the most widespread in the Souss Massa region of Morocco, where more than 15,000 ha of crops are cultivated in greenhouses. Since the yearly rainfall in this area is less than 200 mm and there is a severe water shortage, the water deficit in this area is greater than 260 mm^3. Additionally, 90% of the water resources in this region are used for agriculture. Additionally, excessive groundwater pumping, particularly in coastal locations, is one of the practices that exacerbates the environmental crisis by lowering the water table, raising pumping expenses, and salinizing groundwater as a result of seawater intrusion. A cost-effective way to supply water for the ongoing production of horticultural goods is to employ seawater desalination to irrigate crops like tomatoes, berries, and other vegetable crops. In the Souss Massa region, pumping costs average around US$0.3, while 1 m3 of desalinated water costs US$0.5 on average in 2014 (Hirich et al. 2015).

Farmers approve the use of desalinated water for irrigation to grow various crops despite being aware of the issue of water scarcity. Additionally, future desalination costs will be lower thanks to advancements in technology. Water scarcity affects agricultural productivity in Egypt, as it does in the majority of Mediterranean nations, and is made worse by rising demand and the effects of climate change (Desalinating brackish groundwater is essential for the development of new water resources, Qadir et al. 2007; Elsaeed 2012). According to Islam et al. 2022 concluded that any evaluation of Egypt's water resources must take into account the nation's heavy reliance on the Nile, which accounts for around 95% of Egypt's water budget. Precipitation and groundwater make up little more than 5% of Egypt's total supply of water from other sources. However, the impact of increases or decreases in precipitation close to the Nile's sources can have a greater than anticipated impact on Nile flows. Three factors work together to produce Egypt's total water budget: the Nile (95%), groundwater (1.5%), and precipitation (3.5%) (Gabr et al. 2023; Gabr 2023). As part of a recent major national project, the National Company for Protected Cultures in Egypt is currently constructing 100,000 greenhouses, including 5000 greenhouses, over a 20000 feddan area in the communities of El-Hammam, Abu Sultan, the Tenth of Ramadan, and the village of Hope in Sinai east of Ismailia. Some crops are grown in high-tech greenhouses, which has reduced irrigation water use by 90% while increasing production by a factor of six compared to open crops in the same places. This has increased the availability of several vegetable kinds for consumers at reasonable rates throughout the year.

5. Conclusions and recommendations

Using RO technology to desalinate seawater and brackish water for agriculture in the Arab World is a promising method for sustainable agriculture in arid regions because it (i) uses less water because farmers use efficient irrigation techniques due to the high cost of water, (ii) has fewer negative effects on the soil and can help restore saline soils due to its high water quality, and (iii) uses high-quality, demineralized irrigation water to increase agricultural output, (iv) providing water that is reusable, (v) water is more expensive than traditional water sources, (vi) the potential for groundwater resources to evaporate quickly, (vii) the issue with brine discharge and the requirement for brine management, (viii) Ionically balanced is required everywhere, and (ix) the desalination units consume a lot of electricity therefore using renewable energies is preferred. It should be highlighted that each nation has a cost-effective adaptation strategy based on its water resources, existing levels of usage and efficiency, as well as the practical viability of alternative technologies to close the water gap.

Numerous options are available to decision-makers can be divided into three main operating areas as listed below:

- Enhancing agricultural practices and choosing suitable crop species and types,
- Expanding water reuse for domestic and industrial applications, and
- Enhancing irrigation-based agriculture are all ways to increase water productivity.

Environmental effects of the desalination process, such as alternatives for brine disposal and marine and air contamination. Consequently, it is essential to evaluate each disposal plan in light of its environmental and financial sustainability. However, we should be aware that desalination technologies face some difficulties in achieving widespread adoption, particularly because they necessitate highly educated and/or qualified farmers or users and might not be profitable unless farmers pair them with high-value goods.

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References

Abdul Wahid R., Ang W.L., Mohammad A.W., Johnson D.J., Hilal N. (2021), Evaluating fertilizer-drawn forward osmosis performance in treating anaerobic palm oil mill effluent. *Membranes*, **11**, 566.

ACUAMED (2016), Producción y uso de aguas desaladas para regadío. In Working Day on Irrigation Management under Water

Scarcity Situation; Centro Nacional de Tecnología de Regadíos: San Fernando de Henares, Spain.

ACUAMED. Informe Anual (2017), Ministerio para la transición ecológica: Madrid, Spain, 80.

Adel M. Omar (1983), Simulation of M.S.F. desalination plants, *Desalination*, **45(2),** 65-76.

Al-Anzi B.S., Al-Rashidi A., Abraham L., Fernandes J., Al-Sheikh A., Alhazza A. (2021) Brine management from desalination plants for salt production utilizing high current density electrodialysis-evaporator hybrid system: A case study in Kuwait, *Desalination*, **498**, 114760.

Alotaibi M., Alhajeri N.S., Al-Fadhli F.M., Al Jabri S., Gabr M. (2023) Impact of climate change on crop irrigation requirements in arid regions. *Water Resour. Manag.*, **37**, 1965–1984.

Awaad, H.A.; Mansour, E.; Akrami, M.; Fath, H.E.S.; Javadi, A.A.; Negm, A. (2020), Availability and feasibility of water desalination as a non-conventional resource for agricultural irrigation in the MENA Region: A Review. *Sustainability*, **12**, 7592. https://doi.org/10.3390/su12187592.

Azerrad S.P., Isaacs M., Dosoretz C.G. (2019), Integrated treatment of reverse osmosis brines coupling electrocoagulation with advanced oxidation processes. *Chem. Eng. J.*, **356**, 771–780.

Aznar Sánchez J.A., Belmonte Ureña L.J., Valera D.L. (2017), Perceptions and acceptance of desalinated seawater for irrigation: A case study in the níjar district (Southeast Spain), *Water*, **9**, 408.

Backer S.N., Bouaziz I., Kallayi N., Thomas R.T, Preethikumar G., Takriff M.S., Laoui T., Atieh,M.A. (2022), Review: Brine Solution: Current Status, Future Management and Technology Development. *Sustainability*, **14**, 6752.

Bello A.S., Zouari N., Da'ana D.A., Hahladakis J.N., Al-Ghouti M.A. (2021), An overview of brine management: emerging desalination technologies, life cycle assessment, and metal recovery methodologies. *J. Environ. Manag*, **288**, 112358.

Bijan R., Mahdi A., Fatola F., Ali Asghar A. (2021), Reverse osmosis desalination for irrigation in a pistachio orchard, *Desalination*, **516**, 115236.

Buzaina Moossa, Priyank Trivedi, Haleema Saleem, Syed Javaid Z. (2022), Desalination in the GCC countries- a review, *Journal of Cleaner Production*, **357**, 131717.

El Kharraz J., Ahmed M., Daghari I., Laqbaqbi, M. (2023), Desalination for Agriculture: Is It Affordable?. In: Choukr-Allah R., Ragab R. (eds) Biosaline Agriculture as a Climate Change Adaptation for Food Security. Springer, Cham. https://doi.org/10.1007/978-3-031-24279-3_16.

El Sayed M.M., Abulnour A.M.G., Tewfik S.R., Sorour M.H., Hani H.A., Shaalan H.F. (2022), Reverse osmosis membrane zero liquid discharge for agriculture drainage water desalination: Technical, economic, and environmental assessment. *Membranes*, **12**, 923.

El-Rawy M., Batelaan O., Al-Arifi N., Alotaibi A., Abdalla F., Gabr M.E. (2023), Climate change impacts on water resources in arid and semi-arid regions: A case study in Saudi Arabia. *Water*, **15**, 606.

Elsaeed G. (2012), Effects of climate change on Egypt's water supply. In National Security and Human Health Implications of Climate Change; Fernando, H.J.S., Klai´c, Z., McCulley, J.L., Eds.; Springer: New York, NY, USA, 337–347.

Gabr M.E., El-Ghandour H.A., Elabd S.M. (2023) Prospective of the utilization of rainfall in coastal regions in the context of climatic changes: Case study of Egypt. *Appl. Water Sci*., **13**, 19.

Gabr,M.E. (2023) Land reclamation projects in the Egyptian Western Desert: Management of 1.5 million acres of groundwater irrigation. *Water Int.*, **48**, 240–258.

Gao L., Yoshikawa S., Iseri Y., Fujimori S., Kanae S. (2017), An economic assessment of the global potential for seawater desalination to 2050, *Water*, **9**, 763.

Hanan A. Al-Sarawi, Awadhesh N. Jha, Mohammad A. Al-Sarawi, Brett P. (2015), Lyons, Historic and contemporary contamination in the marine environment of Kuwait: An overview, *Marine Pollution Bulletin*, **100(2),** 621-628.

Hirich A., Choukr-Allah R., Rami A., El-Otmani M. (2015), Feasibility of using desalination for irrigation in the Souss Massa Region in the South of Morocco. In: Baawain, M., Choudri, B., Ahmed, M., Purnama, A. (eds) Recent Progress in Desalination, Environmental and Marine Outfall Systems. Springer, Cham. https://doi.org/10.1007/978-3-319-19123-2_13.

Hisham El-Dessouky, Imad Alatiqi, Hisham E. (1998), Process synthesis: The multi-stage flash desalination system, *Desalination*, **115(2),** 155-179.

Islam S.F.-U., Sander B.O., Quilty J.R., de Neergaard A., van Groenigen J.W., Jensen L.S. (2020), Mitigation of greenhouse gas emissions and reduced irrigation water use in rice production through water-saving irrigation scheduling, reduced tillage and fertilizer application strategies. *Sci. Total Environ*., **739**, 140215.

Jägerskog A., Shawki B. (2022), Advancing knowledge of the water-energy nexus in the GCC Countries, World Bank, Washington, DC.

Jiang C., Wang Y., Zhang Z., Xu T. (2014), Electrodialysis of concentrated brine from ro plant to produce coarse salt and freshwater. *J. Memb. Sci.*, **450**, 323–330.

Jongmin Jeon, Dongkeon Kim, Noori Kim, Suhan Kim (2023), Applicability and limitation of the industrial reverse osmosis system simulators, *Desalination*, **549**, 116358.

Kim Y., Woo Y.C., Phuntsho S., Nghiem L.D., Shon H.K., Hong S. (2017), Evaluation of fertilizer-drawn forward osmosis for coal seam gas reverse osmosis brine treatment and sustainable agricultural reuse. *J. Memb. Sci*., **537**, 22–31.

Korngold E., Aronov L., Daltrophe N. (2009), Electrodialysis of brine solutions discharged from an RO Plant. *Desalination*, **242**, 215–227.

Kress N., Gertner Y., Shoham-Frider E. (2020), Seawater quality at the brine discharge site from two mega size seawater reverse osmosis desalination plants in Israel (Eastern Mediterranean). *Water Res*., **171**, 115402.

Lee, S.; Kim, Y.; Kim, A.S.; Hong, S. Evaluation of Membrane-Based Desalting Processes for RO Brine Treatment. Desalin. Water Treat. 2016, 57, 7432–7439.

Lu J., Wang X. (2020), Volume reduction and water reclamation of reverse osmosis concentrate from coal chemical industry by forward osmosis with an osmotic backwash strategy. *Water Sci. Technol*., **81**, 2674–2684.

Martínez-Alvarez V., González-Ortega M.J., Martín-Gorriz B., Soto-García M., Maestre Valero J.F. (2017), The use of desalinated seawater for crop irrigation in the Segura River Basin (south-eastern Spain), *Desalination*, **364**, 2–16.

Martínez-Alvarez V., Maestre-Valero J.F., González-Ortega M.J., Gallego-Elvira B., Martin-Gorriz B. (2019), Characterization of the Agricultural Supply of Desalinated Seawater in Southeastern Spain. *Water*, **11**, 1233.

Mohamed Al-bahou, Zamzam Al-Rakaf, Hassan Zaki, Hisham E. (2007), Desalination experience in Kuwait, *Desalination*, **204**, (1–3), 403-415.

Nirenkumar P., Umakant B., Weonjung S., Sherub P., Ho Kyong S. (2023), Chapter 18 - Reverse osmosis (RO) membrane development and industrial applications, Editor(s): Xuan-Thanh Bui, Wenshan Guo, Chart Chiemchaisri A.P., *Current developments in biotechnology and bioengineering*, Elsevier, 411-435.

Ogunbiyi O., Saththasivam J., Al-Masri D., Manawi Y., Lawler J., Zhang X., Liu Z. (2021), Sustainable brine management from the perspectives of water, energy and mineral recovery: A comprehensive review. *Desalination*, **513**, 115055.

Olga Barron, Riasat Ali, Geoff Hodgson, David Smith, Ejaz Qureshi, Don McFarlane, Elena Campos, Domingo Zarzo (2015), Feasibility assessment of desalination application in Australian traditional agriculture, *Desalination*, **364**, 33-45.

Pramanik B.K., Thangavadivel K., Shu L. et al. (2016), A critical review of membrane crystallization for the purification of water and recovery of minerals. *Rev Environ Sci Biotechnol*, **15**, 411–439.

Qadir M., Sharma B.R., Bruggeman A., Choukr-Allah R., Karajeh F. (2007) Non-conventional water resources and opportunities for water augmentation to achieve food security in water scarce countries. Agric. *Water Manag.*, **87**, 2–22.

Quist-Jensen C. A., F. Macedonio, E. Drioli (2016), Membrane crystallization for salts recovery from brine-an experimental and theoretical analysis, Desalin. Water Treat., **57**(16).

Quist-Jensen C.A., F. Macedonio, E. Drioli (2015), Membrane technology for water production in agriculture: Desalination and wastewater reuse, *Desalination*, **364**, 17-32, Samuel Bunani, Eren Yörükoğlu, Ümran Yüksel, Nalan Kabay, Mithat Yüksel, Gökhan S. (2015), Application of reverse osmosis for reuse of secondary treated urban wastewater in agricultural irrigation, *Desalination*, **364**, 68-74.

Sanmartino J.A., Khayet M., García-Payo M.C., El-Bakouri H., Riaza A. (2017), Treatment of reverse osmosis brine by direct contact membrane distillation: chemical pretreatment approach. *Desalination*, **420**, 79–90.

SDGs. 2014. The 17 GOALS | Sustainable Development". https://sdgs.un.org/goals. (Assessed on 15 May 2023). https://www.un.org/sustainabledevelopment/water-and-sanitation/

Sethi S., S. Walker, P. Xu and J. E. Drewes (2009), Desalination Product Water Recovery and Concentrate Minimization, Water Research Foundation, Denver, Colorado.

Sewilam H., Nasr P. (2017), Desalinated water for food production in the arab region. In: Amer, K., Adeel, Z., Böer, B., Saleh, W. (eds) The Water, Energy, and Food Security Nexus in the Arab Region. Water Security in a New World. Springer, Cham. https://doi.org/10.1007/978-3-319-48408-2_4.

Shaheen Fatima Anis, Raed Hashaikeh, Nidal Hilal (2019), Reverse osmosis pretreatment technologies and future trends: A comprehensive review, *Desalination*, **452**, 159-195.

Shanxue Jiang, Yuening Li, Bradley P. Ladewig (2017), A review of reverse osmosis membrane fouling and control strategies, *Science of The Total Environment*, **595**, 567-583.

Silber A., Israeli Y., Elingold I., Levi M., Levkovitch I., Russo D., Assouline S. (2015), Irrigation with desalinated water: A step toward increasing water saving and crop yields, *Water Resour. Res*., **51**, 450–464.

Sundrop Farms (2023). https://www.abc.net.au/news/rural/2019-05-15/port-augusta-sundrop-farms-sold-to-investment-fund-morrisonco/11108046?utm_campaign=abc_news_web&utm_content=link&utm_medium=content_shared&utm_source=abc_news_web (Assessed in 10 June 2023).

Suwaileh W., Pathak N., Shon H., Hilal N. (2020), Forward osmosis membranes and processes: a comprehensive review of research trends and future outlook. *Desalination*, **485**, 114455.

Welle PD., Medellín-Azuara J., Viers JH., Mauter MS. (2017), Economic and policy drivers of agricultural water desalination in California's central valley, *Agric Water Manag*., **194**, 192–203.

Integrative Modeling and Optimization of Methylene Blue Dye Removal from Aqueous Solutions via Statistical Experimental Design and Artificial Intelligence

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Abstract:
This study explores the efficient removal of methylene blue through adsorption by employing statistical experimental design techniques. The adsorption process parameters, including adsorbent dose, temperature, and stirring time, were systematically varied, and the response was measured. Artificial neural network (ANN) and response surface methodology (RSM) models were used to develop predictive models, capturing the complex relationships between process variables. Agricultural waste-derived carbonaceous material served as the adsorbent and was characterized using FTIR and SEM. The ANN and RSM models achieved high R^2 values of 0.963 and 0.956, respectively, indicating their effectiveness in modelling the adsorption process. Optimal conditions for maximum removal efficiency were determined as a dose of 10 g/L, temperature of 42.26 °C, and contact time of 7.92 min, confirmed by both ANN aided genetic algorithm and RSM techniques. Under these conditions, a remarkable removal efficiency of 98.29% ± 0.68% was achieved. This study highlights the potential of statistical experimental design and ANN modelling for efficient methylene blue removal through adsorption.
Keywords: Adsorption; ANN; Methylene blue; RSM

1. Introduction

The water supply crisis has emerged as one of the most critical high-impact risks of our time, as highlighted by the World Economic Forum (Liu et al., 2017) .Addressing water scarcity requires the exploration of alternative and unconventional water resources to enhance water availability in regions experiencing shortages (Tzanakakis et al., 2020). Among these resources are wastewater treatment, rainwater harvesting, and seawater desalination. Wastewater treatment helps minimize waste and pollution. Despite the advantages, wastewater treatment must be carried out properly, considering health risks and adhering to quality standards, ensuring the treated water meets environmental requirements for agricultural, industrial, and domestic use (Jhansi & Mishra, 2013). Textile wastewater contains various harmful substances such as toxic dyes, heavy metals, suspended solids, and aromatic compounds (Elhussieny et al., 2008). Methylene blue (MB), among these dyes, is particularly problematic as it exhibits a deep colour, has a low degradation rate, and can cause severe environmental issues even at low concentrations. Consequently, considerable efforts have been made to address this challenge (Zeitoun et al., 2020). One effective method for removing dyes from water is the adsorption process. Selecting a suitable adsorbent with a significant adsorption surface area and a strong affinity for the dyes presents a notable challenge.

Activated carbon, known for its porous structure and extensive surface area, proves to be an efficient adsorbent for this purpose (Husien et al., 2023). Agricultural wastes serve as promising raw materials for producing activated carbon (Elshabrawy et al., n.d.)The use of such waste-derived activated carbon can contribute to more sustainable and environmentally friendly dye removal processes. The use of such waste-derived activated carbon can contribute to more sustainable and environmentally friendly dye removal processes. One of the agricultural wastes utilized in our study is sugarcane bagasse pulp, a byproduct that is produced when sugar is extracted from sugarcane (Elshabrawy et al., 2023). Our research aims to study how effective activated carbon derived from sugarcane bagasse pulp is in removing MB dye from wastewater. Response Surface Methodology (RSM) is a valuable technique that combines mathematical and statistical methods to model and explore the interactions among multiple independent factors. RSM assesses how the dependent factor (response) relates to the independent factors, enabling a thorough comprehension of their individual and combined impacts on the process. It offers several advantages, including the need for fewer experimental runs, providing an understanding of how various parameters interact with the response variable, quicker estimation of response, and more efficient use of time. In this approach, low-order polynomial equations are employed within a predetermined range of independent variables. To evaluate the suitability of the model, the analysis of variance (ANOVA) is also used. These equations are then statistically assessed to find the independent variable values that produce the optimum model. By combining RSM and ANNs, our main objective is to analyze the effectiveness of activated carbon from sugarcane bagasse pulp in removing MB, contributing to more efficient and sustainable wastewater treatment processes, and offering a potential solution to address the water crisis.

2. Methodology

Sugar cane bagasse pulp along with MB of high-purity grade of 98.5% were purchased. The following equipment was used for adsorbent characterization: scanning electron microscopy (SEM, JEOL JSM-6380) to examine the surface structure of the absorbent. Additionally, an FTIR spectrophotometer. The adsorbent was prepared by burning an adequate amount of sugarcane bagasse pulp in a muffin furnace for 1 hr. at 400 ℃. This temperature along with the time are sufficient for activated carbon formation. 100 ml of 50 mg/l methylene blue solution was taken in each beaker for the experiments. The adsorbent dose varied from 1 to 10 g/l. The temperature effect was studied by varying the temperature from 20 to 60 C and the contact time was studied by varying it from 5 to 60 minutes.

All the other parameters that may affect the adsorption process are kept constant. The final solution was measured at wavelength equals to 665 nm.

The removal efficiency was then calculated by the following equation.

$$Removal\ efficiency\ (\%) = \frac{C_o - C_e}{C_o} * 100 \quad (1)$$

where C_o and C_e are the concentrations of methylene blue in the solution before and after the adsorption process.

3. Results and Discussion

Figure 1 shows the FTIR absorption spectra of the prepared activated carbon. The band around 3406.26 cm−1 is attributed to hydroxyl (OH) stretching of cellulose present in the structure, since about one-third of sugarcane plant tissues is covered by cellulose The bands around 2890 cm−1 (2924.1) and in the region 1604 cm−1 (1628.97) indicate the presence of the CH2-group and C= C ring stretching respectively which are both main constituents of the cellulosic structure. Remaining bands at 1382, 1301, 1030, and 690 cm−1 correspond to –OH bending, C-O stretching, C-OH stretching, and C=C bending. Figure 2 shows SEM micrographs of sugarcane bagasse pulp before and after physical activation. The activation of sugarcane bagasse pulp created pores and holes. The produced activated carbon appears to have porous and fibrous texture. The surfaces of the thermally carbonized carbons are full of cavities indicating the possibility for the dye to be adsorbed.
The effect of all the 3 parameters on the adsorption process is shown in Figures 3.

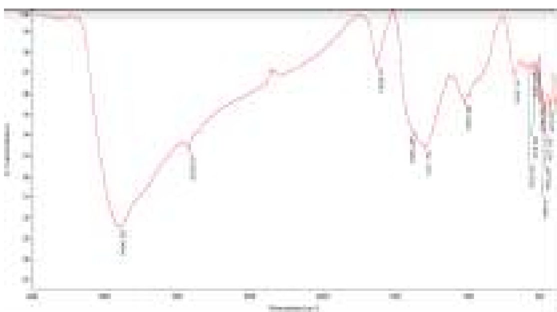

Figure 1. FTIR analysis of the prepared activated carbon

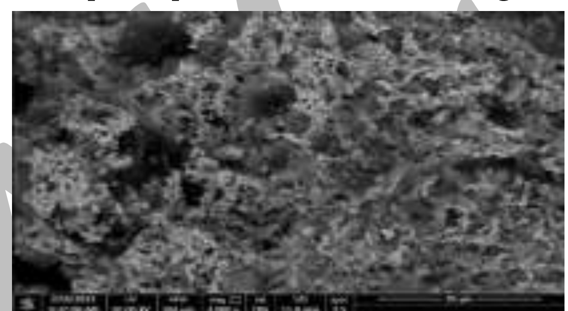

Figure 2. SEM analysis of the prepared activated carbon

The removal efficiency of MB at this range of adsorbent doses is found to be decreasing with increasing temperature. This is attributed to the fact that at high temperatures and high doses, the concentration of active sites on the adsorbent surface may decrease due to increased competition for adsorption sites. At high contact times and elevated temperatures, the thermal energy can cause the desorption of already absorbed MB molecules from the surface of the adsorbent. Statistically designed experiments were carried out using the faced central composite design to model the interactive effect of the independent parameters on the removal efficiency of MB.

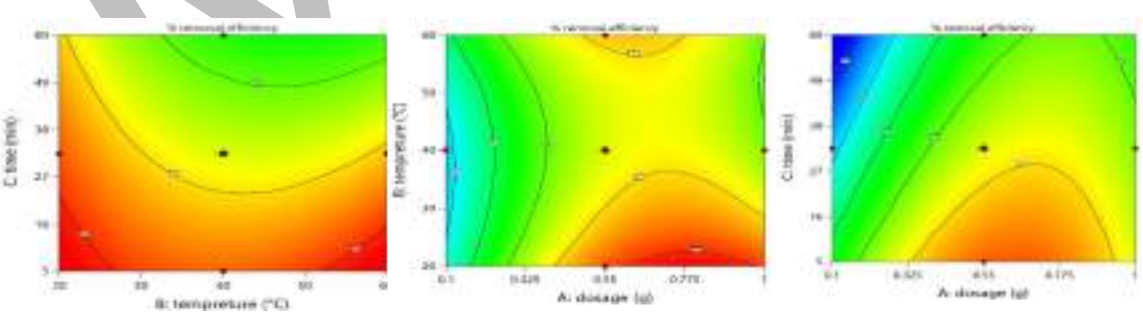

Figure 3. Contour surface graphs showing the effect of temperature, adsorbent dose, and contact time of MB removal efficiency.

The model is considered statistically significant. Thanks to the high correlation coefficient (R^2 = 0.956), a good match between the measured and predicted values of MB removal efficiency. ANN is used to build different interpretations, analyze existing processes, and predict the reactions and performance of systems. RSM, the optimum conditions were 0.868 of adsorbent dosage, 20.01 °C and 14.684 mins for contact time with removal efficiency of 98.672% while ANN optimum operating conditions were dose of 10 g/L, temperature of 42.26 °C, and contact time of 7.92 min for removal efficiency of %98.594. Validation for those results by experiments in triplets showed removal efficiency of 98.13% ± 0.63% and 98.29% ± 0.68% for ANN aided genetic algorithm and RSM respectively.

4. Conclusion

In this study, the efficiency of MB adsorption onto activated carbon driven form sugarcane bagasse pulp was investigated using both of RSM and ANN. R^2 value of 0.963 and 0.956 for ANN and RSM were achieved respectively which ensured that they are effective and reliable techniques to model the adsorption process. At dose of 10 g/L, temperature of 42.26 °C, and contact time of 7.92 min, the best removal was achieved by both ANN aided genetic algorithm and RSM. Maximum removal efficiency of 98.29% ± 0.68% was achieved under optimum conditions. The study's findings therefore demonstrate that employing AC made from sugarcane bagasse pulp is an effective method for MB removal. The results encourage the use of the prepared activated carbon as an adsorbent which can be employed on the membranes surface for the fabrication of adsorptive membranes to be used for industrial wastewater treatment.

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References

Al-Tohamy, R., Ali, S. S., Li, F., Okasha, K. M., Mahmoud, Y. A. G., Elsamahy, T., Jiao, H., Fu, Y., & Sun, J. (2022). A critical review on the treatment of dye-containing wastewater: Ecotoxicological and health concerns of textile dyes and possible remediation approaches for environmental safety. In Ecotoxicology and Environmental Safety (Vol. 231). Academic Press. https://doi.org/10.1016/j.ecoenv.2021.113160

Crini, G. (2006). Non-conventional low-cost adsorbents for dye removal: A review. In Bioresource Technology (Vol. 97, Issue 9, pp. 1061–1085). https://doi.org/10.1016/j.biortech.2005.05.001

Elhussieny, A., Elshabrawy, S. O. M., Mohamed, N., Fahim, I. S., Said, L. A., & Radwan, A. G. (2008). International Journal of Emerging Technology and Advanced Engineering Evaluation of Membranes' Performance in Wastewater Treatment by WAVE Simulation. Certified Journal, 9001(01). https://doi.org/10.46338/ijetae0123_08

Elshabrawy, S. O., Elhussieny, A., Taha, M. M., Pal, K., & Fahim, I. S. (2023). Wastewater treatment via sugarcane bagasse pulp. International Journal of Environmental Science and Technology. https://doi.org/10.1007/s13762-023-04831-x

Elshabrawy, S. O., Mansour, ; Mohammad, Elhussieny, ; Amal, Husien, S., Abdel-Aziz, ; A B, Fahim, I. S., Lobna, ;, Said, A., & Radwan, A. G. (n.d.). Valorization of Agricultural and Marine Waste for Fabrication of Bio-Adsorbent Sheets.

Husien, S., El-taweel, R. M., Mohamed, N., Abdel-Aziz, A. B., Alrefaey, K. A., Elshabrawey, S. O., Mostafa, N. G., Said, L. A., Fahim, I. S., & Radwan, A. G. (2023). Potentials of algae-based activated carbon for the treatment of M.orange in wastewater. Case Studies in Chemical and Environmental Engineering, 7. https://doi.org/10.1016/j.cscee.2023.100330

Jhansi, S. C., & Mishra, S. K. (2013). Wastewater Treatment and Reuse: Sustainability Options (Issue 10). https://about.jstor.org/terms

Kaykhaii, M., Sasani, M., & Marghzari, S. (2018). Removal of Dyes from the Environment by Adsorption Process. Chemical and Materials Engineering, 6(2), 31–35. https://doi.org/10.13189/cme.2018.060201

Liu, J., Yang, H., Gosling, S. N., Kummu, M., Flörke, M., Pfister, S., Hanasaki, N., Wada, Y., Zhang, X., Zheng, C., Alcamo, J., & Oki, T. (2017). Water scarcity assessments in the past, present, and future. In Earth's Future (Vol. 5, Issue 6, pp. 545–559). John Wiley and Sons Inc. https://doi.org/10.1002/2016EF000518

Qadir, M., Sharma, B. R., Bruggeman, A., Choukr-Allah, R., & Karajeh, F. (2007). Non-conventional water resources and opportunities for water augmentation to achieve food security in water scarce countries. In Agricultural Water Management (Vol. 87, Issue 1, pp. 2–22). https://doi.org/10.1016/j.agwat.2006.03.018

Reddy, K. O., Maheswari, C. U., & Shukla, M. (2013). Physico-chemical characterization of cellulose extracted from ficus leaves. Journal of Biobased Materials and Bioenergy, 7(4), 496–499. https://doi.org/10.1166/jbmb.2013.1342

Saleem, J., bin Shahid, U., Hijab, M., Mackey, H., & McKay, G. (n.d.). Production and applications of activated carbons as adsorbents from olive stones. https://doi.org/10.1007/s13399-019-00473-7/Published

Soleimani, M., & Kaghazchi, T. (2007). Agricultural waste conversion to activated carbon by chemical activation with phosphoric acid. Chemical Engineering and Technology, 30(5), 649–654. https://doi.org/10.1002/ceat.200600325

Tzanakakis, V. A., Paranychianakis, N. v., & Angelakis, A. N. (2020). Water supply and water scarcity. In Water (Switzerland) (Vol. 12, Issue 9). MDPI AG. https://doi.org/10.3390/w12092347

Zeitoun, Z., El-Shazly, A. H., Nosier, S., Elmarghany, M. R., Salem, M. S., & Taha, M. M. (2020). Performance evaluation and kinetic analysis of photocatalytic membrane reactor in wastewater treatment. Membranes, 10(10), 1–18. https://doi.org/10.3390/membranes10100276

Zhu, C., Feng, Q., Ma, H., Wu, M., Wang, D., & Wang, Z. (n.d.). Effect of Methylene Blue on the Properties and Microbial Community of Anaerobic Granular Sludge.

Development of polymeric membranes for wastewater treatment

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Abstract
In the framework of the Sustainable Development Goals issued by the United Nations, there has been considerable discussion about equal access to clean water and sanitary facilities. Due to the greatest population and significant economic development, demands on water and purification have significantly risen. Classical wastewater treatment procedures have made some progress over the years in purifying effluents for disposal, but they fall lacking in how they deeply control emerging harmful substances. The potential to reuse treated wastewater for home, agricultural, and industrial needs depends on breakthroughs in purifying technologies. One of the most recent breakthroughs to be implemented effectively is membrane technology. Nanofiltration, microfiltration, reverse osmosis, ultrafiltration, and membrane bioreactors are widely utilized membrane processes depending on features such as size or charge. Over traditional treatment, membrane technology offers various benefits. This review article discusses a number of membrane-related topics, including membrane categorizing, integration of filtration membranes for wastewater treatment, and application in various fields. Furthermore, offer an outlook on the filtering membranes that will be used in the future. Smart membranes have gained interest because of their selectivity, and tunable characteristics. Modified interfacial polymerization approaches have been investigated in addition to adsorptive ultrafiltration mixed matrix membranes.

Keywords: membrane technology; membrane classification ;Application ;wastewater

1. Introduction

Growing water scarcity and heightened awareness associated with water conservation are prompting more industrial manufacturers to explore water recycling within facilities - a strategy that also reduces wastewater effluent volumes [1].

Wastewater generated from the industry is very complex in the case of constituents; hence it is almost impractical to characterize all components as for other industrial wastewaters. This wastewater has high organic content, dark color and toxic matters [2]. One of the impacts related to the discharge of dark color wastewater into receiving waters is the reducing photosynthetic activity of aquatic plants [3]. Moreover, the increase of high organic matter in water leads to a decrease in dissolved oxygen concentration and disturbs the life of the fishes and other organisms consequently [4]. Treatment options include primary treatment such as clarification to remove solids and particulate matter and secondary biological treatment processes for removing biodegradable organic matter and decreasing the effluent toxicity. Additionally, tertiary treatment technologies such as membrane filtration, ultraviolet (UV) light disinfection, ion exchange, and granular activated carbon can also be employed to further treat effluent water to higher qualities. Membrane technologies such as microfiltration, ultrafiltration, and nanofiltration are the most effective strategies for treating water to a level where it can be utilized at the beginning of a process. So clean water remains one of the major social concerns and as the need for clean water increases the demand for new purification technologies with low environmental impact grows. Recognizing these needs, the development of efficient, sustainable, and environmentally friendly water treatment technologies is urgent for our future. One of the most dangerous pollutants in the water is organic dyes which represent an important source of environmental contamination, since they are toxic and cause serious damage to human beings even at very low concentrations and mostly non-biodegradable because it found to be very stable to light and oxidation which makes it very difficult to biodegrade. So the elimination of harmful organic dyes from industrial waste effectively is considered as a massive environmental challenge [5]. Various metal oxides such as TiO_2, ZnO, graphene oxide, and SnO_2 etc. were extensively used as photocatalysts for the photocatalytic degradation of organic pollutants [6]. But the efficiency of photocatalytic on a single semiconductor is still limited owing to the following reasons: i) Quick back reaction between photogenerated (electron-hole) e/h^+ pairs: conduction band electrons (e_{CB}^-) can react with valence band holes (h_{VB}^+) followed by energy release (via radiative or nonradiative decay). ii) the Limited number of metal oxides excited by visible light: The bandgap of most stable semiconductors is greater than 3.2 eV, so only ultraviolet (UV) light can be utilized for hydrogen production. The solar spectrum reaching ground level contains only about 4% of UV light and about 50% of visible light. Thus, the inability to absorb light from the visible region limits the efficiency of photocatalysis to photodegradation of pollutants [7]. Integration of photocatalysis with membrane processes is a promising and ideal alternative to reduce the membrane fouling and improve membrane properties. The application of membrane separation technology to zero-discharge wastewater technology has obvious technological advancement and investment economy. It plays a strategic role in the reform of industrial technology in the 21st century and is considered to be one of the most promising high-tech [8].

2. Membrane Preparation

The membranes were prepared using the phase inversion method. 2 g of NPs were first ultrasonically dispersed for 1 hour in 84 g of DMAc. Thereafter, 12 g of PVC was dissolved in the solution with vigorous stirring after the addition of 2 g of PVP, creating a homogenous casting solution. Degassing for 24 hours to get rid of air bubbles, then casting on a glass plate with a 200 µm thick casting knife drawn onto a non-woven fabric. To complete the solvent/nonsolvent separation, the cast films were immediately submerged in a distilled water coagulation bath without the solvent evaporating. The prepared flat sheet membrane was thoroughly coagulated, repeatedly rinsed in DW to eliminate any leftover solvent, and then kept in clean water for supplementary testing.

3. Membrane Performance Test

The effect of NPs on the pure water flux and rejection was investigated after 30 min in the dark. the pure water flux of the membrane is 1.54 L/(m^2.h) with an efficiency of 76.72% the flux was decreased to 0.55 L/(m^2.h) with the addition of TiO_2 as a result of the reduction, and the efficiency was enhanced to 90.56% and for ZnO membrane but the water flux was improved to 1.53 L/ (m^2.h) and the efficiency increased to 98.90%. but after embedding the PVC membrane with ZnO/TiO_2 both the water flux and the efficiency were enhanced to 4.56 L/ (m^2.h), and 95.31% respectively. As a result of the increase in the porosity of the membranes. all nanocomposite membranes demonstrated higher degradation efficiency to humic acid wastewater in comparison to the blank

PVC membrane, revealing better rejection of nanocomposite membranes in dark conditions, which might propose benefits for NPs in enhancement the property of the membranes.

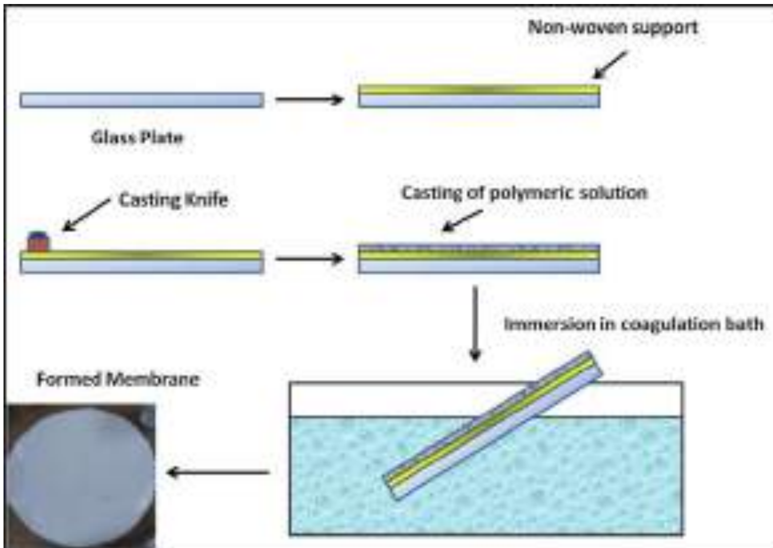

Fig 1. Preparation procedure of photocatalytic nanocomposite membranes

4. Conclusion

The prepared NPs were used to fabricate PVC nanocomposite membranes via the phase inversion method for humic acid wastewater treatment. The surface morphology of the composite membrane and surface roughness were changed significantly. Meanwhile, the addition of NPs improved the membrane porosity, hydrophilicity, pure water flux, and humic acid rejection. The nanocomposite membranes exhibited photocatalytic activity under sunlight based on the photodegradation and permeation of humic acid. Both the water flux and the rejection were enhanced in sunlight and the two couples.

Acknowledgment

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References

1. Ddin, M. T. (2013). *Metal oxide heterostructures for efficient photocatalysts* (Doctoral dissertation, Université Sciences et Technologies-Bordeaux I).
2. Jaafarzadeh, N., Omidinasab, M., & Ghanbari, F. (2016). Combined electrocoagulation and UV-based sulfate radical oxidation processes for treatment of pulp and paper wastewater. *Process Safety and Environmental Protection*, *102*, 462-472.
3. Asha, A., Keerthi Muthukrishnaraj, A., Balasubramanian, N.,2014. Improvement of biodegradability index through electrocoagulation and advanced oxidation process. Int. J. Ind.Chem. 5, 1–6.

4. Liu, X., Zhang, T., Zhou, Y., Fang, L., Shao, Y., 2013. Degradation of atenolol by UV/peroxymonosulfate: kinetics, effect of operational parameters and mechanism. Chemosphere 93, 2717–2724.
5. Aoudjit, L.; Salazar, H.; Zioui, D.; Sebti, A.; Martins, P.M.; Lanceros-Mendez, S. Reusable Ag@TiO2-Based Photocatalytic Nanocomposite Membranes for Solar Degradation of Contaminants of Emerging Concern. Polymers 2021, 13, 3718.
6. Gołąbiewska, A., Kobylański, M., & Zaleska-Medynska, A. (2018). Fundamentals of metal oxide-based photocatalysis.
7. M. Ni, M.K.H. Leung, D.Y.C. Leung, K. Sumathy, A review and recent developments in photocatalytic water-splitting using TiO_2 for hydrogen production, Renew. Sustain. Energy Rev. 11 (2007) 401–425.
8. Derikvandi, H., & Nezamzadeh-Ejhieh, A. (2017). A comprehensive study on electrochemical and photocatalytic activity of SnO2-ZnO/clinoptilolite nanoparticles. Journal of Molecular Catalysis A: Chemical, 426, 158-169.

Technologies for wastewater treatment in aquaponics and their sustainability: A review

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Abstract:
The globe is dealing with a number of major issues, the most significant of which include climate change, population growth, water scarcity, soil erosion, and food security. These issues might be addressed by aquaponics, a closed-loop system that combines hydroponics with aquaculture components. The main components of aquaculture wastewater that can have an adverse effect on fish growth and the environment include dissolved and particulate organic matter, total dissolved solids, and nutrients including phosphorus and nitrogen. In this study, different wastewater treatment methods used in aquaculture are compared along with how effective they are at achieving sustainability. For small-scale aquaponics commercial reverse osmosis filtration system that provides outstanding water quality control is an effective solution to eliminate dangerous chemicals from water. Constructed wetland systems have demonstrated excellent efficacy in the treatment of wastewater containing nitrogen compounds, with removal efficiencies for NH_4-N up to 98% and NO_2-N exceeding 98%. Since just 10% of the entire volume of water is replenished daily, recirculation systems are shown to be more sustainable and effective in managing the volume of effluent in aquaculture units. The use of this technology in a business setting will be especially beneficial to arid regions experiencing water stress.

Keywords: Aquaponics; Sustainability; wetland treatment system; Water quality; Wastewater integrated system.

1. Introduction

The globe is dealing with a number of major issues, the most significant of which include climate change, population growth, water scarcity, soil erosion, and food security. These issues might be addressed by aquaponics, a closed-loop system that combines hydroponics with aquaculture components (Joyce ET AL. 2019). Aquaponics is an integrated multi-trophic system that combines aspects of hydroponics and recirculating aquaculture (Turcios and Papenbrock 2014), wherein nutrient-rich fish tank water is used to support plant development. It is a naturally occurring, soil-free, scaled-down process that occurs in lakes, ponds, and rivers. It is customary to use fish excrement as an agricultural fertilizer. A promising sustainable food production technique, the intertwining of aquacultural and hydroponic methods enables some of the inadequacies of the individual systems to be overcome.

According to Lehman et al. (1993), define sustainable agriculture as a process that does not exhaust any non-renewable resources that are necessary to agriculture in order to sustain agricultural practices, aquaponics can be regarded as a sustainable agricultural production system. According to Francis et al. (2003), "designing systems that close nutrient cycles"—one of the aquaponics' key features—and mimicking natural ecosystems are two more ways to accomplish sustainable agricultural output. While water recirculation minimizes water use, mineral transfers from aquaculture to hydroponics support effective nutrient recycling (Turcios and Papenbrock 2014). High-yield hydroponic systems consume a lot of macro- and micronutrients that come from industrial and mining sources, which use a lot of energy (for manufacturing and transportation) and deplete scarce resources (such as oil and phosphorus) (Ragnarsdottir et al. 2011; Sonneveld et al. 2011; Sverdrup and Ragnarsdottir 2011). Additionally, sporadic dumping of large amounts of nutrient-rich water in no-recirculating systems causes high water consumption as well as surface and groundwater pollution (Gagnon et al. 2010). Aquaponics does not require the frequent water exchange that is accomplished in traditional aquacultural systems. This is because 1 kg of beef meat requires between 5000 and 20,000 L of water (IME 2013) and 1 kg of fish raised in semi-intensive and extensive conventional aquaculture systems needs between 250 and 375,000 L (Al-Hafedh et al. 2003). On the other hand, recirculating aquaculture systems utilize less water (below 100 L kg1) per kg of fish produced and have a high rate of water reuse (i.e., 95%–99%) (Dalsgaard et al. 2013). Instead of being eliminated in gaseous form in denitrification units, surplus nitrate in aquaponics is utilized to produce beneficial plants (Martins et al. 2010; Van Rijn 2013).

The aquaponics concept is hopeful to contribute to both global and urban sustainable food production while also reducing pollution and resource use, even though preliminary research has shown that developed aquaponic system components are not yet fully realized in view of either cost-effectiveness or technical capabilities (Rakocy 2012; Vermeulen and Kamstra 2013). Aquaculture wastewater (AWW) and the catastrophic overfishing of wild fish populations for use as ingredients in fish feed raise environmental concerns (Robaina et al. 2019). Unused feed and feces, which are organic components of aquaculture effluents, harm the ecosystem by degrading recipient water bodies and sediments. The main components of aquaculture wastewater that can have an adverse effect on fish growth and the environment include dissolved and particulate organic matter, total dissolved solids, and nutrients including phosphorus and nitrogen. The enhanced metabolic activity of aerobic bacteria is the main result of the significant volumes of decomposable organic waste in aquaculture effluent. Aerobic nitrification and denitrification reactions are simultaneously inhibited by the anaerobic sulphate reduction reaction that predominates in anaerobic environments (Delaide et al. 2019; (Lu et al. 2019).

The death of sediment macrofauna, which is necessary for bio-irrigation in natural water streams, will result from oxygen deprivation in both processes, further lowering the aeration levels in the receiving water bodies. The environment is severely harmed by the organic enrichment in river sediments caused by an insufficient microscopic animal population. Such an ecosystem is dominated by sulfur-fate reducers and methanogens, which also disrupt the relationship from the river basin to the subsequent level of the food chain (Gott et al. 2019). To improve the sustainability of aquaculture units, all these environmental effects of dumping untreated aquaculture effluent to receiving water bodies should be minimized. The nutrient enrichment of aquaculture wastewater through the feedstock can also result in the eutrophication of lakes and discharge channels, which therefore requires environmentally acceptable treatment methods.

Aquaculture systems also use traditional wastewater treatment techniques that combine physical, chemical, and biological approaches. For the oxidation of organic matter, nitrification, or denitrification, biological processes such as submerged biofilters, trickling filters, rotating biological contactors, and fluidized bed reactors are utilized (Van Rijn 1995). Traditional wastewater treatment techniques are expensive in terms of initial outlay, energy use, and upkeep. In this case, the development of sustainable solutions is crucial for the treatment of aquaculture wastewater.

This study evaluates the challenges facing aquaponic farming operations and identifies which issues still need to be addressed. The latest technology possibilities for treating wastewater from sustainable aquaculture have been thoroughly examined in the review, which is necessary to maintain a sustainable connection between the water, food, and energy chains. Figure 1 shows the study methodology.

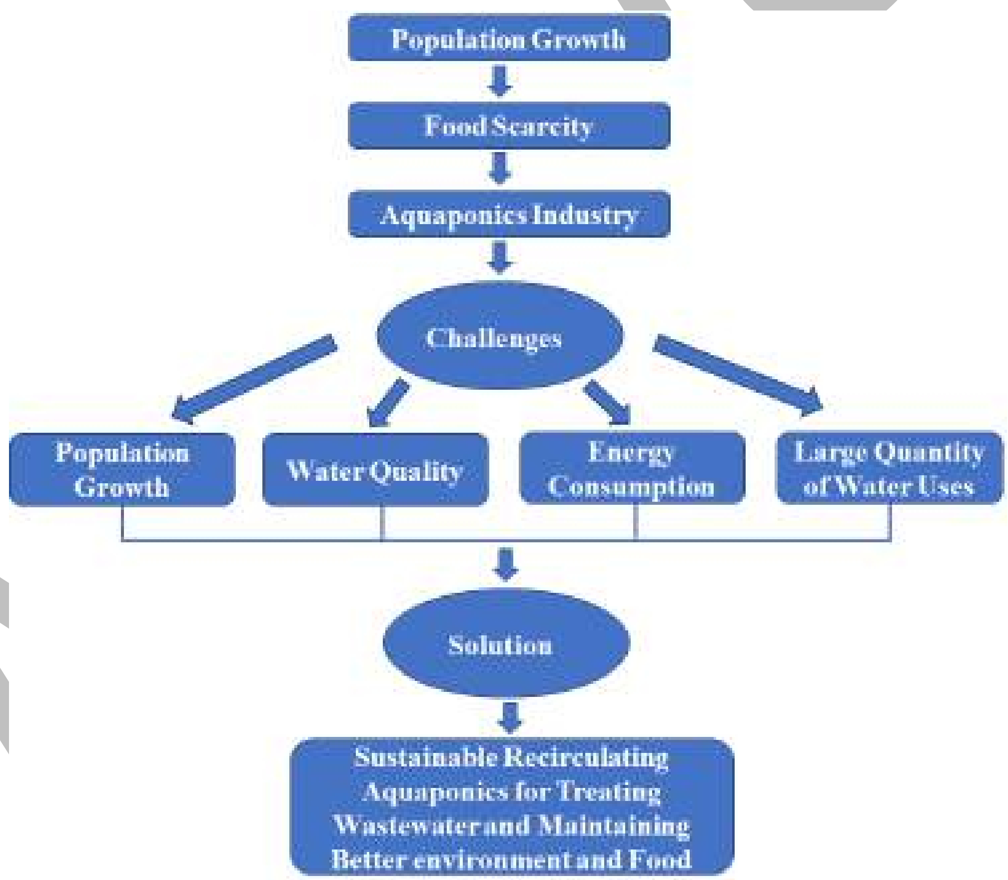


Figure 1 Study methodology.

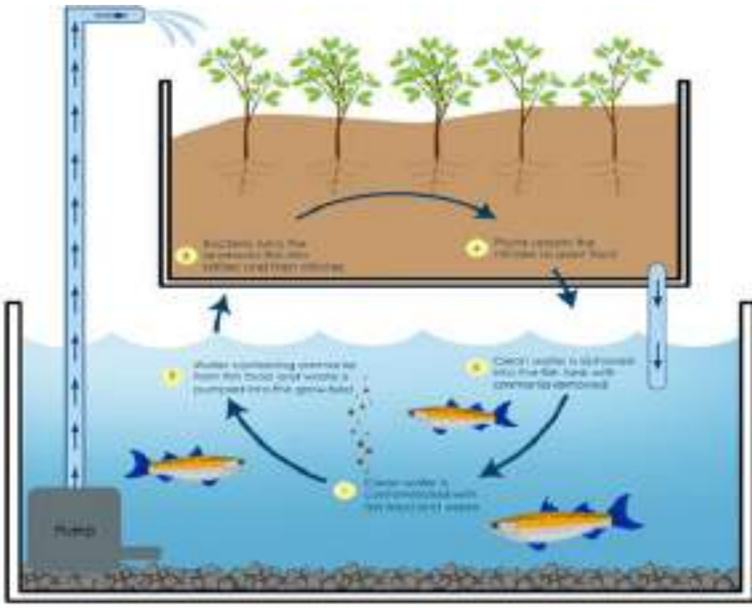
2. Hydroponics and aquaponics systems

The practice of growing plants in a nutrient-rich water solution rather than in soil, known as hydroponics, is well known. Hydroponics systems are closed-loop, which means that they cycle the water solution to use less water overall. In addition to being used for small-scale crop production, such as for salad greens, cannabis, and ornamental plants, hydroponics can also be used in the home and garden (Figure 2A). The agricultural method known as aquaponics is less well-known to many people (Lennard and Goddek 2019).

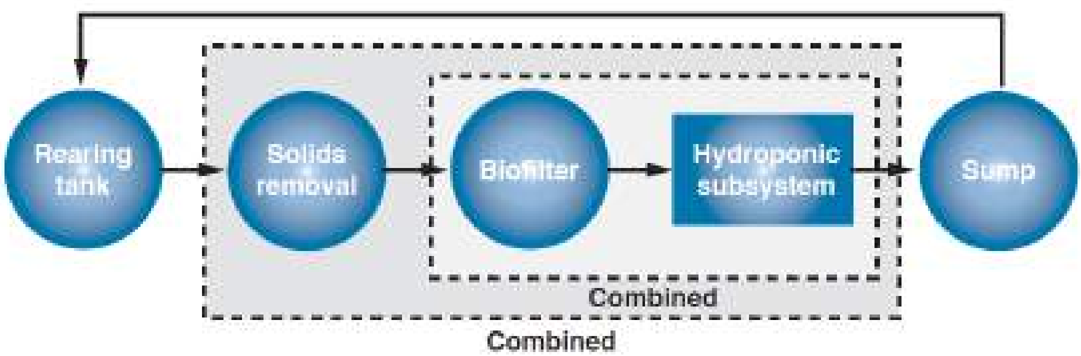
Similar to hydroponic systems, aquaponics makes use of water solutions with the ideal nutrient balance. Fish or other aquatic animals are cultivated alongside plants in aquaponic systems, which is the fundamental distinction between them and hydroponic systems. In aquaponics, plants and animals coexist in a symbiotic connection where the plants feed the aquatic creatures and aid in water filtration while the animals create nutrients in the form of waste that the plants need to grow (Figure 2). The growing method known as aquaponics combines hydroponics and aquaculture in many ways (Espinal and Matulić 2019). Aquaponics holds considerable promise as a way to maximize harvests while minimizing water use in the home and in big commercial agriculture enterprises. Aquaponic systems can be used to grow a variety of plants, but the most popular ones are cannabis, tomatoes, leaf lettuce, peppers, cucumbers, strawberries, cabbage, cruciferous vegetables (broccoli and cauliflower), and leafy greens (chard, bok choy, and spinach).

Aquaponic systems give growers the chance to produce and harvest aquatic organisms, which is an additional benefit. In the closed system, these animals flourish alongside the plants. Even if not all aquatic animals cultivated in a reverse osmosis aquaponics system are harvestable, some of the more well-liked options include Tilapia, Carp (edible and ornamental Koi varieties), Catfish, Trout, Freshwater prawns, Crawfish, Mussels, Baitfish, and Perch. Each plant and animal will have its own unique water quality parameters. Growers must ensure the right water composition for their crops, making filtration systems like reverse osmosis very important.

A



B



C

Figure 2 A: Hydroponics**, B:** Aquaponic system, and **C**: Aquaponic system layout

2.1 Principles of aquaponics

Recirculating aquaculture and hydroponics are combined in aquaponics. Traditional hydroponic systems need mineral fertilizers to provide plants with the nutrients they need, but aquaponic systems employ readily available fish water that is nutrient-rich in fish waste instead. Another benefit of this combination is that excess nutrients do not need to be eliminated by the regular replacement of fresh water with enriched fish water, as is done in aquaculture systems. Fish, bacteria, and plants all coexist in harmony as a result of the system, which also promotes the recycling of nutrients and water (Figure 3).

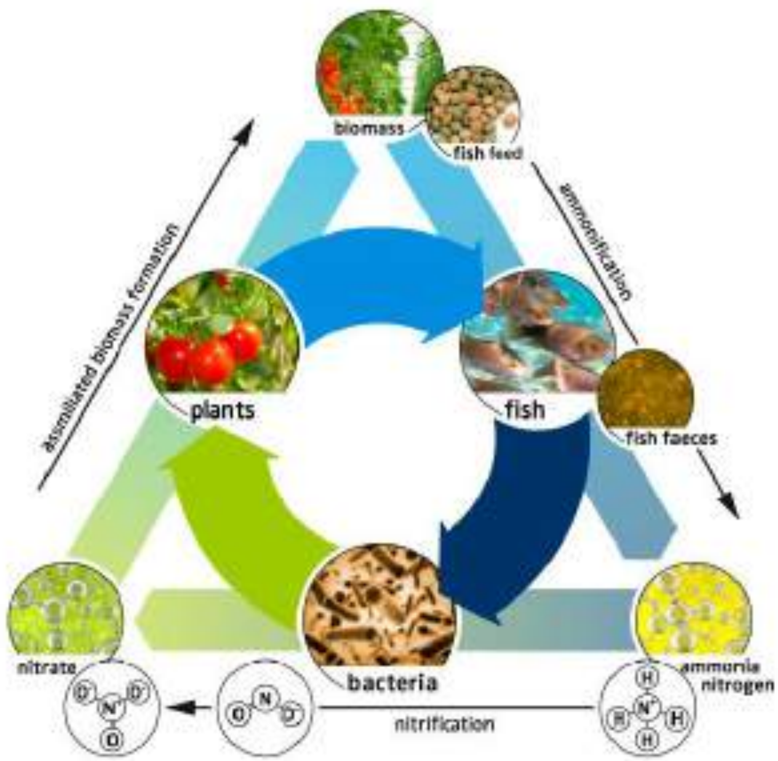


Figure 3. Interdependent aquaponic cycle

For proper growth, plants require macronutrients like C, H, O, P, N, Ca, K, Mg, and S as well as micronutrients like Fe, Mn, Cl, B, Zn, Mo, and Cu. With the exception of C, O, and H, which are obtained from air and water, these elements are present in hydroponic solutions in predetermined ratios and are added in the form of ions (Resh 2012). In aquaponics systems, fish waste (gill discharge, urine, and feces), which contains both soluble and solid organic compounds, is dissolved into nutrient-rich ionic form in the water and fed to plants as a source of nutrients.

Monitoring the concentrations of micro- and macronutrients is necessary to ensure proper plant growth. Monitoring the concentrations of micro- and macronutrients is necessary to ensure proper plant growth. The concentration of some nutrients may need to be adjusted from time to time; for instance, iron is frequently insufficient in fish waste (Damon et al. 1998; Rakocy et al. 2004). Different microorganism communities that are engaged in the processing and solubilization of fish waste must be able to live in aquaponic systems. If the ammonia (NH_4) from fish urine and gill discharge is not eliminated from the system, it can accumulate to dangerous levels. Step-by-step microbial conversion to nitrate can accomplish this. The nitrifying autotrophic bacteria consortium, which forms a biofilm on solid surfaces in the system and is primarily made up of nitroso- and nitro-bacteria (such as Nitrosomonas sp. and Nitrobacter sp.), is one of the most significant microbial components. The nitroso-bacteria in the system first turn the ammonia in the system into nitrite (NO_2), which is then turned into nitrate (NO_3) by the nitro-bacteria (Tyson et al. 2008).

Nitrate, the final byproduct of this bacterial conversion, is far less hazardous to fish and serves as the primary nitrogen source for plant development in aquaponics systems because of its bioconversion (Rakocy et al. 2006; Graber and Junge 2009; Endut et al. 2014). Most systems require a specialized biofiltration unit with extensive nitrification. To achieve the ideal balance between fish nutrient production and plant uptake in each system, the best fish to plant ratio must be determined. This may be based on the feeding rate ratio, which is the quantity of feed consumed daily per m^2 of plant variety, according to Rakocy (2007). For leafy greens growing in raft hydroponic systems, a value of between 60 and 100 $g/day/m^2$ has been advised (Rakocy 2012). For eight water spinach plants (Ipomoea aquatica), Endut et al. (2010) discovered an ideal ratio of 15–42 grams of fish feed m^2 of plant growing with one African catfish (Clarias gariepinus). Therefore, in order to strike the correct balance, the following factors must be understood from the ground up and experienced: (1) Fish species and food consumption rates; (2) Fish food composition, such as the percentage of pure proteins converted to Total Ammonia Nitrogen (TAN); (3) Feeding frequency; (4) Hydroponic system type and design; (5) Types and Physiological Stages of Cultivated Plants (Leafy Greens vs. Fruity Vegetables); (6) Plant Sowing Density; and (7) Chemical Composition of Water Influenced by Fish Waste Mineralization Rate. Furthermore, because fish, bacteria, and plants all share a water cycle, it is important to maintain environmental variables like pH, temperature, and mineral concentrations at a compromise that is as close as possible to each organism's ideal growth conditions.

2.2 Quality of Water in Aquaponic Systems

In aquaponics systems, the quality of the water affects both the plants and the animals. Agricultural runoff, ammonia, heavy metals, petroleum residues, ammonia, chlorine, heavy metals, and high levels of dissolved salts are just a few of the dangerous elements that farmers must make sure the water is free of (Joyce et al. 2019). Along with the possibility of impurities getting into the aquaponics system's water supply, aquatic animals that grow alongside plants produce waste. As this waste builds up more quickly than plant roots can use it, the quality of the water decreases with time. The water solution in the system could turn hazardous to plant and animal life if it is not controlled.

The water in aquaponics systems can be filtered using a variety of techniques. In most systems, the biological filtering action of plant roots and animal activity is supplemented by some kind of chemical or mechanical filtration. Water filtration and a reverse osmosis aquaponics system provide unmatched control over the system's water quality. Reverse osmosis (RO) is a mechanical procedure that imitates the osmosis that occurs naturally in cells. Water travels through cell walls in live cells to create a balance by moving from areas of lower concentration to those of higher concentration. When water is forced through a semipermeable membrane by pressure, reverse osmosis removes sediments, debris, dissolved minerals, and solid waste thanks to the membrane's small pores. An RO filter is used between a reverse osmosis aquaponics system and the incoming water supply, which might be a well or a public water source. The RO filter's impurities are washed away through a drain.

3. Sustainability in aquaculture treatment technologies

3.1 Reverse Osmosis role in the aquaponics

For individuals who use hydroponic or aquaponic systems to raise aquatic plants and animals, RO systems are effective at eliminating dangerous chemicals from water. A commercial reverse osmosis filtration system that provides outstanding water quality control is often used in a reverse osmosis aquaponics system (Turnšek et al. 2019). The biggest commercial RO systems include automatic controllers and can handle 1000 gallons or more of water each day. Precision valves allow aquaponic farmers to regulate the flow and chemistry of both treated and untreated water.

As a result, gardeners can maximize the water's concentration of dissolved minerals and ammonium nitrate, which are essential for the development of both plants and animals. Up to 99% of contaminants, such as heavy metals (mercury, lead, and arsenic), chlorine, fluoride, suspended particles, and pathogens (bacteria and protozoan cysts), may be eliminated using commercial reverse osmosis aquaponics systems. RO systems are effective, efficient, and simple to keep up with. These systems provide clean water for the fish and plants that are raised in the system, which enables aquaponics growers to achieve high yields. Additionally, these strong water filtering systems are employed in bakeries, food processing plants, pubs and restaurants, and pharmaceutical manufacturing facilities. The finest comprehensive, portable, light-commercial reverse osmosis system is the PRO-RO-I as shown in Figure 4. The PRO-RO-I was built with the simplicity of installation, usage, longevity, and peak performance in mind.

Figure 4 PRO-RO-I reverse osmosis aquaponics systems

3.2 Wetland recirculating aquaculture system

Because wetlands have shown to be a workable and affordable approach for treating wastewater (Gabr 2021; Gabr 2022; Gabr etal. 2022; Gabr et al. 2023), constructed wetlands technology is becoming more and more significant in recirculating aquaculture systems (RAS). Figure 5 depicts a marsh that has been artificially created for a recirculating system. Energy is only needed to pump and distribute wastewater in developed wetland systems. By combining plants with aquaculture water, the symbiotic process can be employed to generate a mutually beneficial eco-friendly system in RAS systems. The advantage of constructed wetland systems is their great efficacy in treating sewage containing nitrogen compounds (Table 1). However, in large-scale treatment systems, wetlands are more effective at removing some nutrients, such as ammonium and nitrites, while nitrate and phosphorus removal is ineffective or occasionally detrimentally impacted by wetland passage.

As a result, a lengthy retention period is needed to achieve the requisite nitrogen removal (Kadlec and Knight 1995). They require a considerable amount of land, up to 2.7 times the area of the pond, which is another drawback (Kadlec and Wallace 2009). Wetland systems may be less economically viable as a result, as they require a lower hydraulic loading rate and a longer hydraulic retention time to effectively remove pollutants (Gabr et al. 2023). This issue can be reduced by effective pre-treatment in small artificial wetlands with strong hydraulic loads that are commercially viable and remove 80% of the total suspended solids (TSS) (Gabr 2021). An additional strategy for overcoming the limits of the built-in wetlands in the RAS system is the inclusion of aquaponics.

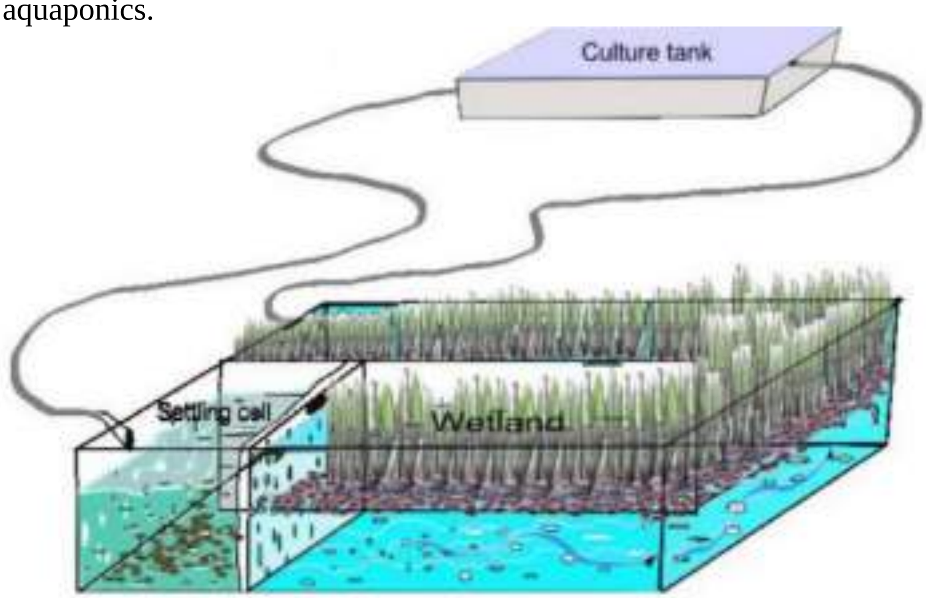


Figure 5 Wetland recirculating aquaculture system

Table 1 pollutant removal efficiency in constructed wetlands (Lin et al. 2002)

Parameter	Average removal efficiency
Suspended solids	47-86%
COD	25-55%
Phosphors	71.2-31.9%
Total inorganic nitrogen	95-98%
NH_4	86-98%
NO_2	More than 99%
NO_3	82-99%

3.3 Recirculating aquaculture system (RAS)

The classic pass away (race away) aquaculture systems need an excess amount of water supply, and the sustainability of the water supply is the most crucial issue to take into account. The typical water sources for raceway aquaculture are groundwater wells as well as surface water from rivers, springs, lakes, and reservoirs. These systems must have enough water flow to either supply the unmet oxygen needs or remove the metabolic waste produced by the aquatic life. The new intake water substantially replaces the water already present in the flow-through unit. Only when the system has a sufficiently high flow velocity can the self-cleaning be accomplished.

By transferring hazardous pollutants back into the effluent and recirculating the cleaned water, the recirculation aquaculture system (RAS) treats it. As a result, RAS systems use a very modest volume of water to produce high numbers of fish. Recirculation of the wastewater into the fish tanks is possible in some or all cases. Depending on the supply and feeding rates, recirculation aquaculture systems typically replace 5 to 10% of the water each day (Emperor 2011; Delong and Losordo 2012). With the use of recirculating aquaculture systems (RASs), fish farming produces less pollution and uses less freshwater, making it more environmentally friendly. Recirculating aquaculture systems must be developed, and this requires the removal of solids, organic debris, ammonia, and nitrite (Lennard and Goddek 2019). Recirculating aquaculture systems allow fish to be raised with other creatures that turn nutrients that have been discharged into waste products into valuable products (Delaide et al. 2019). This makes the system more sustainable than pass away systems.

For the growth of recirculating aquaculture systems, removal of solids, organic debris, ammonia, and nitrite is essential (Lennard and Goddek 2019). Aquaculture systems that use recirculation (RAS) recycle the cleaned water while also relocating hazardous particles are used to remediate wastewater. Because of this, RAS systems only need a relatively modest amount of water to produce big amounts of fish. Recirculating the wastewater to the fish tanks might be done in part or in whole. Depending on the supply and the feeding rates, recirculation aquaculture systems typically have a daily water replacement of 5 to 10% (Emperor 2011; Delong and Losordo 2012). Recirculating aquaculture systems (RASs), which are available, mitigate the impact of fish farming on the environment and reduce the need for freshwater. The growth of recirculating aquaculture systems depends on the removal of sediments, organic debris, ammonia, and nitrite.

4. Discussions

Sustainable development is said to require the security of fundamental resources including water, energy, and food. These resources are under stress as a result of population growth, economic expansion, and shifting consumption patterns. The demand of the population and availability of needs like food are predicted to become difficult in many regions of the world in the near future. The nexus notion can be regarded as a multi-sectoral management tool that works on interrelated and interdependent network systems among several elements, particularly water, energy, and food. Food and energy security do not demonstrate an encouraging performance, according to a case study of sustainable development goal indicators, as their percentage growth in terms of accessibility is lower than in recent years and their sustainability indicator is declining (Cansino-Loeza et al. 2020).

The availability and accessibility of high-quality water is one of the primary problems facing the aquaculture industry, one of the major contributors to the global food supply. This calls for the development of environmentally friendly methods for the treatment of aquaculture wastewater. In order to ensure sustainability, it is crucial to maintain adequate water quality for good marketable goods and to manage the negative consequences brought on by aquaculture wastewater. There are a number of technological issues that need to be resolved before commercial aquaponic systems can be developed that are socially, ecologically, and environmentally sustainable. (1) tailored pest control; (2) increased nutrient solubilization and recovery for better use of the nutrient input and eliminating extra-mineral addition, such as phosphorus recycling; (3) greatly reduced water use by limiting the requirement for water exchange (4) using alternative energy sources for hot, cold, and arid regions; and (5) using fluidized lime-bed reactors, revolutionary pH stabilization techniques that have been successfully applied in natural waters (Sverdrup et al. 1982). Constructed wetlands (CWs) are a green technology for effectively removing nitrogenous waste.

The CW system uses less energy (0.1 kWh/m^3) than aerobic filters (0.28 kWh/m^3) (Brix 1999) making it a more environmentally friendly choice (Gabr et al. 2022; Gabr et al. 2023). The main challenge for the CW system is that as the treatment system is scaled up, it has been discovered that nitrate removal effectiveness decreases. The CW method also has to deal with the need for a vast amount of land Gabr 2021). Pre-treatment was proven to increase the effectiveness and cost-effectiveness of CWs. Aquaponics is a symbiotic method of growing plants and fish that upholds the idea of sustainability. However, this system's energy need is far higher than that of CWs, making it difficult to justify economically. By utilizing renewable energy sources and lowering the number of water pumps in the system, it can be made more economical and energy-efficient.

The rafter aquaponics system has a 46.8% energy demand, making it more environmentally friendly. On the other hand, by substituting freshwater for wastewater in the traditional pass-away system, it is possible to retain the quality of the water while avoiding the expense of wastewater treatment equipment. The replacement of wastewater, which necessitates a significant amount of fresh water, is a crucial problem that the conventional wastewater treatment system must address. Here, the valuable freshwater resource is abused, and untreated effluent can have a negative impact on the environment. Recirculating aquaculture systems (RAS) get around the drawbacks of the traditional system, which uses less fresh water because the wastewater is reused. For the production of huge amounts of fish, the RAS system employs an additional 10% of the total water volume as fresh water, making it more sustainable. The accumulation of nitrate in water, which may impact water quality, is the RAS system's main weakness.

The current solutions to this issue include installing aerobic filters and external carbon sources, however, there are significant drawbacks, including increased cost and energy requirements when treating nitrate-enriched wastewater. The efficiency of nutrient and water utilization in multi-loop aquaponics systems was enhanced by Goddek and Keesman 2020. They suggested an integrated systems approach that has the potential to eliminate the need for excessive fertilizer supplementation and periodic nutrient and water releases, which are currently required to maintain good water quality for fish and an ideal nutrient solution for the plants. Nutrients currently tend to accumulate in the RAS portion of decoupled aquaponics systems while being somewhat scarce in the hydroponics system. Only by switching the subsystems' concentrations in the opposite direction can this issue be resolved from the standpoint of mass balance.

The critical factor in this reverse-engineering process is the amount of water that actually needs to be released daily because it determines the process and concentrate flows. Because it affects the concentration factor of the process water obtained from the RAS, the RO efficiency ratio is crucial. A 4:1 ratio would result in 4 m3 of demineralized water and 1 m^3 of RAS concentrate from 5 m^3 of RAS process water. The system in Figure 6 is provided with a moving bed biofilm reactor (MBBR) that is a very efficient biological treatment method that combines biofilm media with the traditional activated sludge process. Within the aeration and anoxic tanks of the MBBR process, floating High-Capacity Micro Organism Bio Chips medium are used. In addition, an up flow anaerobic sludge blanket reactor (UASB) schematic, the UASB creates a layer of granular sludge that suspends in the tank using an anaerobic process. The anaerobic bacteria in the blanket digest (degrade) the wastewater as it moves upward through it. For the purpose of removing organic substances from water, such as food and waste particles, utilize a protein skimmer (Port. Skim) or foam fractionator.

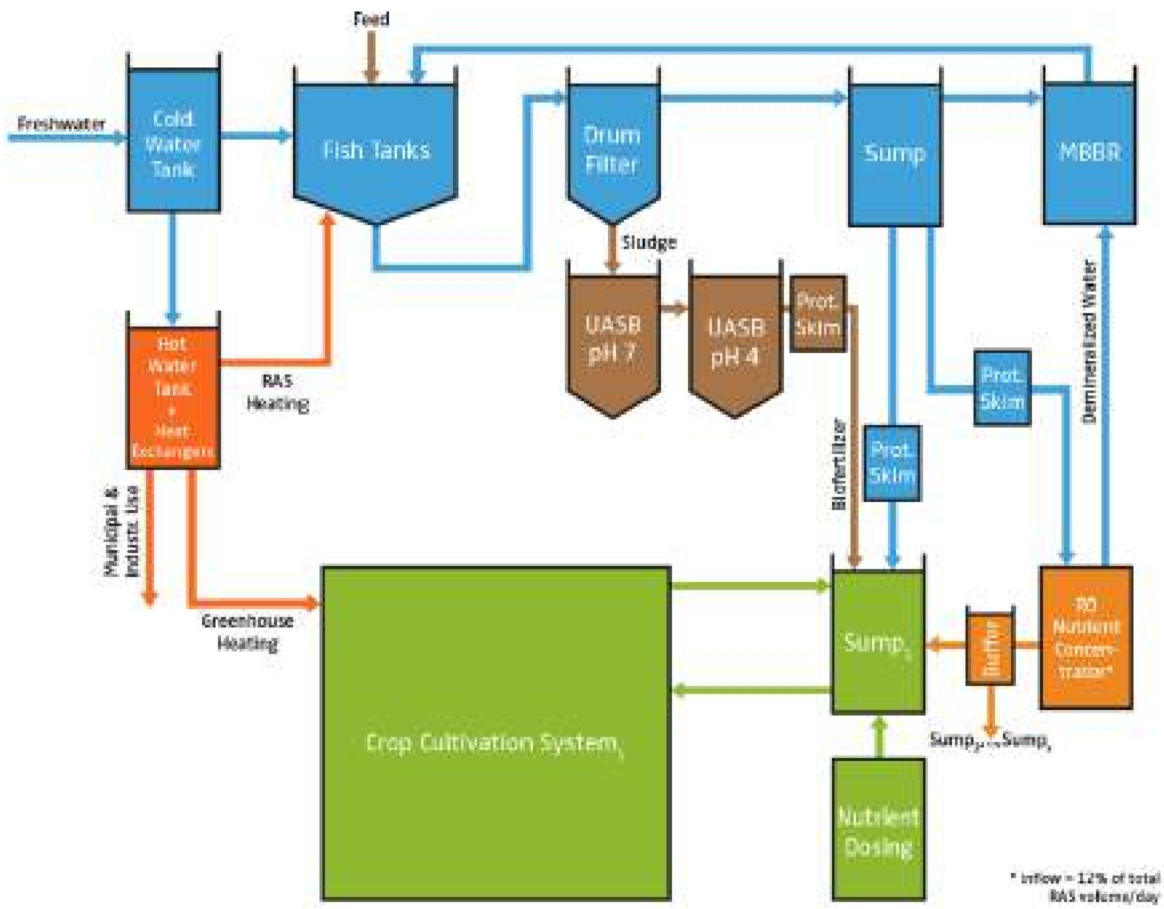


Figure 6 The nutrients are extracted from the RAS in this aquaponic system. As a result, the nutrient concentrator is RAS-dependent. This means that a variety of hydroponics subsystems can use the concentrated nutrient solution in the buffer. Additionally, the RAS's low nutrient concentration makes it possible to use RO technology more effectively.

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References

Al-Hafedh, Y.S.; Alam, A.; Alam, M.A. (2003) Performance of plastic biofilter media with different configuration in a water recirculation system for the culture of Nile tilapia (Oreochromis niloticus). Aquac. Eng., 29, 139–154.

Brix H. (1999). How? Green? Are aquaculture, constructed wetlands and conventional wastewater treatment systems? Water Sci. Technol., 40(3). doi:10.1016/s0273-1223(99)00418-7

Cansino-Loeza B., X.G. Sanchez-Zarco, E.G. Mora-Jacobo, F.E. Saggiante-Mauro, Dalsgaard, J.; Lund, I.; Thorarinsdottir, R.;
Drengstig, A.; Arvonen, K.; Pedersen, P.B. (2013) Farming different species in RAS in Nordic countries: Current status and future perspectives. Aquac. Eng., 53, 2–13.

Damon, E.; Seawright, R.B.; Walker, R.R.S. (1998) Nutrient dynamics in integrated aquaculture hydroponics systems.
Aquaculture, 160, 215–237.

Delaide, B., Monsees, H., Gross, A., Goddek, S. (2019). Aerobic and Anaerobic Treatments for Aquaponic Sludge Reduction and
Mineralisation. In: Goddek, S., Joyce, A., Kotzen, B., Burnell, G.M. (eds) Aquaponics Food Production Systems. Springer, Cham. https://doi.org/10.1007/978-3-030-15943-6_10

Delong D.P., T.M. (2012) Losordo, How to Start a Biofilter, 3, SRAC Publication-Southern Regional Aquaculture Center.

Emperor I. Aquatics (2011). Recirculation systems in aquaculture. Retrieved fro http://www.emperoraquatics.com/aquaculture-
recirculation-systems.php#.UeSRbY03De4.

Endut, A.; Jusoh, A.; Ali, N. Nitrogen budget and effluent nitrogen components in aquaponics recirculation system. Desalin.
Water Treat. 2014, 52, 744–752.

Endut, A.; Jusoh, A.; Ali, N.; Wan Nik, W.B.; Hassan, A. A study on the optimal hydraulic loading rate and plant ratios in
recirculation aquaponic system. Bioresour. Technol. 2010, 101, 1511–1517.

Espinal, C.A., Matulić, D. (2019). Recirculating Aquaculture Technologies. In: Goddek, S., Joyce, A., Kotzen, B., Burnell, G.M. (eds)
Aquaponics Food Production Systems. Springer, Cham. https://doi.org/10.1007/978-3-030-15943-6_3.

Francis, C.; Lieblein, G.; Gliessman, S.; Breland, T.A.; Creamer, N.; Harwood, R.; Salomonsson, L.; Helenius, J.; Rickerl, D.;
Salvador, R.; et al. Agroecology: The Ecology of Food Systems. J. Sustain. Agric. 2003, 22, 99–118.

Gabr ME (2021) Proposing a constructed wetland within the branch drains network to treat degraded drainage water in Tina
Plain, North Sinai, Egypt. Arch Agron. Soil Sci. 67, 1479–1494.

Gabr ME (2022) Design methodology for sewage water treatment system comprised of Imhoff's tank and a subsurface
horizontal flow constructed wetland: A case study Dakhla Oasis, Egypt. J. Environ. Sci. Health Part A, 57:52–64.

Gabr ME, Al-Ansari N, Salem A, Awad A (2023) Proposing a wetland-based economic approach for wastewater treatment in arid
regions as an alternative irrigation water source. Hydrology, 10: 20.

Gabr ME, Salem M, Mahanna H, Mossad M (2022) Floating Wetlands for Sustainable Drainage Wastewater Treatment.
Sustainability, 14: 6101.

Gagnon, V.; Maltais-Landry, G.; Puigagut, J.; Chazarenc, F.; Brisson, J. (2010) Treatment of hydroponics wastewater using

constructed wetlands in winter conditions. Water. Air. Soil Pollut., 212, 483–490.
Goddek, S., Keesman, K.J. (2020) Improving nutrient and water use efficiencies in multi-loop aquaponics systems. Aquacult Int
28, 2481–2490. https://doi.org/10.1007/s10499-020-00600-6.
Gott, J., Morgenstern, R., Turnšek, M. (2019). Aquaponics for the Anthropocene: Towards a 'Sustainability First' Agenda. In:
Goddek, S., Joyce, A., Kotzen, B., Burnell, G.M. (eds) Aquaponics Food Production Systems. Springer, Cham. https://doi.org/10.1007/978-3-030-15943-6_16.
Graber, A.; Junge, R. (2009) Aquaponic systems: Nutrient recycling from fish wastewater by vegetable production. Desalination,
246, 147–156.
Han P, Q. Lu, L. Fan, W. Zhou (2019) A review on the use of microalgae for sustainable aquaculture, Appl. Sci. 9: 2377.
Institution of Mechanical Engineers (IME). Global Food: Waste Not, Want Not; IME: London, UK, 2013; p. 31.
Joyce, A., Goddek, S., Kotzen, B., Wuertz, S. (2019). Aquaponics: Closing the Cycle on Limited Water, Land and Nutrient
Resources. In: Goddek, S., Joyce, A., Kotzen, B., Burnell, G.M. (eds) Aquaponics Food Production Systems. Springer, Cham. https://doi.org/10.1007/978-3-030-15943-6_2.
Kadlec HR, Knight R L (1995) Treatment wetlands, Lewis Publishers, Boca Raton, U.S.A.
Kadlec RH, Wallace S (2009) Treatment wetlands. 2nd ed. Boca Raton (Florida, USA): CRC Press.
Lehman, H.; Clark, E.A.; Weise, S.F. Clarifying the definition of Sustainable agriculture. J. Agric. Environ. Ethics 1993, 6, 127–143.
Lennard, W., Goddek, S. (2019). Aquaponics: The Basics. In: Goddek, S., Joyce, A., Kotzen, B., Burnell, G.M. (eds) Aquaponics
Food Production Systems. Springer, Cham. https://doi.org/10.1007/978-3-030-15943-6_5.
Lin Y.F., S.R. Jing, D.Y. Lee, T.W. Wang (2002) Nutrient removal from aquaculture wastewater using a constructed wetland
system, Aquaculture 209:169–184.
Lu Q, P. Han, Y. Xiao, T. Liu, F. Cahn, L. Leng, H. Liu, J. Zhou (2019) The novel approach of using microbial system for sustainable
development of aquaponics, J. Clean. Prod. 217:573–575.
Martins, C.I.M.; Eding, E.H.; Verdegem, M.C.J.; Heinsbroek, L.T.N.; Schneider, O.; Blancheton, J.P.; D'Orbcastel, E.R.; Verreth,
J.A.J. (2010) New developments in recirculating aquaculture systems in Europe: A perspective on environmental sustainability. Aquac. Eng. 2010, 43, 83–93.
R. Gonzá lez-Bravo, J. Mahlknecht, J.M Ponce-Ortega (2020) Systematic approach for assessing the water−energy−food nexus
for sustainable development in regions with resource scarcities, ACS Sustain. Chem. Eng. 8 (2020) 13734–13748.
Ragnarsdottir, K.V.; Sverdrup, H.U.; Koca, D. (2011) Challenging the planetary boundaries I: Basic principles of an integrated
model for phosphorous supply dynamics and global population size. Appl. Geochem., 26, S303–S306.

Rakocy, J.E. (2012) Aquaponics—Integrating Fish and Plant Culture; Wiley-Blackwell: Hoboken, NJ, USA; pp. 344–386.
Rakocy, J.E. (2007) Aquaponics—Integrating fish and plant culture; Wiley-Blackwell: Hoboken, NJ, USA, 2012; pp. 344–386
Rakocy, J.E. Ten Guidelines for Aquaponic Systems. Aquaponics J., 1, 14–17.
Rakocy, J.E.; Masser, M.P.; Losordo, T.M. (2006) Recirculating aquaculture tank production systems: aquaponics—integrating fish and plant culture; southern regional aquaculture center: Stoneville, MS, USA, 2006; pp. 1–16.
Rakocy, J.E.; Shultz, R.C.; Bailey, D.S.; Thoman, E.S. (2004) Aquaponic production of tilapia and basil: Comparing a batch and staggered cropping system. Acta Hortic., 648, 63–69.
Resh, H.M. (2012) Hydroponic Food Production: A Definitive Guidebook for the Advanced Home Gardener and the Commercial Hydroponic Grower; CRC Press: Boca Raton, FL, USA.
Robaina, L., Pirhonen, J., Mente, E., Sánchez, J., Goosen, N. (2019). Fish Diets in Aquaponics. In: Goddek, S., Joyce, A., Kotzen, B., Burnell, G.M. (eds) Aquaponics Food Production Systems. Springer, Cham. https://doi.org/10.1007/978-3-030-15943-6_13.
Sonneveld, C.; Voogt, W. (2009) Plant Nutrition in Future Greenhouse Production. In Plant Nutrition of Greenhouse Crops; Springer: Heidelberg, The Netherlands pp. 393–403.
Sverdrup, H.; Eklund, H.; Bjerle, I. Kalkning av rinnande vatten-Erfarenheter från en fluidiserad kalkbrunn. Mover. Vatten 1981, 37, 388–394.
Sverdrup, H.U.; Ragnarsdottir, K.V. (2011) Challenging the planetary boundaries II: Assessing the sustainable global population and phosphate supply, using a systems dynamics assessment model. Appl. Geochem., 26, S307–S310.
Turcios, A.E.; Papenbrock, J. (2014) Sustainable Treatment of Aquaculture Effluents-What Can We Learn from the Past for the Future? Sustainability, 6, 836–856.
Turnšek, M., Morgenstern, R., Schröter, I., Mergenthaler, M., Hüttel, S., Leyer, M. (2019). Commercial Aquaponics: A Long Road Ahead. In: Goddek, S., Joyce, A., Kotzen, B., Burnell, G.M. (eds) Aquaponics Food Production Systems. Springer, Cham. https://doi.org/10.1007/978-3-030-15943-6_18.
Tyson, R.V.; Simonne, E.H.; Treadwell, D.D.; White, J.M.; Simonne, A. (2008) Reconciling pH for ammonia biofiltration and cucumber yield in a recirculating aquaponic system with perlite biofilters. HortScience, 43, 719–724.
Van Rijn J. (1996). The potential for integrated biological treatment system in recirculating fish culture. Aquaculture, 139, 181–201.
Van Rijn, J. (2013) Waste treatment in recirculating aquaculture systems. Aquac. Eng., 53, 49–56.

Vermeulen, T.; Kamstra, A. (2013) The need for systems design for robust aquaponic systems in the urban environment, 1004,
71–78.

Recycling Reverse Osmosis Membranes: Addressing the Challenges of Non-Biodegradability and Waste Generation

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Abstract:
Reverse osmosis (RO) technology has emerged as a vital process for desalination. One of the major drawbacks of modern desalination plants is the massive quantities of reverse osmosis (RO) membranes solid waste. This review paper explores the problem of non-biodegradable membranes and the growing concern surrounding the massive accumulation of RO membrane waste. Furthermore, it investigates the feasibility and potential benefits of recycling and reusing RO membranes as a sustainable solution. Reverse osmosis membranes have a limited life span of between five to seven years. Tons of non-biodegradable RO membranes are disposed of annually in landfills which poses severe environmental concerns. Several challenges hinder the widespread adoption of recycling RO membranes, including the presence of irreversible fouling, the diverse composition of membranes, and the need for cost-effective and energy-efficient recycling methods. However, recent advances in membrane treatment techniques, characterization, and material science provide possibilities for overcoming these complications. By embracing recycling and reuse strategies for RO membranes, the water treatment industry can transition towards a more sustainable and environmentally responsible approach. Therefore, recycling RO membranes can offer large economic and environmental benefits.

Keywords: Membrane recycle; Desalination; Reverse osmosis; Sustainability.

1. Introduction

Reverse osmosis (RO) membrane recycling and reuse have gained widespread recognition in the scientific community [1-3]. Currently, reverse osmosis is the most applied technique for water desalination with a more than 70% share of the total desalination plants worldwide [4]. Reverse osmosis process has great potential in eliminating the dissolved contaminants in seawater, however, the membranes suffer from irreversible fouling over time and must be replaced frequently. Tons of end-of-life non-biodegradable membranes have been disposed into the ecosystem which possesses serious environmental concerns [5]. A previous study estimated the mass destined for landfills due to the disposal of 9000 RO modules to be 121.5 tons/year [6]. Statistically, based on the linear economy approach embarrassed by industrial entities, more than 1.5 x 104 tons of RO modules are discarded annually [7]. The market for RO technology is forecasted to increase tremendously by 2030 (Figure 1) due to increased pollution and the lack of freshwater sources [8].

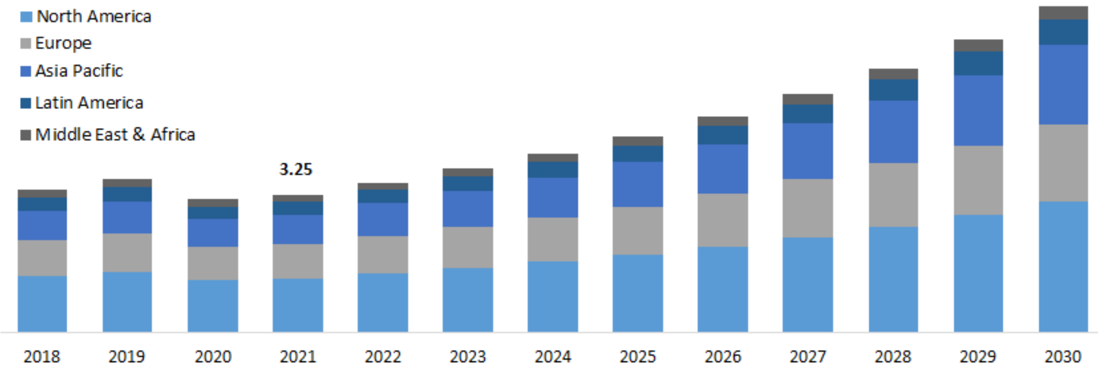

Figure 1 Forecast of the global membrane market size (USD Billion), region based.

There are many potential benefits of reusing and recycling RO membranes. For one thing, it can aid in reducing the cost of water treatment by extending the lifespan of the membranes and reducing the need to purchase new modules. It can reduce the environmental impact of the treatment process by reducing the amount of waste generated and conserving resources. Additionally, by reusing and recycling the materials used to create RO membranes, the amount of energy and resources required to manufacture new membranes in the future are reduced which reduces the carbon footprint of the desalination plants [8-10]. Despite the benefits of reusing and recycling RO membranes, several challenges should be tackled in order to commercialize the membrane recycling process. For instance, the lack of standardization in the industry and the technical challenges related to repairing and cleaning damaged or fouled membranes. In addition, the cost of reusing and recycling RO membranes may still be higher than the cost of simply purchasing new membranes. This can be due to the additional labor and equipment required for membrane conditioning and the fact that the average life span of a recycled membrane is 60% less than that of a new membrane. However, as technology continues to improve and the demand for more sustainable water treatment practices grows, it is likely that the cost of reusing and recycling RO membranes will decrease, making these practices more economically feasible. The aim of this work is to review the state-of-the-art RO membrane reuse and recycling, discuss the problems in current end-of-life RO membrane disposal, and state some of the proposed solutions to the current limitations in membrane recycling.

2. Membrane Disposal and the Non-Biodegradability Issue

Non-biodegradable polymers are utilized extensively for RO membrane synthesis owing to their high thermal and chemical stability. The end-of-life RO membranes are commonly discarded into landfills. The accumulation of non-biodegradable RO membranes in the environment adversely affects wildlife and might affect human communities as well. The membranes tend to break down into their constituting monomers which are usually toxic [11]. Another pollution aspect is landfill leachate which is defined as the toxic liquid that forms due to the leaching of pollutants from a landfill by rainwater [12]. Landfill leachate is a growing environmental concern in low and middle income countries due to the adaptation of the lower-cost open dumps or non-engineered landfills [13]. The extraction of the degraded membrane pieces from either the water or land is expensive and tedious. Furthermore, the degraded pieces can be consumed by land and aquatic animals [14]. Figure 2 illustrates the possible harms caused by landfill leachate. The limited non-biodegradable polymers' recycling infrastructure and elevated mass of disposed materials may lead to the membranes ending up incinerated. End-of-life membrane incineration increases the carbon footprint of the process, contributes to global warming, and increases air pollution through the emission of toxic carbon, nitrogen, and sulfur oxides [15].

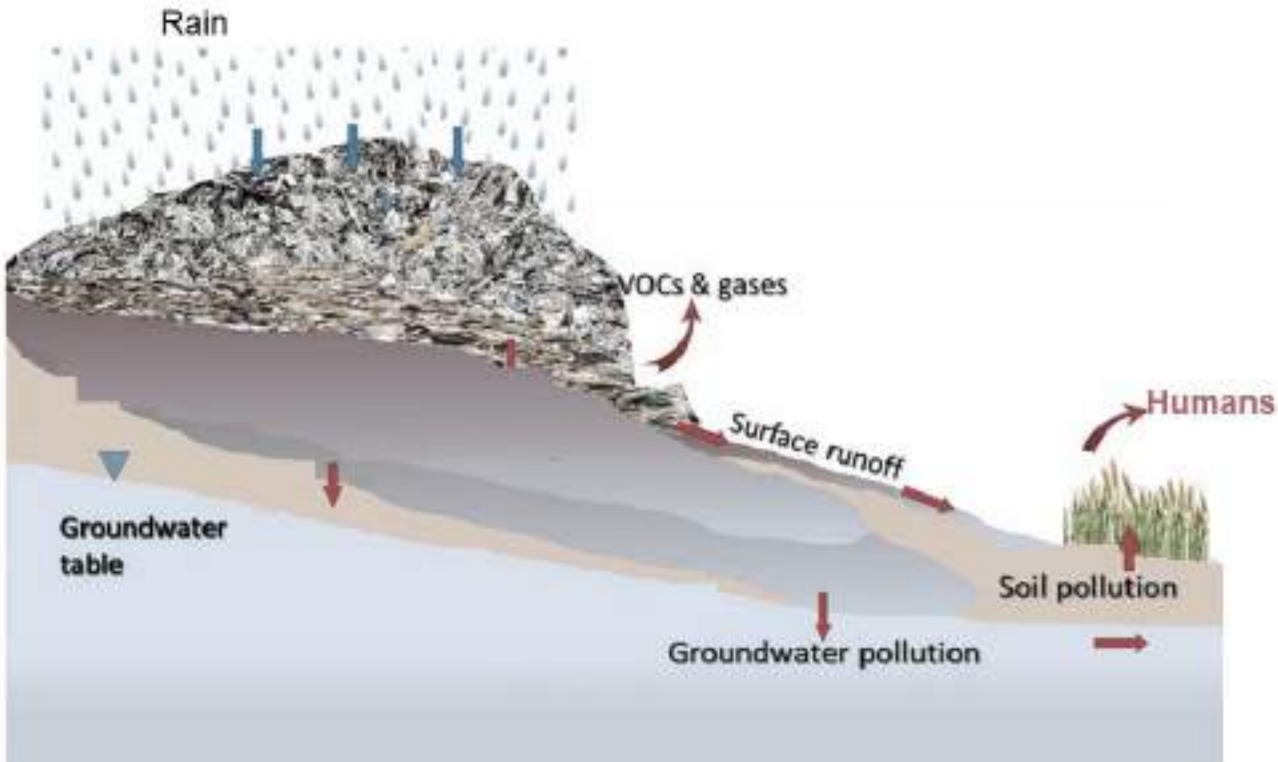

Figure 2 Possible pollutants that leach out to the environment from landfills and the possible pathways.

3. Current Membrane Reuse Options

The waste management hierarchy for RO membranes (Figure 3) prioritizes the possible pathways for reducing environmental pollution from discarded RO membranes. Minimizing the generation of new RO modules is the best option in terms of waste management. Disposal and incineration are the least desired options with efficient energy recovery being a preferable choice than disposal. Direct membrane reuse is recommended over recycling.

Figure 3 End-of-life reverse osmosis membrane management hierarchy.

3.1 Direct Reuse

The research on this approach is very limited in the literature. Two recent publications were reviewed to assess the current state of direct membrane reuse. Pacheco, R. et.al reused discarded 8'' RO membranes from a seawater desalination plant for the treatment of landfill leachate [17]. The authors did not specify the first lifespan of the membrane, however, they stated that the average span considered is within 1 to 3 years. Membrane regeneration to eliminate fouling comprised the use of a chemical wash solution with controlled concentration, pH, and contact time. The membranes with no physical damage could be applied for large-scale treatment while the membranes with external physical damage were used for laboratory tests. Six out of 12 studied membranes could be successfully used for the landfill leachate treatment system. The treatment plant consisted of 12 RO modules in a series double-flow configuration. The plant was operated for 27 months with a combination of the reused membranes and new membranes. the system performance was compared to the system using completely new RO membranes. The treatment results are given in Figure 4. It can be seen that the proper direct reuse of end-of-life RO membranes with new RO membranes could be economically feasible. The transmembrane pressure (TMP) was lower when 50% of the membranes were reused membranes. This is due to the fact that pores expansion occurred during the initial operation period of the membrane and by the chemical cleaning. Remarkably, The treatment efficiency did not vary considerably and remained within the acceptable ranges for water discharge.

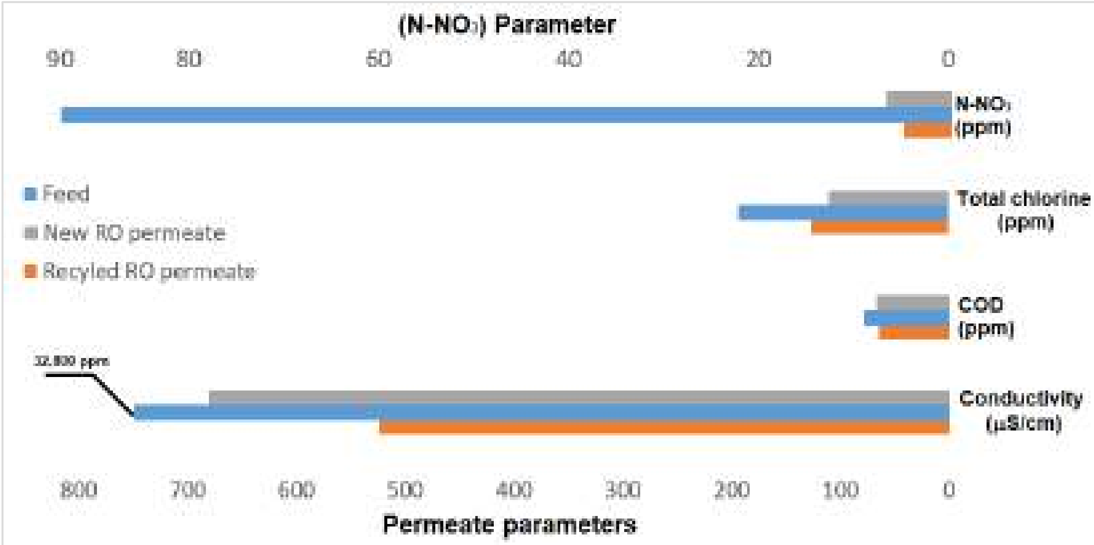

Figure 4 Comparison of the permeate quality from the treatment of landfill leachate.

Another study utilized discarded RO membranes to treat water from a wastewater treatment plant collected after the secondary clarifier step (TDS ~ 1100 ppm, pH ~ 8.05, Total Kjeldahl nitrogen = 33.1 mg/L). The discarded RO membranes were collected from the primary and secondary treatment desalination units and are coded M1 and M2, respectively. Both membranes were initially compared with standard RO membranes against saline water (TDS ~ 33,000 ppm) to assess their performance. The M1 membrane achieved a high rejection of salt (97%) compared to 50% rejection from the M2 membrane. The M1 membrane flux was 34% lower than the standard membrane and that of the M2 membrane was 14% lower than the standard. This is an important result that the feed characteristics to a reverse osmosis membrane during its first lifespan are determinantal to its fate. However, when the membranes were tested for the treatment of secondary wastewater, both membranes achieved high treatment efficiency. The flux was in the range of 56 – 59 L/m2.h and the salt rejection was always higher than 96% at a TMP of 40 bar. Therefore, the membrane state was not a limiting factor in treating mild feeds.

Direct reuse of RO membranes without any additional processing is apparently the most environmentally viable solution. However, a proper assessment of the current state and performance is a must and an efficient chemical cleaning can be essential. A crucial step in membrane reuse is the validation of the old membranes as permeability, rejection, and integrity must be evaluated before involving the membrane back in the process. To do this, a detailed performance report of the membranes after their planned operation time should be acquired from specialized laboratories [19].

3.2 Polyamide Layer Degradation

Most RO membranes utilized currently in industrial applications are thin-film composites consisting of a thin polyamide top layer followed by a porous polysulfone layer, and a polyester support. Therefore, degradation of the polyamide layer can increase the porosity of the RO membrane and achieve water permeabilities within the range of nanofiltration or ultrafiltration [20]. The dense polyamide top layer is prone to degradation by common oxidation agents; Previous studies used different oxidants including sodium hypochlorite, sodium dodecyl sulfate, hydrogen peroxide, potassium permanganate, and acetone [21-23]. The polyamide layer oxidation can be carried out by contacting the membrane in either immersion or active recirculation modes. Active circulation was found to be more effective than passive immersion due to enhanced kinetics and mass transfer [24]. A previous study investigated the effect of contact time of various chemicals on the degradation of the polyamide layer [20]. Dilute sodium hypochlorite was found to be the most efficient in thedegradation of the polyamide layer. The contact time in passive immersion mode had a great influence on the final product permeability and salt rejection. The membrane performance was tested as a function of exposure time to sodium hypochlorite against synthetic brackish water feed (2000 ppm NaCl, 2000 ppm MgSO4, and 250 ppm dextrose). Results showed that the membrane conversion reaction started after 10 hours of modification. Up to 86 hours of degradation the membrane behavior resembled that of a nanofiltration membrane. After 86 hours of degradation, the behavior starts to shift to that of an ultrafiltration membrane. This is obvious from the water permeability and the deterioration in the rejection of the ions. After the first 10 hours, the rejection of the monovalent ions deteriorated rapidly which is an indication of a nanofiltration membrane behavior. After 86 hours, the water permeability increased significantly and the salt rejection started to drop considerably which is an indication of an ultrafiltration membrane.

Larrañaga, A. et.al utilized polysulfone in the preparation of an anion exchange membrane. The polyamide layer was completely eliminated by circulating a 14 wt.% sodium hypochlorite solution [25]. The anion exchange membrane was prepared by casting and phase inversion. The anion exchange resin was mixed with a casting solution containing polyvinyl chloride and the whole solution was cast onto the converted end-of-life RO membrane. The recycled membrane achieved a treatment efficiency that is 87% similar to a standard anion exchange membrane.

4. Current Limitations in RO Membranes Recycling

Recycling of RO membranes is indeed promising in both environmental and economic aspects. However, certain limitations hinder the widespread use of the technology. A main limitation is the use of a proper cleaning solution for a specific membrane condition. If the washing solution is too alkaline, too acidic, or applied for longer periods than required, the membrane will be damaged. Moreover, the current cleaning technologies require a large residence time which in turn increases the capital cost of a large-scale process. In addition, RO membrane cleaning can be ineffective at removing certain contaminants (e.g. bacterial biofilms). Cracking and physical damage to the membrane are other limitations to the process. improper handling during membrane installation can lead to membrane damage and minor cracks development. Moreover, applying overpressure above recommended limits can cause the membrane to crack [26].

5. Conclusion

Membrane recycling and reuse offer numerous advantages. The current methods adapted for end-of-life membrane management such as landfills or incineration are a great waste and adversely affect the environment. The latest trends include using the end-of-life membrane as it is and chemical conditioning for a different application. Reusing the membrane is economically attractive but, the membrane condition strongly affects its applicability. Recycling on the other hand is less affected by the condition of the membrane but requires proper chemical modification. In light of the previous findings, to achieve the circular economy in RO membrane applications, proper handling of the RO membrane in its initial lifespan is mandatory. The operators must ensure regular maintenance, balanced process-chemicals dosing, and the effectiveness of the pretreatment system. A well-established pre-treatment system not only prolongs the lifetime of the RO membrane but also sustains the membrane condition for effective recycling.

References

1. Maddah, Hisham A., Abdulazez S. Alzhrani, M. Bassyouni, M. H. Abdel-Aziz, Mohamed Zoromba, and Ahmed M. Almalki. "Evaluation of various membrane filtration modules for the treatment of seawater." Applied Water Science 8 (2018): 1-13.
2. Elhady, Sarah, Mohamed Bassyouni, Ramadan A. Mansour, Medhat H. Elzahar, Shereen Abdel-Hamid, Yasser Elhenawy, and Mamdou Y. Saleh. "Oily wastewater treatment using polyamide thin film composite membrane technology." Membranes 10, no. 5 (2020): 84.
3. Elhenawy, Y., Kareem Fouad, M. Bassyouni, and Thokozani Majozi. "Design and performance a novel hybrid membrane distillation/humidification–dehumidification system." Energy Conversion and Management 286 (2023): 117039.
4. Mansi, A. E., S. M. El-Marsafy, Y. Elhenawy, and M. Bassyouni. "Assessing the potential and limitations of membrane-based technologies for the treatment of oilfield produced water." Alexandria Engineering Journal (2022).
5.Wang, Jinyan, Jingrun Xing, Ge Li, Zhikan Yao, Zhen Ni, Jing Wang, Songmiao Liang, Zhijun Zhou, and Lin Zhang. "How to extend the lifetime of RO membrane? From the perspective of the end-of-life RO membrane autopsy." Desalination 561 (2023): 116702.
6.Pontié, M., Awad, S., Tazerout, M., Chaouachi, O., & Chaouachi, B. (2017). Recycling and energy recovery solutions of end-of-life reverse osmosis (RO) membrane materials: A sustainable approach. Desalination, 423, 30-40.
7.Rehman, Zia Ur, Hira Amjad, Sher Jamal Khan, Maria Yasmeen, Aftab Ahmad Khan, and Noman Khalid Khanzada. "Performance Evaluation of UF Membranes Derived from Recycled RO Membrane, a Step towards Circular Economy in Desalination." Membranes 13, no. 7 (2023): 628.
8.Polaris Market Research 2021. Reverse Osmosis (RO) Membrane Market Share, Size, Trends, Industry Analysis Report, By End-Use (Water & Wastewater treatment, Industrial Processing); By Type; By Filter Module; By Application; By Region; Segment Forecast, 2022 – 2030. Retrieved from https://www.polarismarketresearch.com/industry-analysis/reverse-osmosis-membrane-market.
9.Lawler, Will, Juan Alvarez-Gaitan, Greg Leslie, and Pierre Le-Clech. "Comparative life cycle assessment of end-of-life options for reverse osmosis membranes." Desalination 357 (2015): 45-54.
10.Morón-López, Jesús, Lucía Nieto-Reyes, Sonia Aguado, Rehab El-Shehawy, and Serena Molina. "Recycling of end-of-life reverse osmosis membranes for membrane biofilms reactors (MBfRs). Effect of chlorination on the membrane surface and gas permeability." Chemosphere 231 (2019): 103-112.
11.Samir, Aya, Fatma H. Ashour, AA Abdel Hakim, and Mohamed Bassyouni. "Recent advances in biodegradable polymers for sustainable applications." Npj Materials Degradation 6, no. 1 (2022): 68.
12.Jayawardhana, Y., P. Kumarathilaka, I. Herath, and M. Vithanage. "Municipal solid waste biochar for prevention of pollution from landfill leachate." In Environmental materials and waste, pp. 117-148. Academic Press, 2016.

13.Wijekoon, Prabuddhi, Pabasari Arundathi Koliyabandara, Asitha T. Cooray, Su Shiung Lam, Bandunee CL Athapattu, and Meththika Vithanage. "Progress and prospects in mitigation of landfill leachate pollution: Risk, pollution potential, treatment and challenges." Journal of hazardous materials 421 (2022): 126627.
14.Eteba, Ahmed, M. Bassyouni, and Mamdouh Saleh. "Removal of hazardous organic pollutants using fly ash." Environ. Ecol. Res 9 (2021): 196-203.
15.Elhenawy, Y., G. H. Moustafa, Attia Mahmoud Attia, A. E. Mansi, Thokozani Majozi, and M. Bassyouni. "Performance enhancement of a hybrid multi effect evaporation/membrane distillation system driven by solar energy for desalination." Journal of Environmental Chemical Engineering 10, no. 6 (2022): 108855.
16.Lejarazu-Larrañaga, Amaia, Junkal Landaburu-Aguirre, Jorge Senán-Salinas, Juan Manuel Ortiz, and Serena Molina. "Thin Film Composite Polyamide Reverse Osmosis Membrane Technology towards a Circular Economy." Membranes 12, no. 9 (2022): 864.
17.García-Pacheco, Raquel, Albert Galizia, Sergi Toribio, Jordi Gabarró, Serena Molina, Junkal Landaburu-Aguirre, Francisco Molina et al. "Landfill Leachate Treatment by Using Second-Hand Reverse Osmosis Membranes: Long-Term Case Study in a Full-Scale Operating Facility." Membranes 12, no. 11 (2022): 1170.
18.Mejía, Hugo Fernando Giraldo, Javiera Toledo-Alarcón, Barbara Rodriguez, José Rivas Cifuentes, Francisco Ovalle Porré, María Paz Loebel Haeger, Natalia Vicencio Ovalle, Carmen Lacoma Astudillo, and Andreina García. "Direct recycling of discarded reverse osmosis membranes for domestic wastewater treatment with a focus on water reuse." Chemical Engineering Research and Design 184 (2022): 473-487.
19.Senan-Salinas, Jorge, Alberto Blanco, Raquel Garcia-Pacheco, Junkal Landaburu-Aguirre, and Eloy Garcia-Calvo. "Prospective Life Cycle Assessment and economic analysis of direct recycling of end-of-life reverse osmosis membranes based on Geographic Information Systems." Journal of Cleaner Production 282 (2021): 124400.
20.García-Pacheco, Raquel, Junkal Landaburu-Aguirre, Serena Molina, Laura Rodríguez-Sáez, Shivanand B. Teli, and Eloy García-Calvo. "Transformation of end-of-life RO membranes into NF and UF membranes: Evaluation of membrane performance." Journal of Membrane Science 495 (2015): 305-315.
21.Stolov, Mikhail, and Viatcheslav Freger. "Degradation of polyamide membranes exposed to chlorine: an impedance spectroscopy study." Environmental science & technology 53, no. 5 (2019): 2618-2625.
22.Zeng, Ganning, Guannan Lian, Yicheng Zhang, Lu Gan, Yong Zhou, Junhong Qiu, Bart van der Bruggen, and Jiangnan Shen. "Potential applications of abandoned aromatic polyamide reverse osmosis membrane by hypochlorite degradation." RSC advances 6, no. 15 (2016): 12263-12271.
23.Yu, Ling, Ran Ling, J. Paul Chen, and Martin Reinhard. "Quantitative assessment of the iron-catalyzed degradation of a polyamide nanofiltration membrane by hydrogen peroxide." Journal of Membrane Science 588 (2019): 117154.
24.Surawanvijit, Sirikarn, Anditya Rahardianto, and Yoram Cohen. "An Integrated approach for characterization of polyamide reverse osmosis membrane degradation due to exposure to free chlorine." Journal of Membrane Science 510 (2016): 164-173.
25.Lejarazu-Larrañaga, Amaia, Serena Molina, Juan Manuel Ortiz, Rodrigo Navarro, and Eloy García-Calvo. "Circular economy in membrane technology: Using end-of-life reverse osmosis modules for preparation of recycled anion exchange membranes and validation in electrodialysis." Journal of Membrane Science 593 (2020): 117423.

26.Senán-Salinas, Jorge, Junkal Landaburu-Aguirre, Jorge Contreras-Martinez, and Eloy García-Calvo. "Life Cycle Assessment application for emerging membrane recycling technologies: From reverse osmosis into forward osmosis." Resources, Conservation and Recycling 179 (2022): 106075.
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Solar Panel Optimization Based on Graphene-Silicon-Droplet Integration

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Abstract:

Solar panels play a vital role in renewable energy systems by converting sunlight into electricity. However, traditional panels have faced limitations in efficiency and cost-effectiveness, hindering widespread adoption. Recent advancements have focused on improving solar panel technologies, including the integration of perovskite-graphene, perovskite-silicon, and droplet materials. Perovskite solar cells have garnered attention due to their strong light-absorption properties and ease of fabrication, offering potential efficiency enhancements. Combining graphene and silicon in perovskite layers introduces benefits, such as improved panel efficiency through enhanced charge transport. Graphene's exceptional conductivity and durability further bolster performance. Additionally, the innovative concept of raindrop energy harvesting capitalizes on falling raindrops' kinetic energy to generate bursts of electrical charge, expanding sustainable energy capture possibilities, especially in regions with ample rainfall. This review comprehensively explores hybrid perovskite-silicon and perovskite-graphene solar panels, coupled with raindrop energy harvesting, elucidating principles, challenges, and potential applications. By evaluating research findings and technological advancements, this approach offers insight into the evolution of solar energy systems, addressing growing energy demands and the urgency for renewable sources.

1. Introduction:

Solar energy has emerged as a pivotal solution in the quest for sustainable and clean energy sources. The rapid advancements in solar panel technologies have led to increased energy conversion efficiencies and expanded deployment. However, the pursuit of even greater efficiency and functionality continues to drive innovative research in this field. A captivating avenue of exploration is the integration of hybrid solar panels, combining the prowess of perovskite, silicon, graphene, and raindrop energy harvesting. This review delves into the intricacies of this promising technology, shedding light on its potential to reshape the landscape of solar energy capture and utilization.

The introduction of graphene, an exceptional conductor with remarkable mechanical and electrical properties, into this dynamic amalgamation ushers in a new era of solar panel design. Graphene's conductivity provides an avenue for improved charge transport, thereby amplifying overall panel efficiency. The latest achievement in graphene-perovskite research has yielded an impressive efficiency of 20.3% in solar cell performance [1]. This breakthrough was achieved through a layered configuration consisting of ITO (Indium Tin Oxide) as the transparent front electrode, SnO_2-GQDs (Tin Oxide with Graphene Quantum Dots) to enhance electrical properties, $CH_3NH_3PbI_3$ (Methylammonium Lead Iodide) as the light-absorbing perovskite layer, Spiro-OMeTAD for efficient hole transport, and Au (Gold) as the back electrode for effective current collection. This innovative arrangement showcases a significant advancement in graphene-perovskite solar cell technology, pushing the boundaries of energy conversion efficiency to 20.3%. [2]

Perovskite-silicon hybrid solar cells represent a significant leap forward in solar energy technology. Perovskite-silicon solar cells hold the potential to achieve higher efficiencies by integrating the exceptional light-absorption properties of perovskite materials with the well-established efficiency of silicon, making strides toward more cost-effective and sustainable solar energy solutions. Additionally, the combination of perovskite, silicon, and graphene augments the durability and longevity of the solar panel, promising enhanced performance over extended lifetimes [3]. In recent advancements in silicon-perovskite research, a team of scientists led by Saudi Arabia's KAUST has achieved an exceptional power conversion efficiency of 33.7% for a perovskite-silicon solar cell. Notably, this 1 cm^2 cell demonstrated impressive performance metrics, including an open-circuit voltage of 1.974 V, a short-circuit current density of

20.99 mA/cm², and a remarkable fill factor of 81.3%. This groundbreaking achievement highlights the significant progress in pushing the efficiency boundaries of silicon-perovskite solar cell technology, showcasing its potential for high-performance and sustainable energy conversion. [4]

An ingenious twist to this technological narrative is the incorporation of raindrop energy harvesting. The notion of capturing energy from raindrops not only speaks to innovative engineering but also addresses the growing need for diversified energy sources. Raindrop impact, otherwise an untapped resource, presents an opportunity to supplement solar energy conversion by harnessing the kinetic energy of falling raindrops [5]. This concept opens doors to novel applications, particularly in regions characterized by frequent rainfall or variable weather patterns. The most recent accomplishment in droplet energy harvesting (DEH) involves the development of a strip-like DEH panel. This innovative design transition from coplanar-electrode DEH panels delicately addresses the parasitic capacitance challenge, resulting in a remarkable achievement of sustaining a high output voltage of 103.47V. This advancement underscores the potential of the strip-like DEH panel to overcome technical limitations and achieve substantial gains in energy harvesting efficiency. [6]

This paper navigates the complexities and potential of dual-layer perovskite-silicon and perovskite-graphene solar panels crowned with raindrop energy harvesting technology. By examining the underlying principles, addressing challenges, and envisioning practical applications, this study contributes to the evolving discourse on harnessing renewable energy from multiple fronts. As the world steers toward a sustainable energy future, the integration of cutting-edge technologies like these hybrid solar panels, equipped to capture the energy of raindrops, holds the promise of reshaping our energy landscape.

2. Proposed Structure

The whole solar panel configuration represents a pioneering amalgamation of advanced materials and energy capture mechanisms. Comprising two perovskite layers, a silicon layer, and a graphene layer, this innovative design optimally captures sunlight for conversion into electricity. The perovskite layers excel in light absorption, generating electron-hole pairs to initiate energy conversion. Silicon enhances charge separation and collection efficiency. Graphene, a superior conductor, facilitates charge transport, amplifying overall panel performance.

Topping this intricate structure is a raindrop panel, (see Fig.1) a remarkable addition that harnesses rain's kinetic energy. As raindrops impact the panel, they generate electrical charge, further contributing to power generation. This adaptive and multifunctional configuration demonstrates the synergy between diverse materials and energy sources, making the whole solar panel a promising contender for efficient and sustainable energy harvesting in diverse environmental conditions.

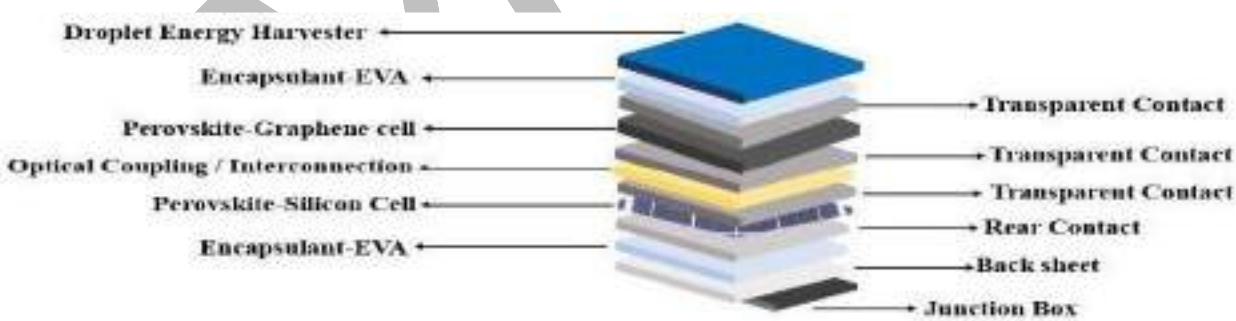

Figure 1: Structure of the proposed solar panel

3. Perovskite/Silicon tandem solar cell:

The fabrication process of perovskite/silicon tandem solar cells combines perovskite and silicon technologies to create a unified device with enhanced solar spectrum capture and greater overall efficiency.

The optimized parameters are as follows: a top perovskite layer thickness of 100 nm, doping concentrations of 5 × 1019 cm-3, and defect density of 1 × 1013 cm-3. For the bottom silicon absorber layer, the optimized parameters are a thickness of 50 μm, doping concentrations of 5 × 1016 cm-3, defect density of 1 × 1012 cm-3, and a work function of 5.3 eV. Chlorinated ITO serves as the front contact of the tandem cell. [7]

This optimization resulted in impressive efficiency (29.82%), a high VOC of 0.7992 V, a JSC density of 43.39 mA/cm2, and a substantial fill factor of 85.98% for the 2T Cs0.8Rb0.2SnI3 perovskite – silicon tandem solar cell (See Fig.2). [8]

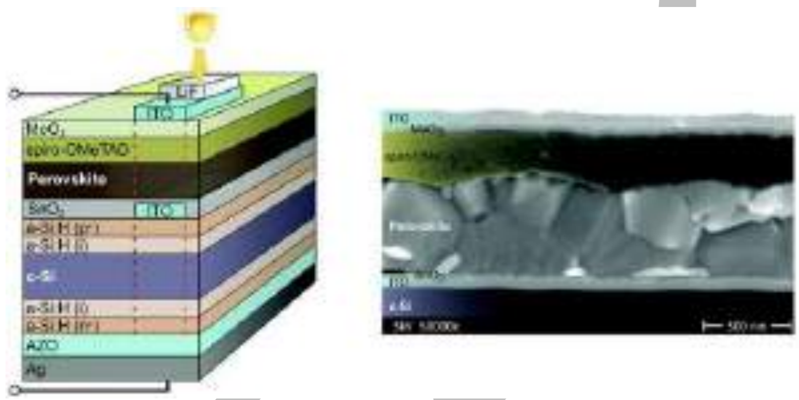

Figure 2: The device structure and corresponding cross-section scanning electron microscope image of a 2T perovskite/Si tandem solar cell with conductive ITO layer as the interconnection layer between sub cells.

3.1. Perovskite fabrication:

ITO-coated glass slides will be vertically processed: acetone ultrasonic treatment, surfactant-enhanced purified water bath, deionized water bath, and isopropanol bath. Slides will be exposed to hot acetone vapor and UV/O3 for 15 min, then moved to a nitrogen glovebox for Cs0.8Rb0.2SnI3 deposition. PC61BM and bathocuproine (BCP) films will follow via thermal evaporation (pressure < 1 × 10−5mbar) with substrate rotation. Aluminum electrodes will be shadow-mask deposited for six devices per slide. [9]

3.2. Silicon fabrication:

In this research, all Si films will be produced using the HWCVD process at a substrate temperature of 150°C, filament temperature of 1700°C, total gas flow of 20 sccm, and gas pressure of 1 Pa. The doping gas concentration (Sd = dopant/ (dopant + SiH4 + H2)) for n-type and p-type films will be maintained between 0.1% and 1%. Before Si film deposition, c-Si wafers will be dipped in a 2% HF solution to etch the native oxide. The c-Si substrate will then undergo H atom pre-treatment, involving H2 decomposition through 1700°C hot filaments for 10–180 seconds. Aluminum paste will be screen-printed for the rear surface (Al) and graphite inks for Ag electrodes. [10]

3.3. Silicon- perovskite tandem Fabrication:

On the fabricated silicon solar cell, just before metallization, a layer of Cs0.8Rb0.2SnI3 prepared from room temperature solutions of RbI, CsI and SnCl2 and tin (II) halide mixed together in 0.8: 0.2: 1: 0.1 M ratio, deposited by spin coating and thereafter, chlorinated ITO deposited by thermal evaporation. [11]

3.4. Simulation and Results:

Utilizing SCAPS-1D software (ver. 3.3.03), parameters were adjusted in various software panels to model device behavior in a two-band gap system. Here, higher/lower bandgap absorber materials create upper/lower cells for optimal operation, with perovskite bandgaps (1.4-1.9 eV) surpassing silicon (≈1.1 eV), crucial for efficient two-band gap structures. SCAPS employs Poisson's equation (1) for semiconductors' electrons and holes, alongside continuity and transport equations (2), (3), solved via Newton-Raphson and Gummel methods [7]. The simulation outcomes underscore the significance of fine-tuning absorber thickness, defect, and doping densities, electron transport layer (ETL) thickness, and conduction band offset (CBO) for enhanced efficiency in Cs1-xRbxSnI3 perovskite. Optimization of these factors, along with absorber and defect densities, led to impressive efficiency levels in both the Cs1-xRbxSnI3 and C-Si (p) absorber layers within the perovskite-silicon tandem solar cell configuration. [12]

$$\frac{d}{dx}\left(\in[x]\frac{d\varphi}{dx}\right) = q[p(x) - n(x) + N_d + (x) - N_a - (x) + p_t\,(x) - \; n_t\,(x)] \qquad \text{Equ (1)}$$

$$\frac{dp_n}{dt} = G_P - \frac{P_n - P_{no}}{\mathcal{T}_P} - P_n\,u_P\,\frac{dE}{dx} - \; u_P\,E\,\frac{dp_n}{dx} + D_P\,\frac{d^2p_n}{dx^2} \qquad \text{Equ (2)}$$

$$\frac{dn_P}{dt} = G_n - \frac{n_p - n_{po}}{\mathcal{T}_n} - n_p\,u_n\,\frac{dE}{dx} - \; u_n\,E\,\frac{dn_p}{dx} + D_n\,\frac{d^2n_p}{dx^2} \qquad \text{Equ (3)}$$

Where:

$\in[x]$ Permittivity as a function of position x	u_P : Hole mobility
$\frac{d\varphi}{dx}$ Gradient of electric potential with respect to position x	$\frac{dE}{dx}$: Gradient of electric field with respect to position x
q : Elementary charge	E : Electric field strength
$p(x)$: Hole concentration at position x	D_P: Diffusion coefficient for holes
$n(x)$: Electron concentration at position x	$\frac{d^2p_n}{dx^2}$: Second derivative of hole concentration with respect to position x
$N_d + (x)$ Concentration of ionized acceptor dopants at position x	$\frac{dn_P}{dt}$: Time derivative of electron concentration, n_p
$N_a - (x)$: Concentration of ionized donor dopants at position x	G_n: Generation rate of electron-hole pairs per unit volume
$p_t\,(x)$: Concentration of trapped holes at position x	n_p: Electron concentration
$n_t\,(x)$: Concentration of trapped electrons at position x	n_{po}: Equilibrium electron concentration
$\frac{dp_n}{dt}$: Time derivative of hole concentration, p_n	$\mathcal{T}_n$: Characteristic recombination time for electrons
G_P : Generation rate of electron-hole pairs per unit volume	u_n : Electron mobility
P_n : Hole concentration	$\frac{dE}{dx}$: Gradient of electric field with respect to position x
P_{no} : Equilibrium hole concentration	D_n: Diffusion coefficient for electrons
$\mathcal{T}_P$: Characteristic recombination time for holes	$\frac{d^2n_p}{dx^2}$: Second derivative of electron concentration with respect to position x

The outcomes presented in (see Table 1) reveal the achieved results, while the J-V spectra illustrated (See Fig.3) further support the findings. Simulation analyses demonstrate that optimization of parameters such as absorber thickness, defect and doping densities, ETL thickness, doping densities, and front contact for Cs1-xRbxSnI3 perovskite significantly contribute to elevated efficiencies. Similarly, considerable efficiency gains were obtained through the meticulous refinement of parameters encompassing thickness, doping densities, and defect densities for both the Cs1-xRbxSnI3 and C-Si (p) absorber layers in the Cs1-xRbxSnI3 perovskite-silicon tandem solar cell.

Table 1: *Initial and refined parameters for Cs1-xRbxSnI3 perovskite and Cs1-xRbxSnI3 perovskite-silicon tandem solar cells.*

SOLAR CELL		Open Circuit Voltage, Voc (V)	Short Circuit Current Density, Jsc (mA/cm2)	Fill Factor, FF (%)	Power Conversion Efficiency, PCE (%)
Cs1-xRbxSnI3	Initial	0.4757	6.63	65.97	2.08
Perovskite	Final	1.0356	23.76	83.18	20.46
Crystalline Silicon		0.7400	43.29	83.30	26.68
Cs1-xRbxSnI3	Initial	0.7855	40.99	85.84	27.64
Perovskite Silicon tandem	Final	0.7992	43.39	85.98	29.82

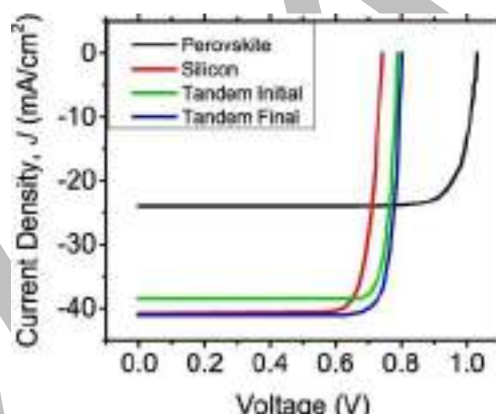

figure (3). Optimized and initial current-voltage (JV) curves for the perovskite, silicon, initial, and final tandem solar cells.

4. Graphene in Perovskite solar cells:

Perovskite solar cells (PSCs) have emerged as a promising avenue for next-generation photovoltaic (PV) technologies, characterized by their rapidly increasing power conversion efficiencies (PCEs) and cost-effectiveness. Despite facing challenges like operational instability in harsh conditions, significant strides have been taken in enhancing the efficiency and stability of PSCs. Notably, the integration of elemental two-dimensional (2D) materials such as graphene, phosphorene, antimonene, bismuthene, and borophene has shown immense potential in various PSC components due to their compelling attributes, including optical transparency, electrical conductivity, and carrier transport properties. These monoelemental 2D materials offer finely tunable electronic properties, rendering them highly attractive for PV applications. (See Fig.4) This review highlights recent breakthroughs and accomplishments in the utilization of monoelemental 2D materials in PSCs. While substantial progress has been achieved in this innovative field, certain aspects remain unresolved, necessitating further exploration. [2]

In recent times, growing interest in elemental two-dimensional (2D) materials stems from their cost-effectiveness, tunability, and compatibility with solution-based processes. Graphene's groundbreaking discovery in 2004 led to notable advancements and a Nobel Prize in Physics in 2010. Concurrently, perovskite solar cell (PSC) research has surged. [13]

Diverse 2D nanomaterials, from graphene to MXene and TMDs, find utility in PSCs. These materials possess unique properties due to their layered structure, including strong in-plane chemical bonds and versatile electronic characteristics. Graphene's strategic integration within PSC layers (See Table 2), significantly enhances efficiency. This synergy between 2D materials and PSC technology showcases promise for innovative solar energy capture and underscores the potential for sustainable energy solutions. [14]

Table 2: Layered Configuration and Efficiency Enhancement: Perovskite and Graphene Integration in Solar Cell Structures

Graphene usage in PSCs layer as	NO.	Device structure	Jsc [mA cm−2]	Voc [V]	FF	PCE [%]	REF.
Transparent Conductive Electrode (TCE)	1.1	PES/graphene/NiOx/CH3NH3PbI3/PCBM/AZO/Ag/AZO	20.90	0.93	0.73	**14.2**	**[15]**
	1.2	PI/Cu-grid/graphene/PEDOT: PSS/perovskite/PC61BM/ZnO/Ag	21.70	0.99	0.76	**16.4**	**[15]**
	1.3	Glass/TFSA-doped-graphene/PEDOT: PSS/FAPbI3−xBrx/PCBM/Al	21.45	1.07	0.77	**18.2**	**[15]**
Electron Transporting Layer (ETL)	2.1	FTO/Graphene/TiO2/CH3NH3PbI3−xClx/Spiro-OMeTAD/Au	21.90	1.04	0.73	**15.6**	**[16]**
	2.2	ITO/SnO2-GQDs/CH3NH3PbI3/Spiro -OMeTAD/Au	23.05	1.13	0.78	**20.3**	**[1]**
	2.3	ITO/SnO2-NDI-graphene/perovskite/Spiro-OMeTAD/Au	22.66	1.08	0.82	**20.2**	**[15]**
Perovskite Layer (PL)	3.1	ITO/cp-TiO2/perovskite/Spiro-OMeTAD/Au	20.10	1.03	0.75	**15.6**	**[17]**
	3.2	FTO/cp-TiO2/mp-TiO2/perovskite-N-rGO/Spiro-OMeTAD/Au	21.80	1.15	0.74	**18.7**	**[18]**
	3.3	FTO/cp-TiO2/mp-TiO2/perovskite/MoS2 QDs:f	22.49	1.11	0.80	**20.1**	**[19]**
HTL	4.1	ITO/GO/CH3NH3PbI3−xClx/PCBM/ZnO/Al	17.46	1.00	0.71	**12.4**	**[20]**
	4.2	FTO/cp-TiO2/perovskite/Spiro-OMeTAD/CVD-graphene/Au	21.10	1.09	0.68	**15.7**	**[15]**
	4.3	ITO/SnO2/perovskite/rGO+Spiro-OMeTAD/Au	23.05	1.11	0.71	**18.1**	**[21]**
Conductive Back Electrode (CBE)	5.1	FTO/cp-TiO2/mp-TiO2/perovskite/graphene	16.70	0.94	0.73	**11.5**	**[22]**
	5.2	FTO/SnO2/perovskite/Spiro-OMeTAD/graphene/graphene/FTO	22.78	1.05	0.78	**18.7**	**[23]**
	5.3	FTO/cp-TiO2/mp-TiO2/perovskite/Spiro-OMeTAD/Ti1-rGO/FTO	26.00	1.06	0.79	**21.6**	**[24]**

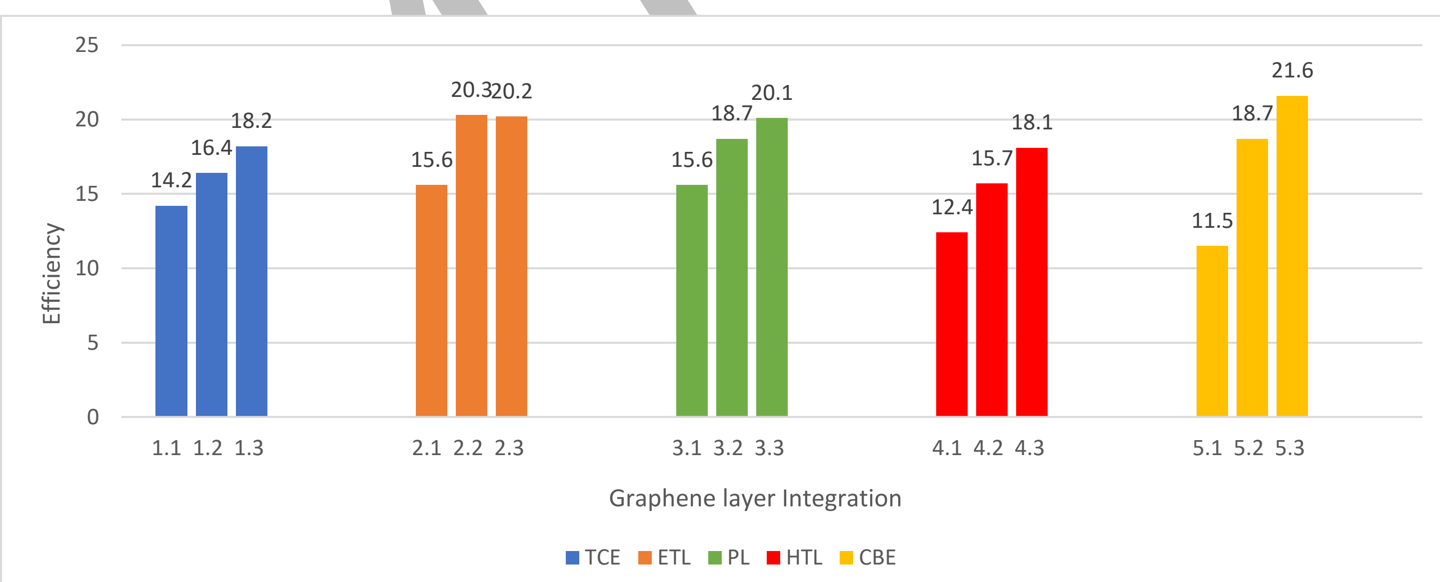

Figure (4). Performance Impact of Graphene Integration in Perovskite Solar Cell Layers: A Comparative Analysis

5. Droplet Layer:

5.1. Latest Research:

Recent studies have introduced a novel approach to enhance droplet energy harvesting (DEH) [25] efficiency through the implementation of a strip-like DEH panel for random droplets. By optimizing the position-sensitive output voltage, peak output is achieved when a droplet contacts the drain electrode at its maximum spreading area, thereby enhancing the overall efficiency of droplet energy harvesting. This innovative design transition from coplanar-electrode DEH panels delicately addresses the parasitic capacitance challenge, resulting in a remarkable achievement of sustaining a high output voltage of 103.47V (see Table 3). [26]

Table 3: Droplet Layer

Cell Type	Coplanar-Electrode DEH Cell
Panel Dimensions	210mm x 297mm
Weight	Very Light
Open Circuit Voltage	26.6 volts
Short Circuit Current	273.6 mA
Output Voltage	103.47 volts

5.2. Mechanism:

The underlying mechanism of these Nano-generators revolves around the interaction between water droplets and dielectric layers. This operational principle is supported by time-resolved voltage waveforms. In a design reminiscent of transistors, the coplanar electrodes and the spreading water droplet assume the roles of: source, drain, and gate, respectively (see Fig.5). The dynamic contact status of the droplet with the drain electrode governs the on/off state of the device. [27]

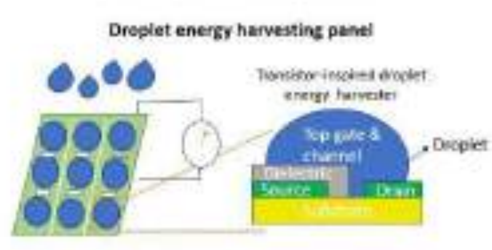

Figure 5: coplanar electrodes and the spreading water

5.3. Efficiency:

The efficiency of this approach hinges on two key factors. Firstly, the attainment of a sizeable droplet spreading area and swift droplet departure are crucial for optimal performance, closely tied to the hydrophobic nature of the dielectric layer. [28, 29] Moreover, augmenting droplet volume and dripping height can further enhance output performance. For dielectric materials, elevated surface charge density and hydrophobicity are prerequisites to achieving heightened output efficiency. [27]

5.3.1 Coplanar-electrode structure for maintaining high performance in a large-area panel

To maintain high performance in large-area panels, the new coplanar electrode DEH cell can effectively mitigate the reversible conversion effect of parasitic capacitance compared to the conventional non-planar electrode DEH cell. The coplanar-electrode DEH panel delicately alleviates the parasitic capacitance issue, maintaining a high output voltage of 103.47 volts. [26,]

5.3.2 Environmental Impact

It characterized the robustness under two extreme conditions:

1. When the source–drain gap was covered by water, the output performance remained unchanged.
2. After taking out from water, the output voltage gradually recovered and stabilized at about 220 V in 3 min.

The study ensured stable output voltages (170 V to 240 V) for three samples over a 6-month span, with output variations attributed to surface charge density changes during storage. Sample 3's performance was restored and improved by rubbing it with Nylon, yielding a remarkable output of around 340 V—surpassing untreated devices. These findings underscore the durability and potential of the droplet energy harvesting panels for practical applications, emphasizing stability and performance endurance. [26]

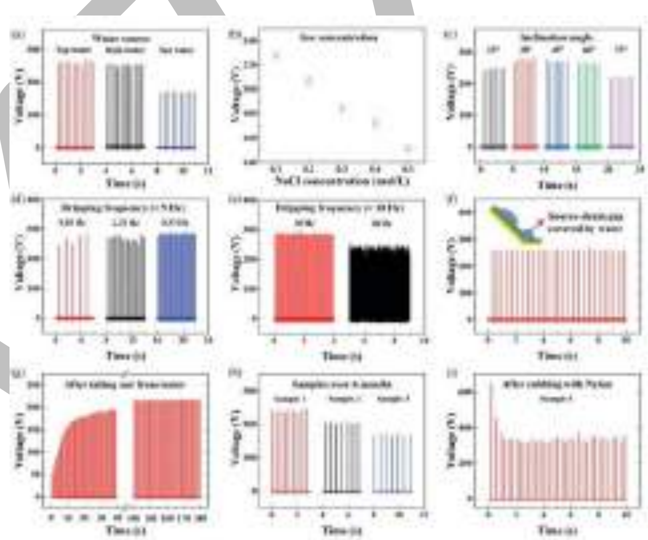

Figure 3: Robustness and stability. (a) Water source; (b) ion concentration; (c) inclination angle; (d) dripping frequency (o5 Hz); (e) dripping frequency (410 Hz); (f) source–drain gap covered by water; (g) after taking out from water; (h) samples over 6 months; (i) performance recover

5.4. Materials:

This transistor inspired structure DEH cell consists of 3 layers (see Fig.6): [27]

1. The coplanar source electrode and drain electrode which separated by etching a gap with a width of 1 mm on the ITO.
2. A fluorinated ethylene propylene (FEP) layer, a promising dielectric material with strong electron-attraction ability. [28, 29]
3. Substrate of polyethylene terephthalate (PET), hydrophobic material.

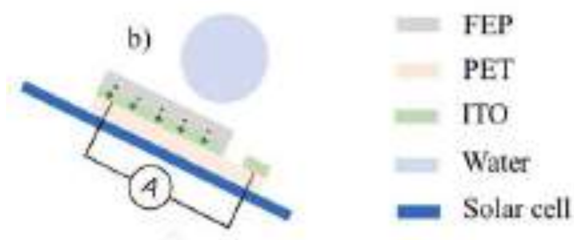

Figure 6: schematic drawings of its working principle

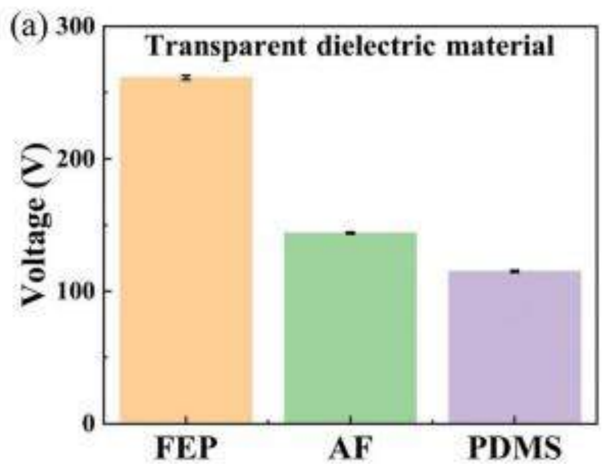

Figure 7: Output performances; using various transparent dielectric materials.

4.5 Power Generation and Voltage:

In the context of large-area panels, the coplanar-electrode DEH panel demonstrates its prowess in effectively mitigating parasitic capacitance concerns, thereby sustaining an impressive output voltage of 103.47V. For broader validation, we conducted a comparative analysis of output performances using various transparent dielectric materials (see Fig.7). Remarkably, the average output for FEP material reached 266.6 V. Notably, the chosen FEP material in this study boasts a combination of advantageous attributes, including heightened surface charge density, pronounced hydrophobicity, exceptional transparency, and cost-effectiveness. [26]

6. Conclusion:

In conclusion, this paper highlights a remarkable convergence of scientific innovation and technological prowess in the realm of solar energy harvesting. The integration of two perovskite layers, one with silicon and the other with graphene, has yielded a monumental achievement with an exceptional efficacy of up to 33.7% and 23.1% respectively. This synergistic approach showcases the potential for significantly elevating the efficiency of solar panels through strategic material pairing and optimization. Furthermore, the addition of a raindrop energy harvesting panel atop this hybrid configuration introduces a pioneering avenue for harnessing renewable energy. The ability to collect energy from raindrops, coupled with the impressive output voltage of 103 V DC, underscores the comprehensive and forward-thinking nature of this research. the presented solar panel configuration embodies a significant stride towards meeting these challenges. This multi-layered approach, encompassing perovskite, silicon, graphene, and raindrop energy harvesting, epitomizes the synthesis of scientific discovery and practical application. The amalgamation of these elements not only holds promise for advancing the efficiency and viability of solar energy capture but also offers a glimpse into the potential for diversified and adaptable energy solutions in an ever-evolving energy landscape. With its impressive achievements and innovative design, this research opens doors to a future where renewable energy generation is both efficient and resilient, making a profound impact on the global pursuit of sustainable development.

Reference:

[1] Suragtkhuu, S., Sunderiya, S., Myagmarsereejid, P., Purevdorj, S., Bati, A. S. R., Bold, B., Zhong, Y. L., Davaasambuu, S., & Batmunkh, M. (2023). Graphene-Like Monoelemental 2D Materials for Perovskite Solar Cells. In Advanced Energy Materials (Vol. 13, Issue 12, p. 2204074). Wiley. https://doi.org/10.1002/aenm.202204074

[2] Xie, J., Huang, K., Yu, X., Yang, Z., Xiao, K., Qiang, Y., Zhu, X., Xu, L., Wang, P., Cui, C., & Yang, D. (2017). Enhanced Electronic Properties of SnO2 via Electron Transfer from Graphene Quantum Dots for Efficient Perovskite Solar Cells. In ACS Nano (Vol. 11, Issue 9, pp. 9176–9182). American Chemical Society (ACS). https://doi.org/10.1021/acsnano.7b04070

[3] Lamanna, E., Matteocci, F., Calabrò, E., Serenelli, L., Salza, E., Martini, L., Menchini, F., Izzi, M., Agresti, A., Pescetelli, S., Bellani, S., Del Río Castillo, A. E., Bonaccorso, F., Tucci, M., & Di Carlo, A. (2020). Mechanically Stacked, Two-Terminal Graphene-Based Perovskite/Silicon Tandem Solar Cell with Efficiency over 26%. In Joule (Vol. 4, Issue 4, pp. 865–881). Elsevier BV. https://doi.org/10.1016/j.joule.2020.01.015

[4] Xu, L., Liu, J., Toniolo, F., De Bastiani, M., Babics, M., Yan, W., Xu, F., Kang, J., Allen, T., Razzaq, A., Aydin, E., & De Wolf, S. (2022). Monolithic Perovskite/Silicon Tandem Photovoltaics with Minimized Cell-to-Module Losses by Refractive-Index Engineering. In ACS Energy Letters (Vol. 7, Issue 7, pp. 2370–2372). American Chemical Society (ACS). https://doi.org/10.1021/acsenergylett.2c01142

[5] Xu, X., Li, P., Ding, Y., Xu, W., Liu, S., Zhang, Z., Wang, Z., & Yang, Z. (2022). Droplet energy harvesting panel. In Energy & Environmental Science (Vol. 15, Issue 7, pp. 2916–2926). Royal Society of Chemistry (RSC). https://doi.org/10.1039/d2ee00357k

[6] Helseth, L. E. (2021). Harvesting energy from light and water droplets by covering photovoltaic cells with transparent polymers. In Applied Energy (Vol. 300, p. 117394). Elsevier BV. https://doi.org/10.1016/j.apenergy.2021.117394

[7] Akoto, E., Isahi, V., Odari, V., Maghanga, C., & Nyongesa, F. (2023). Monolith Cs1-xRbxSnI3 perovskite – silicon 2T tandem solar cell using SCAPS-1D. In Results in Optics (Vol. 12, p. 100470). Elsevier BV. https://doi.org/10.1016/j.rio.2023.100470

[8] Cheng, Y., & Ding, L. (2021). Perovskite/Si tandem solar cells: Fundamentals, advances, challenges, and novel applications. In SusMat (Vol. 1, Issue 3, pp. 324–344). Wiley. https://doi.org/10.1002/sus2.25

[9] Qasim Agha, D. N., & Algwari, Q. T. (2021). The influence of the interface layer between the electron transport layer and absorber on the performance of perovskite solar cells. In IOP Conference Series: Materials Science and Engineering (Vol. 1152, Issue 1, p. 012033). IOP Publishing. https://doi.org/10.1088/1757-899x/1152/1/012033

[10] Almansouri, I., Ho-Baillie, A., Bremner, S. P., & Green, M. A. (2015). Supercharging Silicon Solar Cell Performance by Means of Multijunction Concept. In IEEE Journal of Photovoltaics (Vol. 5, Issue 3, pp. 968–976). Institute of Electrical and Electronics Engineers (IEEE). https://doi.org/10.1109/jphotov.2015.2395140

[11] Nowsherwan, G. A., Jahangir, K., Usman, Y., Saleem, W., & Khalid, M. (2021). Numerical Modeling and Optimization of Perovskite Silicon Tandem Solar Cell Using SCAPS-1D. Sch Bull, 7(7), 171-184.

[12] Babics, M., De Bastiani, M., Ugur, E., Xu, L., Bristow, H., Toniolo, F., Raja, W., Subbiah, A. S., Liu, J., Torres Merino, L. V., Aydin, E., Sarwade, S., Allen, T. G., Razzaq, A., Wehbe, N., Salvador, M. F., & De Wolf, S. (2023). One-year outdoor operation of monolithic perovskite/silicon tandem solar cells. In Cell Reports Physical Science (Vol. 4, Issue 2, p. 101280). Elsevier BV. https://doi.org/10.1016/j.xcrp.2023.101280

[13] Gong, K., Hu, J., Cui, N., Xue, Y., Li, L., Long, G., & Lin, S. (2021). The roles of graphene and its derivatives in perovskite solar cells: A review. In Materials & Design (Vol. 211, p. 110170). Elsevier BV. https://doi.org/10.1016/j.matdes.2021.110170

[14] Muchuweni, E., Martincigh, B. S., & Nyamori, V. O. (2021). Perovskite Solar Cells: Current Trends in Graphene-Based Materials for Transparent Conductive Electrodes, Active Layers, Charge Transport Layers, and Encapsulation Layers. In Advanced Energy and Sustainability Research (Vol. 2, Issue 9, p. 2100050). Wiley. https://doi.org/10.1002/aesr.202100050

[15] Hong, J. A., Jung, E. D., Yu, J. C., Kim, D. W., Nam, Y. S., Oh, I., Lee, E., Yoo, J.-W., Cho, S., & Song, M. H. (2019). Improved Efficiency of Perovskite Solar Cells Using a Nitrogen-Doped Graphene-Oxide-Treated Tin Oxide Layer. In ACS Applied Materials & Interfaces (Vol. 12, Issue 2, pp. 2417–2423). American Chemical Society (ACS). https://doi.org/10.1021/acsami.9b17705

[16] Wang, J. T.-W., Ball, J. M., Barea, E. M., Abate, A., Alexander-Webber, J. A., Huang, J., Saliba, M., Mora-Sero, I., Bisquert, J., Snaith, H. J., & Nicholas, R. J. (2013). Low-Temperature Processed Electron Collection Layers of Graphene/TiO2 Nanocomposites in Thin Film Perovskite Solar Cells. In Nano Letters (Vol. 14, Issue 2, pp. 724–730). American Chemical Society (ACS). https://doi.org/10.1021/nl403997a

[17] Li, H., Tao, L., Huang, F., Sun, Q., Zhao, X., Han, J., Shen, Y., & Wang, M. (2017). Enhancing Efficiency of Perovskite Solar Cells via Surface Passivation with Graphene Oxide Interlayer. In ACS Applied Materials & Interfaces (Vol. 9, Issue 44, pp. 38967–38976). American Chemical Society (ACS). https://doi.org/10.1021/acsami.7b10773

[18] Hadadian, M., Correa-Baena, J.-P., Goharshadi, E. K., Ummadisingu, A., Seo, J.-Y., Luo, J., Gholipour, S., Zakeeruddin, S. M., Saliba, M., Abate, A., Grätzel, M., & Hagfeldt, A. (2016). Enhancing Efficiency of Perovskite Solar Cells via N-doped Graphene: Crystal Modification and Surface Passivation. In Advanced Materials (Vol. 28, Issue 39, pp. 8681–8686). Wiley. https://doi.org/10.1002/adma.201602785

[19] Najafi, L., Taheri, B., Martín-García, B., Bellani, S., Di Girolamo, D., Agresti, A., Oropesa-Nuñez, R., Pescetelli, S., Vesce, L., Calabrò, E., Prato, M., Del Rio Castillo, A. E., Di Carlo, A., & Bonaccorso, F. (2018). MoS2 Quantum Dot/Graphene Hybrids for Advanced Interface Engineering of a CH3NH3PbI3 Perovskite Solar Cell with an Efficiency of over 20%. In ACS Nano (Vol. 12, Issue 11, pp. 10736–10754). American Chemical Society (ACS). https://doi.org/10.1021/acsnano.8b05514

[20] Wu, Z., Bai, S., Xiang, J., Yuan, Z., Yang, Y., Cui, W., Gao, X., Liu, Z., Jin, Y., & Sun, B. (2014). Efficient planar heterojunction perovskite solar cells employing graphene oxide as hole conductor. In Nanoscale (Vol. 6, Issue 18, pp. 10505–10510). Royal Society of Chemistry (RSC). https://doi.org/10.1039/c4nr03181d

[21] Suragtkhuu, S., Tserendavag, O., Vandandoo, U., Bati, A. S. R., Bat-Erdene, M., Shapter, J. G., Batmunkh, M., & Davaasambuu, S. (2020). Efficiency and stability enhancement of perovskite solar cells using reduced graphene oxide derived from earth-abundant natural graphite. In RSC Advances (Vol. 10, Issue 15, pp. 9133–9139). Royal Society of Chemistry (RSC). https://doi.org/10.1039/d0ra01423k

[22] Yan, K., Wei, Z., Li, J., Chen, H., Yi, Y., Zheng, X., Long, X., Wang, Z., Wang, J., Xu, J., & Yang, S. (2015). High-Performance Graphene-Based Hole Conductor-Free Perovskite Solar Cells: Schottky Junction Enhanced Hole Extraction and Electron Blocking. In Small (Vol. 11, Issue 19, pp. 2269–2274). Wiley. https://doi.org/10.1002/smll.201403348

[23] Zhang, C., Wang, S., Zhang, H., Feng, Y., Tian, W., Yan, Y., Bian, J., Wang, Y., Jin, S., Zakeeruddin, S. M., Grätzel, M., & Shi, Y. (2019). Efficient stable graphene-based perovskite solar cells with high flexibility in device assembling via modular architecture design. In Energy & Environmental Science (Vol. 12, Issue 12, pp. 3585–3594). Royal Society of Chemistry (RSC). https://doi.org/10.1039/c9ee02391g

[24] Zhang, C., Liang, S., Liu, W., Eickemeyer, F. T., Cai, X., Zhou, K., Bian, J., Zhu, H., Zhu, C., Wang, N., Wang, Z., Zhang, J., Wang, Y., Hu, J., Ma, H., Xin, C., Zakeeruddin, S. M., Grätzel, M., & Shi, Y. (2021). Ti1–graphene single-atom material for improved energy level alignment in perovskite solar cells. In Nature Energy (Vol. 6, Issue 12, pp. 1154–1163). Springer Science and Business Media LLC. https://doi.org/10.1038/s41560-021-00944-0

[25] Guigon R, Chaillout JJ, Jager T, Despesse G. Harvesting raindrop energy: experimental study. Smart Mater Struct 2008; 17:015039. https://doi.org/ 10.1088/0964-1726/17/01/015039.

[26] Xu, X., Li, P., Ding, Y., Xu, W., Liu, S., Zhang, Z., Wang, Z., & Yang, Z. (2022). Droplet energy harvesting panel. In Energy & Environmental Science (Vol. 15, Issue 7, pp. 2916–2926). Royal Society of Chemistry (RSC). https://doi.org/10.1039/d2ee00357k

[27] Helseth, L. E. (2021). Harvesting energy from light and water droplets by covering photovoltaic cells with transparent polymers. Applied Energy, 300, 117394.

[28] Zheng L, Lin ZH, Cheng G, Wu W, Wen X, Lee S, et al. Silicon-based hybrid cell for harvesting solar energy and raindrop electrostatic energy. Nano Energy 2014;9: 291–300. https://doi.org/10.1016/j.nanoen.2014.07.024.

[29] Zheng L, Cheng G, Chen J, Lin L, Wang J, Liu Y, et al. A hybridized power panel to simultaneously generate electricity from sunlight, raindrops, and wind around the clock. Adv Energy Mater 2015;1501152. https://doi.org/10.1002/ aenm.201501152.

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4th International Conference for Membrane Technology & Its Applications

Acceptance letter

Dear Dr. Ahmed Abdelnaby Kabeel

Thank you for submitting an Abstract/Article to present at the 4th International Conference for Membrane Technology and Its Applications which is scheduled to take place between 28-29 August 2023, Grand Hotel, Port Said City, Egypt. On behalf of the Organizing Committee, I am delighted to inform you that your Abstract/Article entitled "Solar Panel Optimization Based on Graphene-Silicon-Droplet Integration" has been accepted for Oral presentation. We look forward to your presentation.

Your details are as follows:

Title:	Solar Panel Optimization Based on Graphene-Silicon-Droplet Integration
Authors:	Nada A. Abd Elshafy, Abdelrahman E. Hamouda, Arwa E. Abozaher, Haneen M. Siyaam, Ahmed A. Kabeel
Presenting Author:	Dr. Ahmed Abdelnaby Kabeel

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Title:	Technologies for wastewater treatment in aquaponics and their sustainability: A review
Authors:	Mohamed Elsayed Gabr, Nawaf S. Alhajeri, Fahad M. Al-Fadhli, and Salem Al Jabri
Presenting Author:	Mohamed Elsayed Gabr

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Your details are as follows:

Title:	Approach to designing a vertical sub-surface flow constructed wetland for wastewater treatment in arid climates
Authors:	Mohamed Elsayed Gab, and Osami Saied Rageh
Presenting Author:	Dr. Mohamed Elsayed Gabr

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4th International Conference for Membrane Technology & Its Applications

Acceptance letter

Dear Assoc. Prof. Ramadan Abd-Alghany Ali Elkateb

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Your details are as follows:

Title:	Residual Soil as Low-cost natural adsorbent for adsorption of cationic dye from aqueous solutions
Authors:	R.A. Mansour, Riham Atif
Presenting Author:	Assoc. Prof. Ramadan Abd-Alghany Ali Elkateb

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4th International Conference for Membrane Technology & Its Applications

Acceptance letter

Dear Dr. Sohier Mohamed. Abobakr

Thank you for submitting an Abstract/Article to present at the 4th International Conference for Membrane Technology and Its Applications which is scheduled to take place between 28-29 August 2023, Grand Hotel, Port Said City, Egypt. On behalf of the Organizing Committee, I am delighted to inform you that your Abstract/Article entitled "Magnetite-Cellulose Core Shell Nano Structure in Polymer Composite Materials for Storage Energy Applications" has been accepted for Oral presentation. We look forward to your presentation.

Your details are as follows:

Title:	Magnetite-Cellulose Core Shell Nano Structure in Polymer Composite Materials for Storage Energy Applications
Authors:	Sohier Mohamed. Abobakr , A.M. Abdelghany
Presenting Author:	Dr. Sohier Mohamed. Abobakr

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The administrative headquarters of the association: 33 Al-Bohuth Street - the National Research Center - the main building - the fourth floor. Mobile:01151660060 – 01158000214 – 01020007741 – 01112688290
www.mtaic.org, Email :membranetech13@gmail.com

4th International Conference for Membrane Technology & Its Applications

<u>The payment ways:</u>

Bank transfer on the Egyptian Society for membrane technology (الجمعية المصرية لتكنولوجيا الأغشية) , The Arab African International Bank, National Research Centre Branch, Account No. 1103576110010201

IBAN: EG360057012001103576110010201

or : **Vodafone Cash on the mobile: 01001172692**

For contact:

Mobile: **+201009152503**, **+201006525752** **WhatsApp**: **+201001821083**

Please do not hesitate to contact me if you have any questions.

Best Regards

Conference Co-Chairman

Heba Abdallah

4th International Conference for Membrane Technology & Its Applications

Acceptance letter

Dear Prof. Dr. Mohamed Hassen Elkiki

Thank you for submitting an Abstract/Article to present at the 4th International Conference for Membrane Technology and Its Applications which is scheduled to take place between 28-29 August 2023, Grand Hotel, Port Said City, Egypt. On behalf of the Organizing Committee, I am delighted to inform you that your Abstract/Article entitled "Joint Effect of Sediment Transport and Floodplain Divergence on Flow Pattern in Compound Channels" has been accepted for Oral presentation. We look forward to your presentation.

Your details are as follows:

Title:	Joint Effect of Sediment Transport and Floodplain Divergence on Flow Pattern in Compound Channels
Authors:	Hesham, M., Elkiki, M., Selim, T. and Elsakka, M
Presenting Author:	Prof. Dr. Mohamed Hassen Elkiki

Please check the above details of your presentation carefully as all conference material will be printed with this information. If there are any corrections, please inform us as soon as possible by email to: info@mtaic.org .

Conference venue: *Grand Hotel.*
Address: *Atef El-Sadat Street, Port Said Governorate, Egypt.*
Website: *www.mtaic.org*

To finalize your registration, you should pay 1900 EGP for registration**.**

Attendance package including the conference bag with the printed materials, coffee break, and lunch.
The Attendance without Accommodation fees: 1900EGP

- **Regular With Acc. 3 days in Grand Hotel (2 nights) : 3300 EGP**
- **Regular With Acc. 2 days in Grand Hotel (1 night) : 2600 EGP**

4th International Conference for Membrane Technology & Its Applications

<u>The payment ways:</u>

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For contact:

Mobile: **+201009152503**, **+201006525752** **WhatsApp**: **+201001821083**

Please do not hesitate to contact me if you have any questions.

Best Regards

Conference Co-Chairman

Heba Abdallah

4^{th} International Conference for Membrane Technology & Its Applications

Acceptance letter

Dear Dr. Rabab Reda Mohamed Ibrahim

Thank you for submitting an Abstract/Article to present at the 4^{th} International Conference for Membrane Technology and Its Applications which is scheduled to take place between 28-29 August 2023, Grand Hotel, Port Said City, Egypt. On behalf of the Organizing Committee, I am delighted to inform you that your Abstract/Article entitled "Stability, Analysis and Control of Power System Using Artificial Intelligence" has been accepted for Oral presentation. We look forward to your presentation.

Your details are as follows:

Title:	Stability, Analysis and Control of Power System Using Artificial Intelligence
Authors:	Dr. Amira. A .Elsonbaty, Dr. Rabab Reda Mohamed Ibrahim
Presenting Author:	Rabab Reda Mohamed Ibrahim

Please check the above details of your presentation carefully as all conference material will be printed with this information. If there are any corrections, please inform us as soon as possible by email to: info@mtaic.org .

Conference venue: *Grand Hotel.*
Address: *Atef El-Sadat Street, Port Said Governorate, Egypt.*
Website: *www.mtaic.org*

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4th International Conference for Membrane Technology & Its Applications

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Please do not hesitate to contact me if you have any questions.

Best Regards

Conference Co-Chairman

Heba Abdallah

4th International Conference for Membrane Technology & Its Applications

Acceptance letter

Dear Prof. Dr. Mohamed Hassen Elkiki

Thank you for submitting an Abstract/Article to present at the 4th International Conference for Membrane Technology and Its Applications which is scheduled to take place between 28-29 August 2023, Grand Hotel, Port Said City, Egypt. On behalf of the Organizing Committee, I am delighted to inform you that your Abstract/Article entitled "Predicting Seepage Losses from Cracked Lined Canals Using ANN and GEP Models" has been accepted for Oral presentation. We look forward to your presentation.

Your details are as follows:

Title:	Predicting Seepage Losses from Cracked Lined Canals Using ANN and GEP Models
Authors:	Elshaarawy, M. , Elkiki, M . , Selim, T. and Eltarabily, M.
Presenting Author:	Prof. Dr. Mohamed Hassen Elkiki

Please check the above details of your presentation carefully as all conference material will be printed with this information. If there are any corrections, please inform us as soon as possible by email to: info@mtaic.org .

Conference venue: *Grand Hotel.*
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Please do not hesitate to contact me if you have any questions.

Best Regards

Conference Co-Chairman

Heba Abdallah

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www.mtaic.org, Email :membranetech13@gmail.com

4th International Conference for Membrane Technology & Its Applications

Acceptance letter

Dear Dr. Yasser Mohamed Tawfic Ali

Thank you for submitting an Abstract/Article to present at the 4th International Conference for Membrane Technology and Its Applications which is scheduled to take place between 28-29 August 2023, Grand Hotel, Port Said City, Egypt. On behalf of the Organizing Committee, I am delighted to inform you that your Abstract/Article entitled "Synthesis of Zinc Oxide Nanoparticles by co-precipitation Methods and their activity against bacteria" has been accepted for Oral presentation. We look forward to your presentation.

Your details are as follows:

Title:	Synthesis of Zinc Oxide Nanoparticles by co-precipitation Methods and their activity against bacteria
Authors:	Yasser Mohamed Tawfic Ali
Presenting Author:	Dr. Yasser Mohamed Tawfic Ali

Please check the above details of your presentation carefully as all conference material will be printed with this information. If there are any corrections, please inform us as soon as possible by email to: info@mtaic.org .

Conference venue: *Grand Hotel.*
Address: *Atef El-Sadat Street, Port Said Governorate, Egypt.*
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Please do not hesitate to contact me if you have any questions.

Best Regards

Conference Co-Chairman

Heba Abdallah

CERTIFICATE

Awarded to

Dr. Amira El Sonbaty

for his / her contribution as an

Attendance

in the Conference entitled

4th International Conference for Membrane Technology and Its Applications

28-29 August 2023

Grand Hotel Port Said , Egypt

International Conference Membrane Technology & Its Applications MTAIC The Organizing Committee

Conference Chairman

Prof. Ahmed Shaban

CERTIFICATE

Awarded to

Dr. Hend Gado

for his / her contribution as an

Attendance

in the Conference entitled

4th International Conference for Membrane Technology and Its Applications

28-29 August 2023

Grand Hotel Port Said , Egypt

Conference Chairman

Prof. Ahmed Shaban

CERTIFICATE

Awarded to

Dr. Reham Atef

for his / her contribution as an

Attendance

in the Conference entitled

4^{th} International Conference for Membrane Technology and Its Applications

28-29 August 2023

Grand Hotel Port Said , Egypt

Conference Chairman

Prof. Ahmed Shaban

CERTIFICATE

Awarded to

Ass. Prof. Mohamed Gabr

for his / her contribution as an

Organizer

in the webinar entitled

4th International Conference for Membrane Technology and Its Applications

28-29 August 2023

Grand Hotel Port Said , Egypt

Shaban

Conference Chairman

Prof. Ahmed Shaban

CERTIFICATE

Awarded to

Ass. Prof. Mohamed Gabr

for his / her contribution as an

Conference Chairperson

in the webinar entitled

4th International Conference for Membrane Technology and Its Applications

28-29 August 2023

Grand Hotel Port Said , Egypt

Conference Chairman

Prof. Ahmed Shaban

CERTIFICATE

Awarded to

Ass. Prof. Mohamed Elsayed Gabr

for his / her contribution as an

Speaker

in the webinar entitled

4th International Conference for Membrane Technology and Its Applications

28-29 August 2023

Grand Hotel Port Said , Egypt

Conference Chairman

Prof. Ahmed Shaban

CERTIFICATE

Awarded to

Prof. Khaled Samir

for his / her contribution as an

Attendance

in the Conference entitled

4th International Conference for Membrane Technology and Its Applications

28-29 August 2023

Grand Hotel Port Said , Egypt

Conference Chairman

Prof. Ahmed Shaban

4:22

Reminder: Paper publication (4th International conference for membrane technology and its applications)

Membrane Technology
to mohamed.gabr@ndeti.edu.eg

اليوم ١٢:٠٩ م

Dear All,

For all the speakers who want to publish their articles in **The Port Said Engineering Research Journal** as a special issue for **The 4th International conference for membrane technology and its applications** , They should adjust their articles by using the attached template of Port Said Engineering Research Journal format .

Note : The submission deadline is 26 October 2023.
We apologize for the repetition if you already send your article.

Best Regards

Conference Secretary

Dahlia Ahmed

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السيد الأستاذ الدكتور/ **أحمد شعبان**

رئيس الجمعية المصرية لتكنولوجيا الأغشية

تحية طيبه ... وبعد

فانه يطيب لي بداية أن اتقدم لسيادتكم بأصدق تحياتي وخالص أمنياتي لسيادتكم ، داعيا المولى عز وجل أن ينعم عليكم بموفور الصحة ودوام التوفيق.

بالإشارة إلى المؤتمر الدولي الرابع لتكنولوجيا الأغشية المقرر عقدة يومى ٢٨ -٢٩ أغسطس ٢٠٢٣ بفندق جراند بمدينة بورسعيد ، والمعهد أحد منظمي هذا المؤتمر .

نتشرف بالاحاطة بأن المعهد شكل لجنة من السادة أعضاء هيئة التدريس بالمعهد للمشاركة فى تنظيم وإدارة المؤتمر من السادة أعضاء هيئة التدريس الآتية أسماؤهم بعد :

١- الأستاذ الدكتور/ اوسامي سعيد راجح أستاذ هندسة الموانى بكلية الهندسة جامعة المنصورة وعميد المعهد العالي للهندسة والتكنولوجيا بدمياط الجديدة وعضو لجنة المحكمين باللجنة العلمية الدائمة (الموارد المائية) لترقية الأساتذة والأساتذة المساعدين- وعضو لجنة الكود المصري للمراسي النهرية ومحكم بمجلتي المنصورة والإسكندرية للعلوم الهندسية.

٢- الأستاذ الدكتور/ محمد حسن الكيكى أستاذ الرى والهيدروليكا ورئيس قسم الهندسة المدنية بالمعهد العالي للهندسة والتكنولوجيا بدمياط الجديدة وعضو لجنة المحكمين باللجنة العلمية الدائمة (الموارد المائية) لترقية الأساتذة والأساتذة المساعدين- ومحكم بمجلات بورسعيد البحثية الهندسية- مجلة المصرية للعلوم هندسة الزقازيق- مجلة العلوم الهندسية جامعة أسيوط- المجلة الأمريكية لعلوم وهندسة المياه.

٣- الدكتور/ محمد السيد احمد جبر الأستاذ المساعد بقسم الهندسة المدنية بالمعهد العالي للهندسة والتكنولوجيا بدمياط الجديدة- ومحكم بمجلة ادارة الموارد المائية و مجلة الهندسة المدنية بدار النشر اسبرنجر.

٤- الدكتور/ رمضان عبد الغني علي الكاتب أستاذ مساعد الكيمياء الفيزيائية – قسم العلوم الأساسية والهندسية بالمعهد العالي للهندسة والتكنولوجيا بدمياط الجديدة. استشاري معتمد تقييم الأثر البيئى بوزارة البيئة – محكم في مجلة كلية العلوم جامعة دمياط.

وتفضلوا سيادتكم بقبول وافر التحية والإحترام ،،،

عميد المعهد

أ.د. اوسامى سعيد راجح

وزارة التعليم العالي – المعهد العالي للهندسة والتكنولوجيا – دمياط الجديدة

قرار رقم (٧٢) بتاريخ ٢٠٢٣/٠٨/٠٧

عميد المعهد :

- بعد الإطلاع على القانون رقم ٥٢ لسنة ١٩٧٠ بشأن تنظيم المعاهد العالية الخاصة .
- وعلى قانون رقم ٨١ لسنة ٢٠١٦ بشأن الخدمة المدنية
- وعلى القرار الوزاري رقم ١٠٨٨ لسنة ١٩٧٨ بإصدار لائحة المعاهد التابعة والخاضعة لإشراف وزارة التعليم العالي.
- وعلى اللائحة الداخلية للمعهد العالي للهندسة والتكنولوجيا بمدينة دمياط الجديدة والمعتمدة والصادر بها القرار الوزاري رقم (٢٠٣٦) بتاريخ ٢٠١٢/٣/٣ (بنظام الساعات المعتمدة).
- وعلى اللائحة الداخلية للمعهد والمعتمدة والصادر بها القرارات الوزارية (رقم ١٣٢٨ في ٢٠١٩/٠٤/١٤ الجزء الاكاديمي، رقم ١٩٩٩ في ٢٠٢٠/٠٧/٠٨ الجزء الاداري) بنظام الفصول الدراسية.
- وعلى المؤتمر الدولي الرابع لتكنولوجيا الأغشية وتطبيقاتها المقرر عقدة خلال الفترة من ٢٨ – ٢٩ أغسطس ٢٠٢٣ والمنعقد بفندق جراند ببورسعيد والجهات المنظمة للمؤتمر هي :
  - جامعة بورسعيد
  - المركز القومي للبحوث
  - جمعية المياه والتكنولوجيا بجامعة المنصورة
  - المعهد العالي للهندسة والتكنولوجيا بدمياط الجديدة

قرر

أولا : تشكل لجنة من السادة أعضاء هيئة التدريس ممثلين المعهد في اللجنة التنظيمية وجلسات المؤتمر وهم :

١- الأستاذ الدكتور/ اوسامي سعيد راجح أستاذ هندسة الموانى بكلية الهندسة جامعة المنصورة وعميد المعهد العالي للهندسة والتكنولوجيا بدمياط الجديدة وعضو لجنة المحكمين باللجنة العلمية الدائمة (الموارد المائية) لترقية الأساتذة والأساتذة المساعدين- وعضو لجنة الكود المصري للمراسي النهرية ومحكم بمجلة الإسكندرية للعلوم الهندسية.

٢- الأستاذ الدكتور/ محمد حسن الكيكي أستاذ الري والهيدروليكا ورئيس قسم الهندسة المدنية بالمعهد العالي للهندسة والتكنولوجيا بدمياط الجديدة وعضو لجنة المحكمين باللجنة العلمية الدائمة (الموارد المائية) لترقية الأساتذة والأساتذة المساعدين- ومحكم بمجلات بورسعيد البحثية الهندسية- مجلة المصرية للعلوم هندسة الزقازيق- مجلة العلوم الهندسية جامعة أسيوط- المجلة الأمريكية لعلوم وهندسة المياه.

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٤- الدكتور/ رمضان عبد الغنى على الكاتب أستاذ مساعد الكيمياء الفيزيائية – قسم العلوم الأساسية والهندسية بالمعهد العالي للهندسة والتكنولوجيا بدمياط الجديدة- استشاري معتمد تقييم الأثر البيئي بوزارة البيئة – محكم في مجلة كلية العلوم جامعة دمياط

ثانيا : على جهات الاختصاص مراعاة تنفيذ ذلك .

عميد المعهد

أ.د . اوسامى سعيد راجح