Tudományos, szakmai konferencia részvételek

Projektünk első éve alatt a projekthez szorosan kötődően 6 db tudományos konferencia részvétel történt, melyeken 10 db különböző anyaggal vettünk részt:

I. 2024.03.06-08. Balatonszárszón a XV. Környezetvédelmi Analitikai és Technológiai konferencián egy szóbeli előadás tartása („Innovatív módszerek alkalmazása a szennyvíztisztításban és tejipari szennyvíztisztításban” címmel: [MTMT közlemény azonosító: 35069466]) és egy poszter bemutatása („Ultraszűrések intenzifikálása az áramlási viszonyok megváltoztatásával” címmel: [MTMT: 35069477])

II. 2024.04.18. Hódmezővásárhelyen a „21st WELLMANN INTERNATIONAL SCIENTIFIC CONFERENCE” nemzetközi konferencián egy darab poszter bemutatása („Application possibilities of low-pressure membrane separation processes in the dairy industry” címmel: [MTMT: 35069492])

III. 2024.05.31. Szegeden az „International Conference on Science, Technology, Engineering and Economy (ICOSTEE 2024)” nemzetközi konferencián két darab poszter bemutatása („CASCADE MEMBRANE SYSTEM FOR SELECTIVE SEPARATION OF FUNCTIONAL COMPOUNDS FROM DAIRY BY-PRODUCTS” [MTMT: 35068257] és „ENHANCING MEMBRANE SEPARATION EFFICIENCY THROUGH THE UTILIZATION OF 3D-PRINTED TURBULENCE PROMOTERS DERIVED FROM RECYCLED PET BOTTLES, WITH INTEGRATION INTO FILTRATION MODULE” címekkel: [MTMT: 35069368])

IV. 2024.10.7-8. Szegeden az „30th International Symposium on Analytical and Environmental Problems (ISAEP 2024)” nemzetközi konferencián egy szóbeli előadás tartása („ANALYZING FLOW DYNAMICS WITH 3D PRINTED TURBULENCE PROMOTERS IN ULTRAFILTRATION UNIT TO MITIGATE MEMBRANE FOULING” címmel: [MTMT: 35465796]) és két darab poszter bemutatása („CASCADE MEMBRANE SYSTEM FOR EFFECTIVE COD REMOVAL FROM DAIRY BY-PRODUCT” [MTMT: 35465839] és „IMPACT OF SPACER GEOMETRY ON ULTRAFILTRATION PERFORMANCE IN A FILTER MODULE” címekkel: [MTMT: 35466592])

V. 2024.11.7-9. Debrecenben a „10th International Scientific Conference on Advances in Mechanical Engineering (ISCAME 2024)” nemzetközi konferencián két darab poszter bemutatása („Investigation of the Ultrafiltration Performance of Different Whey Solutions in a Dead-End Membrane Separation System” [MTMT: 35639572] és „Optimization of Ultrafiltration Parameters in a Laboratory-Scale Unit Using Dairy Model for Membrane Fouling Mitigation” címekkel: [MTMT: 35639548])

VI. 2024.12.03-04. ONLINE módon előadás tartása a brüsszeli „IDF Circularity in the Dairy Chain Symposium 2024” nemzetközi konferencián meghívott előadóként („Dairy wastewater treatment by advanced membrane separation techniques” címmel)

XV. Környezetvédelmi Analitikai és Technológiai Konferencia

és

63. Magyar Spektrokémiai Vándorgyűlés

Balatonszárszó, SDG Családi Hotel és Konferencia-központ
2024. március 6-8.

Program és előadásösszefoglalók

1

Kiállítók / Támogatók:

ABL&E–JASCO Magyarország Kft.

AKTIV INSTRUMENT Kft.
ANALITIKAI BERENDEZÉSEK, AUTOMATA ANALIZÁTOROK
1145 Budapest Pétervárad u. 14.
Tel.: (1)-789-2778, Fax: (1)-785-8489
Mail: kozpont@aktivinstrument.hu
web: www.aktivinstrument.hu

DONAU LAB Budapest
Member of LPPgroup

SILIKON

SHIMADZU
Excellence in Science

CLAIND
GAS GENERATORS AND PURIFIERS

Biotage

labex

perform

Isotoptech Zrt.

UNICAM
Magyarország Kft.

Analysis & Sensing | ASA | Chemistry Europe

H-1015 Budapest, Hattyú utca 18. II/8

ISBN 978-615-6018-23-6

Szervezők
MKE Környezet-analitikai és Technológiai Társaság
MKE Élelmiszer-tudományi Szakosztály
MKE Analitikai Szakosztály
MKE Magyar Spektrokémiai Társaság
MTA Spektrokémiai Munkabizottság

XV. Környezetvédelmi Analitikai és Technológiai Konferencia
és
63. Magyar Spektrokémiai Vándorgyűlés

Konferencia társelnökök:

- Simonné Sarkadi Livia, az MKE Tiszteletbeli Örökös Elnöke
- Záray Gyula, az SKT Tiszteletbeli Elnöke

A szervezőbizottság tagjai:
MKE Környezet-analitikai és Technológiai Társaság

- Braun Mihály
- Buzás Ilona
- Ágoston Csaba
- Alapi Tünde
- Domokos Endre
- Horváth Krisztián
- Maász Gábor
- Raisz Iván
- Mika László Tamás

MKE Élelmiszer-tudományi Szakosztály

- Abrankó László

MKE Analitikai Szakosztály

- Adányiné Kisbocskói Nóra
- Osváth Szabolcs

MKE Magyar Spektrokémiai Társaság

- Ziegler Ildikó
- Baranyai Edina

MTA Spektrokémiai Munkabizottság

- Bencs László
- Baranyai Edina

MKE Titkárság

- Androsits Beáta
- Schenker Beatrix
- Szabó János Zoltán

Tartalomjegyzék

Beköszöntő

Tisztelt Kollégák!

Szerencsére túl vagyunk a virtuális térbe való kényszerítés időszakán és újra személyes részvétellel rendezhetjük meg hagyományos konferenciáinkat.

Két nagy múltra visszatekintő konferencia sorozatunk idei rendezvényét, a korábbi időszak pozitív tapasztalata alapján, ismét egyidőben egy jól bevált helyszínen, családias környezetben tartjuk. Ez az együttműködés jó mintául szolgálhat a többi MKE szakosztály számára is a kapcsolatok kiszélesítése, egymás eredményeinek megismerésére és a közvetlen eszmecsere előnyeinek hasznosítására.

A két konferencia a **XV. Környezetvédelmi Analitikai és Technológiai Konferencia (KAT2024) és a 63. Magyar Spektrokémiai Vándorgyűlés,** melyeket **2024. március 6 – 8. között Balatonszárszón** az **SDG Családi Hotel és Konferenciaközpontban** tartunk párhuzamos rendezvényként, lehetővé téve a résztvevők számára az előadások áthallgatási lehetőségét.

A konferencia szervezésben együttműködő felek az MKE Környezet-analitikai és Technológiai Társasága (MKE KATT), az MKE Élelmiszertudományi Szakosztálya, az MKE Analitikai Szakosztálya, valamint MKE Spektrokémiai Társasága (SKT) és az MTA Spektrokémiai Munkabizottsága.

Mindkét konferencia meghirdetett témakörei lehetőséget biztosítanak a tudományterületek legújabb tudományos és gyakorlati eredményeinek megismerésére. Az egyetemi és kutatóintézeti résztvevők mellett számos ipari szakember jelenlétében a környezetvédelmet érintő forró témák is terítékre kerülnek.

Köszönjük dr. Raisz Anikó államtitkár asszonynak, hogy elvállalta a konferencia fő védnökségét.

Minden résztvevő számára kívánunk eredményes konferenciát, gyümölcsöző szakmai kapcsolatok kiépítését és nem utolsó sorban kellemes együtt töltött időt ebben a szép és kellemes környezetben.

Üdvözlettel,

Simonné Sarkadi Livia MKE Tiszteletbeli Örökös Elnöke	Záray Gyula SKT Tiszteletbeli Elnöke

A XV. KATT és 63. MSV Konferencia Programja

2024. 03. 06. szerda

9:00-		*Regisztráció*

XV. KATT és 63. MSV konferencia megnyitója
Elnök: Simonné Sarkadi Livia, Záray Gyula

11:00 - 11:20		Megnyitó
11:20 - 11:50	PL1	Ágoston Csaba: A levegőterheltség lokális jellegének vizsgálata
11:50 - 12:00		Török Tibor Emlékérem átadás
12:00 - 12:30	PL2	Kristóf János: Réteges szerkezetű anyagok spektroszkópiai analízise (kalandozások a spektrokémia területén)
12:30 - 13:00	PL3	Hermann Zsolt: Fenntarthatósági jelentés a gyakorlatban - a CSRD hatása az adatok gyűjtésére, értelmezésére és publikálására a MOL Nyrt-nél.
13:00-14:00		*Ebéd*

XV. KATT Élelmiszerminőség, élelmiszerbiztonság és a környezeti paraméterek
Elnök: Simonné Sarkadi Livia

14:00-14:30	PL4	Bánáti Diána: Fenntartható, alternatív fehérje források iránti igény az élelmiszerláncban
14:30-14:50	O1	Nagy László: Automatizált módszer fehérjetartalom megbízható mérésére különféle mintákból környezetszennyező és egészségkárosító vegyszerek alkalmazása nélkül
14:50-15:10	O2	Osváth Szabolcs, Homoki Zsolt, Kövendiné Kónyi Júlia, Szigeti Ágnes, Szarkáné Németh Ágnes, Glavatszkih Nándor: Az ERMAH bemutatása 2.: élelmiszerminták
15:10 - 15:30	O3	Kertész Szabolcs, László Zsuzsanna, Veréb Gábor, Csanádi József, Beszédes Sándor, Lendvai Edina, Ábrahám Imre, Garabné Ábrahám Nóra, Süveges-Gruber Andrea, Hodúr Cecília: Innovatív módszerek alkalmazása a szennyvíztisztításban és tejipari melléktermékek hasznosításában
15:30 - 16:00	PL5	Simonné Sarkadi Livia: Chemistry Europe kiadói szervezet bemutatása – Új lehetőségek publikációs tevékenységre / Introduction of the chemistry europe publishing organization – New opportunities for publication
16:00 - 16:20		*Kávészünet / poszter*

XV. KATT Analitikai módszerek a szennyezettség, illetve az összetétel meghatározására
Elnök: Maász Gábor

O3

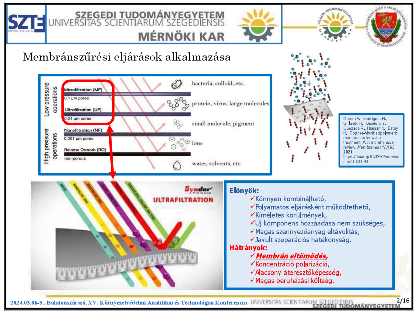
INNOVATÍV MÓDSZEREK ALKALMAZÁSA A SZENNYVÍZTISZTÍTÁSBAN ÉS TEJIPARI MELLÉKTERMÉKEK HASZNOSÍTÁSÁBAN

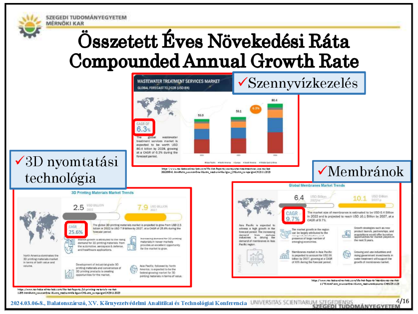
Kertész Szabolcs[a*], László Zsuzsanna[a], Veréb Gábor[a], Csanádi József[a], Beszédes Sándor[a], Lendvai Edina[a], Ábrahám Imre[b], Garabné Ábrahám Nóra[b], Süveges-Gruber Andrea[b], Hodúr Cecilia[a]

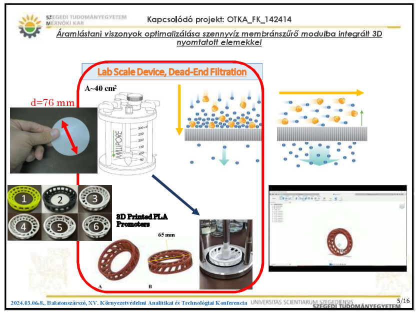
[a]Szegedi Tudományegyetem Mérnöki Kar
6725 Szeged Moszkvai krt. 9.
[b]Unichem Vegyipari, Kereskedelmi, Szolgáltató Kft.
6760 Kistelek Kőiskola út 3.
[*]E-mail: kertesz@mk.u-szeged.hu

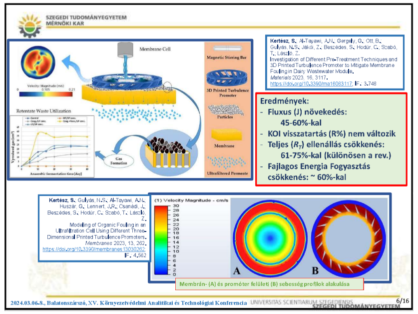
A környezettel kapcsolatos problémák megoldása, például az egyre hatékonyabb szennyvíztisztítás nagy hangsúlyt kap napjainkban, így a magas környezeti kockázatot jelentő, szerves anyagokkal terhelt szennyvizek tisztítása is egyre fontosabbá válik. A korszerű tisztítási technológiák gyakori részét képzik a membránszeparációs eljárások, melyek intenzifikálásával és a hagyományos módszerekkel történő összekapcsolásával a környezeti terhelés jelentős mértékben csökkenthető.
Munkánk során kutatjuk a membránszűrő modulokban kialakuló áramlástani viszonyokat és azok megváltoztatásának lehetőségeit, hatásait az eljárások paramétereire vonatkozóan. Elsődleges célunk a membrán felületi nyíróerők nagyságának növelésével, a talán legnagyobb hátrányt jelentő membránok eltömődésének jelentős csökkentése. Ezt innovatív módon a membrán modul mechanikai vibrációjával és a modulokba illesztett 3D nyomtatott elemekkel, turbulencia növelőkkel valósítjuk meg. Másodlagos célunk így, a saját tervezésű turbulencia növelők gyártására alkalmas, 3D nyomtatható alapanyagok és kialakítások kiválasztása, ezek mechanikai stabilitásának tesztelése. Ezek szűrőmodulokba illesztésével az áramlási viszonyok megváltoztathatók, így a membránszeparációs hatékonyság javítható. Ez gyorsabb műveletet, azaz magasabb fluxusokat, és alacsonyabb membrán eltömődéseket, azaz kisebb ellenállási értékek kialakulását jelenti. Ráadásul az eltömődési mechanizmusok modellezésének segítségével, a létrejövő felületi és nedvesedési tulajdonságok, anyag kölcsönhatások meghatározásával a gyakorlat számára is hasznos alkalmazási információkat nyerhetünk.
Intézetünk a szennyvíztisztítás mellett melléktermékek hasznosításával is foglalkozik. A tejipari gyártási folyamatok során nagy mennyiségben keletkező író és tejsavó régóta ismert magas tápértékükről és az immunrendszert segítő komponenseiről. Mivel azonban az immunstimuláló vegyületek többsége érzékeny a hőkezelésre, célunk ennek helyettesítése, un. nem-termikus élelmiszer-feldolgozási technológiák kombinációjával. Ezek a technológiák a következők lehetnek: Mikroszűrés (MF), az író és a tejsavó kezdeti mikrobiális terhelésének csökkentésére és a funkcionális tejvegyületek előzetes koncentrálására; Ultraszűrés (UF), a funkcionális vegyületek szelektív koncentrálásához; és MF/UF kombinációjával megvalósított diaszűrés. Ipari partnerrel együttműködve a különböző módon eltömődött membránok tisztítására többféle összetétellel rendelkező, saját gyártású speciális tisztítószereket is tesztelük a membránok minél több ciklusban megvalósítható szűréseinek fenntartása érdekében és a zöld-kémia elvek szigorú szabályainak betartása mellett.

A kutatás a Nemzeti Kutatási, Fejlesztési és Innovációs Hivatal, NKFI-FK-142414 és 2022-1.2.6-TÉT-IPARI-TR-2022-00011 azonosító számú projektek finanszírozásából valósul meg.

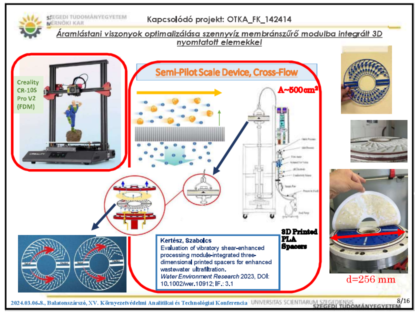


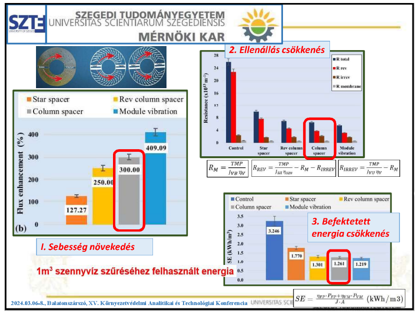






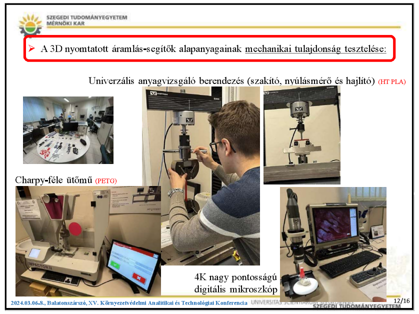

20 kDa PES UF,
3 bar, 400 rpm
Tervezés és 3D nyomtatások:
Különböző anyagú áramlás-segítők
1: PLA, 2: Gyantás, 3: TPU, 4: Fém


Kapcsolódó projekt: OTKA_FK_142414
Áramlástani viszonyok optimalizálása szennyvíz membránszűrő modulba integrált 3D nyomtatott elemekkel
Semi-Pilot Scale Device, Cross-Flow
d=256 mm


SZEGEDI TUDOMÁNYEGYETEM
UNIVERSITAS SCIENTIARUM SZEGEDIENSIS
MÉRNÖKI KAR
2. Ellenállás csökkenés
I. Sebesség növekedés
3. Befektetett energia csökkenés
1m³ szennyvíz szűréséhez felhasznált energia

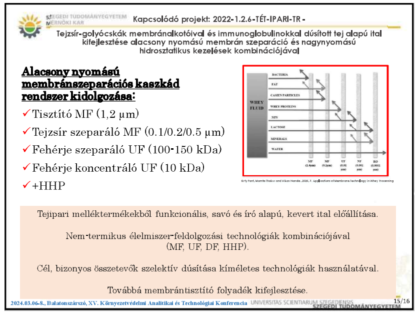

SZEGEDI TUDOMÁNYEGYETEM
UNIVERSITAS SCIENTIARUM SZEGEDIENSIS
MÉRNÖKI KAR
Fellépő problémák, esetleges megoldási lehetőségek?
Nyomtatási probl., elmozdulás, szeletelés?
Modul rögzítési probl.
Anyaggyengeség
Anyagerősítés és csere
PLA – erős. PLA - PETG
Alakfejlesztés
Szálerősítés
Rögzítési és tartásjavítás


A 3D nyomtatott áramlás-segítők alapanyagainak mechanikai tulajdonság tesztelése:


A 3D nyomtatott áramlás-segítők alapanyagainak mechanikai tulajdonság tesztelése:
Charpy-féle ütőmű
4K nagy pontosságú digitális mikroszkóp


PET filament előállító prototípussal saját filament gyártása és promóter nyomtatása
Kapcsolódó kutatási terület:
Gergely Gréta


Témához kapcsolódó konferencia részvételek
Eddig megjelent publikációk


Alacsony nyomású membránszeparációs kaszkád rendszer kidolgozása:
Tisztító MF (1,2 µm)
Tejzsír szeparáló MF (0.1/0.2/0.5 µm)
Fehérje szeparáló UF (100-150 kDa)
Fehérje koncentráló UF (10 kDa)
+HHP


Köszönöm a megtisztelő figyelmet!
Köszönetnyilvánítás:

MKE

Magyar Spektrokémiai Társaság

XV. Környezetvédelmi Analitikai és Technológiai Konferencia
és
63. Magyar Spektrokémiai Vándorgyűlés

Balatonszárszó, SDG Családi Hotel és Konferencia-központ
2024. március 6-8.

Program és előadásösszefoglalók

Kiállítók / Támogatók:

ABL&E–JASCO Magyarország Kft.

AKTIV INSTRUMENT Kft.
ANALITIKAI BERENDEZÉSEK, AUTOMATA ANALIZÁTOROK
1145 Budapest Pétervárad u. 14.
Tel.: (1)-789-2778, Fax: (1)-785-8489
Mail: kozpont@aktivinstrument.hu
web: www.aktivinstrument.hu

DONAU LAB Budapest
Member of LPPgroup

SILIKON

SHIMADZU
Excellence in Science

CLAIND
GAS GENERATORS AND PURIFIERS

Biotage

labex

perform

Isotoptech Zrt.

UNICAM
Magyarország Kft.

Analysis & Sensing | ASA | Chemistry Europe

H-1015 Budapest, Hattyú utca 18. II/8

ISBN 978-615-6018-23-6

Szervezők

MKE Környezet-analitikai és Technológiai Társaság

MKE Élelmiszer-tudományi Szakosztály

MKE Analitikai Szakosztály

MKE Magyar Spektrokémiai Társaság

MTA Spektrokémiai Munkabizottság

XV. Környezetvédelmi Analitikai és Technológiai Konferencia

és

63. Magyar Spektrokémiai Vándorgyűlés

Konferencia társelnökök:

- Simonné Sarkadi Livia, az MKE Tiszteletbeli Örökös Elnöke
- Záray Gyula, az SKT Tiszteletbeli Elnöke

A szervezőbizottság tagjai:

MKE Környezet-analitikai és Technológiai Társaság

- Braun Mihály
- Buzás Ilona
- Ágoston Csaba
- Alapi Tünde
- Domokos Endre
- Horváth Krisztián
- Maász Gábor
- Raisz Iván
- Mika László Tamás

MKE Élelmiszer-tudományi Szakosztály

- Abrankó László

MKE Analitikai Szakosztály

- Adányiné Kisbocskói Nóra
- Osváth Szabolcs

MKE Magyar Spektrokémiai Társaság

- Ziegler Ildikó
- Baranyai Edina

MTA Spektrokémiai Munkabizottság

- Bencs László
- Baranyai Edina

MKE Titkárság

- Androsits Beáta
- Schenker Beatrix
- Szabó János Zoltán

Tartalomjegyzék

Beköszöntő

Tisztelt Kollégák!

Szerencsére túl vagyunk a virtuális térbe való kényszerítés időszakán és újra személyes részvétellel rendezhetjük meg hagyományos konferenciáinkat.

Két nagy múltra visszatekintő konferencia sorozatunk idei rendezvényét, a korábbi időszak pozitív tapasztalata alapján, ismét egyidőben egy jól bevált helyszínen, családias környezetben tartjuk. Ez az együttműködés jó mintául szolgálhat a többi MKE szakosztály számára is a kapcsolatok kiszélesítése, egymás eredményeinek megismerésére és a közvetlen eszmecsere előnyeinek hasznosítására.

A két konferencia a **XV. Környezetvédelmi Analitikai és Technológiai Konferencia (KAT2024) és a 63. Magyar Spektrokémiai Vándorgyűlés,** melyeket **2024. március 6 – 8. között Balatonszárszón** az **SDG Családi Hotel és Konferenciaközpontban** tartunk párhuzamos rendezvényként, lehetővé téve a résztvevők számára az előadások áthallgatási lehetőségét.

A konferencia szervezésben együttműködő felek az MKE Környezet-analitikai és Technológiai Társasága (MKE KATT), az MKE Élelmiszertudományi Szakosztálya, az MKE Analitikai Szakosztálya, valamint MKE Spektrokémiai Társasága (SKT) és az MTA Spektrokémiai Munkabizottsága.

Mindkét konferencia meghirdetett témakörei lehetőséget biztosítanak a tudományterületek legújabb tudományos és gyakorlati eredményeinek megismerésére. Az egyetemi és kutatóintézeti résztvevők mellett számos ipari szakember jelenlétében a környezetvédelmet érintő forró témák is terítékre kerülnek.

Köszönjük dr. Raisz Anikó államtitkár asszonynak, hogy elvállalta a konferencia fő védnökségét.

Minden résztvevő számára kívánunk eredményes konferenciát, gyümölcsöző szakmai kapcsolatok kiépítését és nem utolsó sorban kellemes együtt töltött időt ebben a szép és kellemes környezetben.

Üdvözlettel,

Simonné Sarkadi Livia MKE Tiszteletbeli Örökös Elnöke	Záray Gyula SKT Tiszteletbeli Elnöke

Poszterek listája

P1. Alapi Tünde, Veres Bence, Farkas Luca, Dinesh Chandola:
Perszulfát sók alkalmazása vizek szerves mikroszennyezőinek eltávolítására különböző nagyhatékonyságú oxidációs eljárások során

P2. Sajtos Zsófi, Ragyák Ágota Zsófia, Hódi Fruzsina, Szigeti Viktória, Bellér Gábor, Baranyai Edina:
Régi mézek 5-hidroxi-metil-furfurol-tartalmának mennyiségi meghatározása

P3. Kertész Szabolcs, Hodúr Cecilia, Csanádi József, Veréb Gábor, Szpisják-Gulyás Nikolett, Lennert József Richárd, Gergely Gréta, Csott Hajnalka, László Zsuzsanna:
Ultraszűrések intenzifikálása az áramlási viszonyok megváltoztatásával

P4. Fazekas Ákos Ferenc, Beszédes Sándor, Hodúr Cecilia, Jákói Zoltán, Kertész Szabolcs, Veréb Gábor, László Zsuzsanna:
Lehetséges válaszok a szennyvíztisztítás új kihívásaira

P5. Urbán Orsolya, Palásti Dávid, Bélteki Ádám, Kámán Judit, Veres Miklós, Galbács Gábor:
Kísérleti Rendszer Fejlesztése és Alkalmazása Polimerek Lézer Indukált Plazmaspektroszkópiás Tulajdonságainak Vizsgálatára

P6. F.A. Casian-Plaza, D.J. Palásti, B. Bálint, G. Galbács:
Laser-induced breakdown spectroscopy method development for the qualitative discrimination analysis of plants

P7. Kajner Gyula, Bélteki Ádám, Cseh Martin, Geretovszky Zsolt Ajtai Tibor, Rwegasira Almachius, Galbács Gábor:
3D nyomtatással előállított műanyag koncentrikus porlasztó fejlesztése és vizsgálata

P8. Ragyák Ágota, Sajtos Zsófi, László Elemér, Baranyai Edina:
Környezeti változások lenyomata a borospohárban - Tokaji aszúk elemanalitikai vizsgálata

P9. Zsófi Sajtos, Bálint Varga, Enikő Szvák, Ildikó Pap, Edina Baranyai:
The elemental analysis of the mummies of Vác

P3

ULTRASZŰRÉSEK INTENZIFIKÁLÁSA AZ ÁRAMLÁSI VISZONYOK MEGVÁLTOZTATÁSÁVAL

Kertész Szabolcs*, Hodúr Cecilia, Csanádi József, Veréb Gábor, Szpisják-Gulyás Nikolett, Lennert József Richárd, Gergely Gréta, Csott Hajnalka, László Zsuzsanna

Szegedi Tudományegyetem Mérnöki Kar
6725 Szeged Moszkvai krt. 9.
**E-mail: kertesz@mk.u-szeged.hu*

A XXI. századra a gyors populációnövekedés miatt a környezetvédelem területén egyre több kihívással kell szembenéznünk. Jelentős vízhiány, nagymértékű vízszennyezés és a szennyezett vizek megfelelő kezelése, mára talán a legkomolyabb környezetvédelmi problémákká váltak. A különböző eredetű és összetételű szennyvíz típusok tisztítására a membrános eljárásokhoz tartozó ultraszűrés kiváló alternatív megoldást nyújt, mivel napjainkban már más eljárásokkal kombinálva az ipari és szennyvíztisztítási technológiák számos alkalmazásában jelentős szerepet kapott.
Munkánk során tejipari szennyvíz szerves anyag terhelésének csökkentési lehetőségét vizsgáltuk ultraszűrő keverőegységben. Első körben a működtetési paraméterek közül a keverési sebességet (0-200-400 rpm értékekkel), nyomást (2-4 bar) és az ultraszűrő polimer membránok vágási értékét (10-20-50 kDa) teszteltük. Eredményeink alapján kiválasztottuk a membránszűrési tulajdonságokra vonatkozó optimum értékeket (400 rpm, 3 bar, 20 kDa). Ezt követően az ultraszűrő modulban kialakuló áramlási viszonyok javítása érdekében a vizsgált cellába illeszthető, saját tervezésű, 3D nyomtatott elemeket/turbulencia növelőket teszteltünk. Célunk ezen elemek modulba illesztése melletti ultraszűrési tulajdonságokra, fluxusra, visszatartásra és eltömődésre gyakorolt hatások részletes kutatása. Ezt követően a második körben alakvizsgálatokat végeztünk. A vizsgált 4 különböző alak közül, a legjobb eredményeket adó 'PLA kiindulási' turbulencia növelőt választottuk. Így a harmadik körös anyagvizsgálatokat ezen alakra terveztük, úgy hogy szálhúzásos 3D nyomtatással PLA (polylactic acid, politejsav), TPU (thermoplastic polyurethane, termoplasztikus poliuretán), illetve Fém anyagokból, és Gyantás anyagból is, kinyomtattuk a vizsgálandó turbulencia fokozókat. Ezek modulba illesztése mellett kapott ultraszűrési eredményeink alapján a Gyantás anyagú mutatta a legkiemelkedőbb fluxus javulást és membrán eltömődés csökkentést.
Továbbá, a szennyvízkezelésen túl, az alacsony nyomásigényű membránszeparációs eljárások, a tejipari melléktermékek hasznosításához szükséges szelektív leválasztásra és/vagy dúsításra is alkalmasak lehetnek. A tejiparban nagy mennyiségben keletkező író és tejsavó összetevőinek többsége hőérzékeny, ezért a nem-termikus élelmiszer-feldolgozási technológiák közül a mikroszűrést (0,1; 0,2; 0,45 μm pórusméretű polimer membránokkal) és ultraszűrést (10, 100, 150 kDa vágási értékekkel) is vizsgáljuk részletesen. Ezekkel célunk a kezdeti mikrobiális terhelés csökkentése, és a funkcionális komponensek dúsítása (elsősorban a laktoglobulin G/membránfehérjék/foszfolipidek/lipid frakciók savóból és tejzsír-golyócska membrán alkotók íróból) előzetes, majd szelektív koncentrálása. Ezt követően az eltömődött membránok speciális tisztítószerekkel végzett tisztítása, elsősorban a körkörös gazdaság elveinek figyelembevétele érdekében.

A kutatásokat a Nemzeti Kutatási, Fejlesztési és Innovációs Hivatal, NKFI-FK-142414 és 2022-1.2.6-TÉT-IPARI-TR-2022-00011 azonosító számú projektje finanszírozza.

XV. Környezetvédelmi Analitikai és Technológiai Konferencia
2024. március 6-8., Balatonszárszó

FACULTY OF ENGINEERING
UNIVERSITAS SCIENTIARUM SZEGEDIENSIS
UNIVERSITY OF SZEGED

ULTRASZŰRÉSEK INTENZIFIKÁLÁSA AZ ÁRAMLÁSI VISZONYOK MEGVÁLTOZTATÁSÁVAL

Kertész Szabolcs*, Hodúr Cecilia, Csanádi József, Veréb Gábor, Szpisják-Gulyás Nikolett, Lennert József Richárd, Gergely Gréta, Csott Hajnalka, László Zsuzsanna

Szegedi Tudományegyetem Mérnöki Kar, 6725 Szeged Moszkvai krt. 9., Tel: +36 62 54 6580

*E-mail: kertesz@mk.u-szeged.hu

1. Bevezetés és célkitűzés

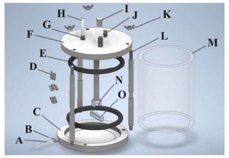
Napjainkban a gyors populációnövekedés miatt a környezetvédelem területén egyre több kihívással kell szembenéznünk. Ilyen például a jelentős mértékű vízhiány, nagymértékű vízszennyezés és a szennyezett vizek megfelelő kezelése, melyek mára talán a legkomolyabb környezetvédelmi problémákká váltak. Ehhez kapcsolódik, hogy a különböző eredetű és összetételű szennyvíz típusok tisztítására a membránszeparációs eljárásokhoz tartozó ultraszűrés kiváló alternatív megoldást nyújthat, mivel már más eljárásokkal kombinálva az ipari és szennyvíztisztítási technológiák számos alkalmazásában jelentős szerepet kapott. Munkánk során elsődleges célunk volt egy laboratóriumi méretű tejipari modell szennyvíz ultraszűrő keverőegységben részletesen vizsgálni és optimalizálni a működtetési paramétereket (I. kísérletsorozat). Kutattuk továbbá a szűrőcellába illeszthető, különböző alakú (II. kísérletsorozat) és anyagú (III. kísérletsorozat), saját tervezésű 3D nyomtatott turbulencia növelők szűrési tulajdonságokra gyakorolt hatásait.

2. Anyagok és módszerek

- Tejipari modell szennyvíz (5 gL^{-1} sovány tejporból (Tutti Kft, Magyarország), és 0,5 gL^{-1} anionos detergensből (Chemipur CI80, Szeged, Magyarország) 25 °C-os csapvízzel előállítva:

	KOI [mg/L]	Zavarosság [NTU]	Vezetőképesség [mS]	pH
Modell tejipari szennyvíz	5200	1150	0,89	8,7

- Kevertethető laboratóriumi membránszűrő cella (Merck Millipore for MF and UF, Németország);



Kevertetett ultraszűrő cella robbantott 3D modellje (Autodesk Inventor programmal készült saját szerkesztés)
(*A*: Szűrlet/Permeátum elvezető cső, *B*: Permeátum kiáramlási csonk, *C*: Alsó rozsdamentes acél berendezés alj, *D*: Rögzítő, falkitámasztó elemek, *E*: O-gyűrű tömítés, *F*: Felső berendezés tető, *G*: Nyomás betáplálási nyílás, *H*: Nyomáscső, *I*: Betöltő nyílás kupak, *J*: Biztonsági szelep, *K*: Rögzítő anyák, *L*: Tartó rudak, *M*: Vastagfalú üveg henger, *N*: Keverőmágnes tartó, *O*: Keverőmágnes baba)

Műveleti paraméterek:
- keverési sebesség:
  - 0 rpm
  - 200 rpm
  - 400 rpm
- transzmembrán nyomás:
  - 2 bar (0,2 MPa)
  - 4 bar (0,4 MPa)
- ultraszűrő polimer PES membránok vágási értékei:
  - 10 kDa
  - 20 kDa
  - 50 kDa

Turbulencia növelők 3D nyomtatása az alakvizsgálathoz:
- Az első három turbulencia növelő: FDM technológia, Fusion 360 szoftver; Ultimate Cure 5.0.0 program; Creality CR-10S Pro V2 típusú 3D nyomtató (Kína), politejsav (PLA) alapú kompozit filament;
- A negyedik (duplázott) poliamid (PA) műanyag: JF technológia, HP Jet Fusion 5200 típusú nyomtató (Győr, Magyarország):

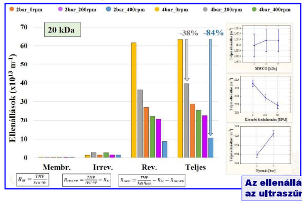
Az anyagvizsgálathoz:
- Az első PLA, a második gyantás (SLA, Anycubic Photon S 3D nyomtató (Kína), Anycubic Eco UV Resign anyagból), a harmadik termoplasztikus poliuretán (TPU) és a negyedik rozsdamentes acél anyagból készült, ami DMLS technológia, EOSINT M270 (EOS, Németország) nyomtató, fém anyagból:

További analitika:
- pH mérő (Thermo Scientiifc Orion 5-Star Plus Multifunction Benchtop Meter, Egyesült Államok)
- Zavarosság meghatározó (Hach 2100N Turbidimeter, Egyesült Államok)
- Kémiai oxigénigény roncsoló és fotométer (Lovibond RD 125 és MD 200, Németország)

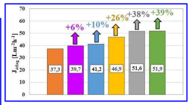
3. Tejipari szennyvíz ultraszűrésének eredményei

I. Az első kísérletsorozatunk (18 db kísérlet) eredményeink alapján kiválasztottuk a membránszűrési tulajdonságokra vonatkozó optimum értékeket:

400 rpm, 3 bar, 20 kDa:



Az ellenállási értékek alakulása az ultraszűrések során



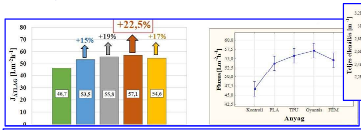
Az átlag permeátum fluxusok alakulása a paraméterek változtatásának hatására.

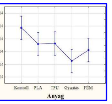
II. Ezt követően a második körben (10 db kísérlet) alakvizsgálatokat végeztünk. A vizsgált 4 különböző alak közül, a legjobb eredményeket adó **'PLA kiindulási'** turbulencia növelőt (1-es típust) választottuk:

Kontroll · PLA kiindulási · PLA mini · PLA vékonyított · PA duplázott

Az átlag permeátum fluxusok és szerves anyag visszatartások értékeinek alakulása.

III. Így a harmadik körös anyagvizsgálatokat (10 db kísérlet) ezen alakra terveztük: Ezek modulba illesztése mellett kapott ultraszűrési eredményeink alapján a **Gyantás** anyagú mutatta a legkiemelkedőbb fluxus javulást és membrán eltömődés csökkentést.





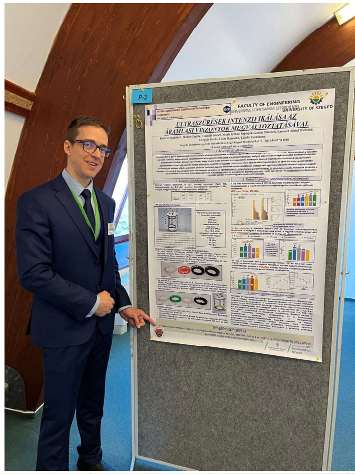
4. Tejipari melléktermék hasznosítás

Továbbá, az alacsony nyomásigényű membránszeparációs eljárások (MF, UF), a tejipari melléktermékek hasznosításához szükséges szelektív leválasztásra is alkalmasak. A tejiparban nagy mennyiségben keletkező író és tejsavó összetevőinek többsége hőérzékeny, ezért a nem-termikus élelmiszer-feldolgozási technológiák közül a mikroszűrést (0,1; 0,2; 0,45 µm pórusméretű polimer membránokkal) és ultraszűrést (10, 100, 150 kDa vágási értékekkel) is vizsgáljuk részletesen. Ezekkel célunk a kezdeti mikrobiális terhelés csökkentése, és a funkcionális komponensek dúsítása (elsősorban a laktoglobulin G/membránfehérjék/foszfolipidek/lipid frakciók savóból és tejzsír-golyócska membrán alkotók íróból) előzetes, majd szelektív koncentrálása. Ezt követően az eltömődött membránok speciális tisztítószerekkel végzett tisztítása, elsősorban a körkörös gazdaság elveinek figyelembevétele érdekében.

Köszönetnyílvánítás

A kutatásokat a Nemzeti Kutatási, Fejlesztési és Innovációs Hivatal, NKFI-FK-142414 és 2022-1.2.6-TÉT-IPARI-TR-2022-00011 azonosító számú projektje finanszírozza.

Nemzeti Kutatási, Fejlesztési és Innovációs Hivatal
AZ NKFI ALAPBÓL MEGVALÓSULÓ PROJEKT



Tudományos, szakmai konferencia részvételek

Projektünk első éve alatt a projekthez szorosan kötődően 6 db tudományos konferencia részvétel történt, melyeken 10 db különböző anyaggal vettünk részt:

I. 2024.03.06-08. Balatonszárszón a XV. Környezetvédelmi Analitikai és Technológiai konferencián egy szóbeli előadás tartása („Innovatív módszerek alkalmazása a szennyvíztisztításban és tejipari szennyvíztisztításban” címmel: [MTMT közlemény azonosító: 35069466]) és egy poszter bemutatása („Ultraszűrések intenzifikálása az áramlási viszonyok megváltoztatásával” címmel: [MTMT: 35069477])

II. 2024.04.18. Hódmezővásárhelyen a „21st WELLMANN INTERNATIONAL SCIENTIFIC CONFERENCE” nemzetközi konferencián egy darab poszter bemutatása („Application possibilities of low-pressure membrane separation processes in the dairy industry” címmel: [MTMT: 35069492])

III. 2024.05.31. Szegeden az „International Conference on Science, Technology, Engineering and Economy (ICOSTEE 2024)” nemzetközi konferencián két darab poszter bemutatása („CASCADE MEMBRANE SYSTEM FOR SELECTIVE SEPARATION OF FUNCTIONAL COMPOUNDS FROM DAIRY BY-PRODUCTS” [MTMT: 35068257] és „ENHANCING MEMBRANE SEPARATION EFFICIENCY THROUGH THE UTILIZATION OF 3D-PRINTED TURBULENCE PROMOTERS DERIVED FROM RECYCLED PET BOTTLES, WITH INTEGRATION INTO FILTRATION MODULE” címekkel: [MTMT: 35069368])

IV. 2024.10.7-8. Szegeden az „30th International Symposium on Analytical and Environmental Problems (ISAEP 2024)” nemzetközi konferencián egy szóbeli előadás tartása („ANALYZING FLOW DYNAMICS WITH 3D PRINTED TURBULENCE PROMOTERS IN ULTRAFILTRATION UNIT TO MITIGATE MEMBRANE FOULING” címmel: [MTMT: 35465796]) és két darab poszter bemutatása („CASCADE MEMBRANE SYSTEM FOR EFFECTIVE COD REMOVAL FROM DAIRY BY-PRODUCT” [MTMT: 35465839] és „IMPACT OF SPACER GEOMETRY ON ULTRAFILTRATION PERFORMANCE IN A FILTER MODULE” címekkel: [MTMT: 35466592])

V. 2024.11.7-9. Debrecenben a „10th International Scientific Conference on Advances in Mechanical Engineering (ISCAME 2024)” nemzetközi konferencián két darab poszter bemutatása („Investigation of the Ultrafiltration Performance of Different Whey Solutions in a Dead-End Membrane Separation System” [MTMT: 35639572] és „Optimization of Ultrafiltration Parameters in a Laboratory-Scale Unit Using Dairy Model for Membrane Fouling Mitigation” címekkel: [MTMT: 35639548])

VI. 2024.12.03-04. ONLINE módon előadás tartása a brüsszeli „IDF Circularity in the Dairy Chain Symposium 2024” nemzetközi konferencián meghívott előadóként („Dairy wastewater treatment by advanced membrane separation techniques” címmel)

AGRA | SZTE MGK | SZTE SZEGEDI TUDOMÁNYEGYETEM UNIVERSITY OF SZEGED

110 ÉVE AZ OKTATÁS ÉS A TUDOMÁNY SZOLGÁLATÁBAN. 100 ÉVE SZEGED ÉS A RÉGIÓ FEJLŐDÉSÉÉRT.

21st WELLMANN INTERNATIONAL SCIENTIFIC CONFERENCE

BOOK OF ABSTRACTS

18th April 2024

Hódmezővásárhely

University of Szeged Faculty of Agriculture Hódmezővásárhely (Hungary)

Banat's University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania" from Timisoara

Faculty of Management and Rural Turism (Romania) Hungarian Academy of Sciences Regional Committee in Szeged (Hungary)

Foundation for Agricultural Modernization and Rural Development, Hódmezővásárhely (Hungary)

21ST WELLMANN INTERNATIONAL SCIENTIFIC CONFERENCE

Book of Abstracts

University of Szeged Faculty of Agriculture

18th April 2024

Published by: University of Szeged Faculty of Agriculture Andrássy út 15.

6800 Hódmezővásárhely, Hungary

Responsible publisher:

Edit Mikó dean

ISBN 978-963-306-980-6

APPLICATION POSSIBILITIES OF LOW-PRESSURE MEMBRANE SEPARATION PROCESSES IN THE DAIRY INDUSTRY

Szabolcs Kertész[1]*, Aws N. Al-Tayawi[1], Gréta Gergely[1], József Richárd Lennert[2], József Csanádi[3], Gábor Veréb[1], Sándor Beszédes[1], Zsuzsanna László[1], Ábrahám Imre[4], Garabné Ábrahám Nóra[4], Süveges-Gruber Andrea[4], Cecilia Hodúr[1]

[1]Department of Biosystems Engineering, Faculty of Engineering, University of Szeged, Szeged, HUNGARY
[2]Department of Power Electronics and E-Drives, Audi Hungaria Faculty of Automotive Engineering, Széchenyi István University, Győr, HUNGARY
[3]Department of Food Engineering, Faculty of Engineering, University of Szeged, Szeged, HUNGARY
[4]Unichem Chemical, Manufacturing and Trading Ltd., Kistelek, HUNGARY

*corresponding author: kertesz@mk.u-szeged.hu

The treatment of dairy wastewater characterized by high organic loads has become of utmost importance. Through the utilization of membrane processes in conjunction with traditional methods, significant alleviation of environmental burdens can be realized. In our research, we investigate the flow dynamics within different low-pressure membrane separation filter modules on the filtration process parameters. Our primary scope was to mitigate membrane fouling, a major drawback, by enhancing membrane surface shear rates. This was achieved through innovative methods involving mechanical vibration of the module and the incorporation of 3D-printed turbulence promoters within the modules. Integration of these promoters into modules allows for manipulation of flow dynamics, thus enhancing membrane separation efficiency. This results in accelerated operation, characterized by increased flux rates, and reduced membrane fouling, leading to lower resistance values. Dairy by-products, such as buttermilk and whey, abundant in dairy processing, are recognized for their nutritional richness and immune-supporting compounds. Our objective is to explore alternative, non-thermal food processing technologies, such as microfiltration (MF) to diminish initial microbial loads while concentrating milk components, and ultrafiltration (UF) for selective concentration of bioactive compounds. In cooperation with an industrial partner, they also test self-produced special cleaning agents with various compositions for cleaning membranes that are fouled in different ways in order to maintain the filtration of the membranes in as many cycles as possible and in compliance with the strict rules of green chemistry principles. The research is funded by the Hungarian National Research, Development and Innovation Office, NKFI-FK-142414 and 2022-1.2.6-TÉT-IPARI-TR-2022-00011 projects.

21st WELLMANN INTERNATIONAL SCIENTIFIC CONFERENCE
Hódmezővásárhely, 18th of April, 2024

APPLICATION POSSIBILITIES OF LOW-PRESSURE MEMBRANE SEPARATION PROCESSES IN THE DAIRY INDUSTRY

Szabolcs Kertész[1]*, Aws N. Al-Tayawi[1], Gréta Gergely[1], József Richárd Lennert[2], József Csanádi[3], Gábor Veréb[1], Sándor Beszédes[1], Zsuzsanna László[1], Imre Ábrahám[4], Nóra Garabné Ábrahám[4], Andrea Süveges-Gruber[4], Cecilia Hodúr[1]

[1]Department of Biosystems Engineering, Faculty of Engineering, University of Szeged, Szeged, HUNGARY
[2]Department of Power Electronics and E-Drives, Audi Hungaria Faculty of Automotive Engineering, Széchenyi István University, Győr, HUNGARY
[3]Department of Food Engineering, Faculty of Engineering, University of Szeged, Szeged, HUNGARY
[4]Unichem Chemical, Manufacturing and Trading Ltd., Kistelek, HUNGARY
*E-mail: kertesz@mk.u-szeged.hu

INTRODUCTION

In this research, **the flow dynamics** within different low-pressure membrane separation filter modules on the filtration process parameters **were investigated**. The primary scope was **to mitigate membrane fouling**, a major drawback, by enhancing membrane surface shear rates. This was achieved through **innovative methods involving mechanical vibration** of the module **and the incorporation of 3D-printed turbulence promoters** within the modules. Integration of these promoters into modules allows for manipulation of flow dynamics, thus enhancing membrane separation efficiency. This results in accelerated operation, characterized by **increased flux rates, and reduced membrane fouling, leading to lower resistance values.**

MATERIALS AND METHODS

Dairy model wastewater: 5 gL^{-1} skimmed milk powder (Tutti Kft., Hungary) and 0.5 gL^{-1} anionic detergent (Chemipur Cl80, Szeged, Hungary) produced with tap water at 25 °C; **Laboratory membrane filter cell**: (Merck Millipore for MF and UF, Germany);
3D printing of turbulence promoters for form testing: The first three turbulence promoters: FDM technology, Fusion 360 software; Ultimate Cure 5.0.0 program; Creality CR-10S Pro V2 type 3D printer (China), polylactic acid (PLA) based composite filament;
The fourth (doubled) polyamide (PA) plastic: JF technology, HP Jet Fusion 5200 type printer (Győr, Hungary):

3D printing of turbulence promoters for material testing:
The first is PLA, the second is made of resin (SLA, Anycubic Photon S 3D printer (China), Anycubic Eco UV Resign material), the third is made of thermoplastic polyurethane (TPU) and the fourth is made of stainless steel material, which is DMLS technology, EOSINT M270 (EOS, Germany) printer, made of metal

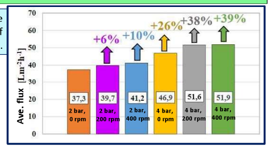
Operational parameters: **mixing speed:** 0 rpm; 200 rpm; 400 rpm; **transmembrane pressure (TMP):** 2 bar (0.2 MPa); 4 bar (0.4 MPa); **cut off values** of ultrafiltration polymer PES membranes: 10 kDa; 20 kDa; 50 kDa;
Additional analytics: pH meter (Thermo Scientific Orion 5-Star Plus Multifunction Benchtop Meter, United States); **Turbidity** determination (Hach 2100N Turbidimeter, United States); Chemical oxygen demand (**COD**) digester and photometer (Lovibond RD 125 and MD 200, Germany)

RESULTS AND DISCUSSION

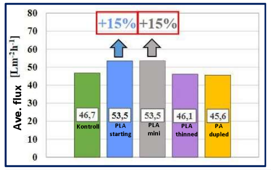
Results of ultrafiltration of dairy wastewater

1. Based on the results of our first series of experiments, 18 experiments, we selected the **optimum values** for the membrane filtration properties:
400 rpm, 3 bar, 20 kDa:

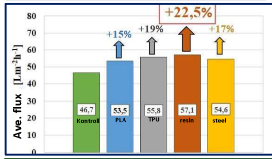
Increasing of the average permeate fluxes as a result of changing the parameters.

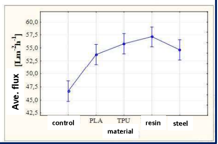


2. After that, **form tests** were performed in the second round with 10 experiments. Among the 4 different forms tested, we chose the 'PLA starting' turbulence promoter (type 1) that gave the best results:



3. Thus, we planned the third round of **material tests**, 10 experiments, in this way: Based on our ultrafiltration results obtained after fitting them into the module, the resin material showed the most outstanding flux improvement and reduction of membrane fouling.





Dairy by-product utilization

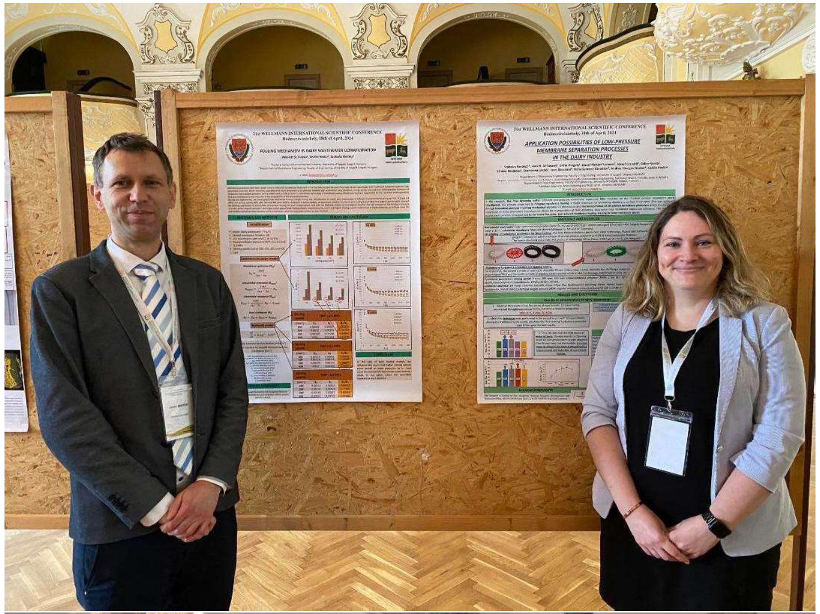
Furthermore, membrane separation processes with low pressure (MF, UF) are also suitable for the selective separation required for the utilization of dairy by-products. Most of the components of buttermilk and whey, which are produced in large quantities in the dairy industry, are heat-sensitive, therefore among **the non-thermal food processing technologies**, microfiltration (with polymer 0.1, 0.2, 0.45 μm membranes) and ultrafiltration (with 10, 100, 150 kDa cut off) **are also examined in detail**. The aim is to reduce the initial microbial load and to enrich the functional components (mainly lactoglobulin G/membrane proteins/phospholipids/lipid fractions from whey and milk fat globule membrane constituents from buttermilk) and then selectively concentrate them. Afterwards, **the fouled membranes are cleaned with special cleaning agents**, mainly in order to take into account the principles of the circular economy.

ACKNOWLEDGEMENTS

The research is funded by the Hungarian National Research, Development and Innovation Office, NKFI-FK-142414 and 2022-1.2.6-TÉT-IPARI-TR-2022-00011 projects.

National Research, Development and Innovation Office Hungary
PROJECT FINANCED FROM THE NRDI FUND

FACULTY OF ENGINEERING
UNIVERSITAS SCIENTIARUM SZEGEDIENSIS
UNIVERSITY OF SZEGED



Tudományos, szakmai konferencia részvételek

Projektünk első éve alatt a projekthez szorosan kötődően 6 db tudományos konferencia részvétel történt, melyeken 10 db különböző anyaggal vettünk részt:

I. 2024.03.06-08. Balatonszárszón a XV. Környezetvédelmi Analitikai és Technológiai konferencián egy szóbeli előadás tartása („Innovatív módszerek alkalmazása a szennyvíztisztításban és tejipari szennyvíztisztításban” címmel: [MTMT közlemény azonosító: 35069466]) és egy poszter bemutatása („Ultraszűrések intenzifikálása az áramlási viszonyok megváltoztatásával” címmel: [MTMT: 35069477])

II. 2024.04.18. Hódmezővásárhelyen a „21st WELLMANN INTERNATIONAL SCIENTIFIC CONFERENCE” nemzetközi konferencián egy darab poszter bemutatása („Application possibilities of low-pressure membrane separation processes in the dairy industry” címmel: [MTMT: 35069492])

III. 2024.05.31. Szegeden az „International Conference on Science, Technology, Engineering and Economy (ICOSTEE 2024)” nemzetközi konferencián két darab poszter bemutatása („CASCADE MEMBRANE SYSTEM FOR SELECTIVE SEPARATION OF FUNCTIONAL COMPOUNDS FROM DAIRY BY-PRODUCTS” [MTMT: 35068257] és „ENHANCING MEMBRANE SEPARATION EFFICIENCY THROUGH THE UTILIZATION OF 3D-PRINTED TURBULENCE PROMOTERS DERIVED FROM RECYCLED PET BOTTLES, WITH INTEGRATION INTO FILTRATION MODULE” címekkel: [MTMT: 35069368])

IV. 2024.10.7-8. Szegeden az „30th International Symposium on Analytical and Environmental Problems (ISAEP 2024)” nemzetközi konferencián egy szóbeli előadás tartása („ANALYZING FLOW DYNAMICS WITH 3D PRINTED TURBULENCE PROMOTERS IN ULTRAFILTRATION UNIT TO MITIGATE MEMBRANE FOULING” címmel: [MTMT: 35465796]) és két darab poszter bemutatása („CASCADE MEMBRANE SYSTEM FOR EFFECTIVE COD REMOVAL FROM DAIRY BY-PRODUCT” [MTMT: 35465839] és „IMPACT OF SPACER GEOMETRY ON ULTRAFILTRATION PERFORMANCE IN A FILTER MODULE” címekkel: [MTMT: 35466592])

V. 2024.11.7-9. Debrecenben a „10th International Scientific Conference on Advances in Mechanical Engineering (ISCAME 2024)” nemzetközi konferencián két darab poszter bemutatása („Investigation of the Ultrafiltration Performance of Different Whey Solutions in a Dead-End Membrane Separation System” [MTMT: 35639572] és „Optimization of Ultrafiltration Parameters in a Laboratory-Scale Unit Using Dairy Model for Membrane Fouling Mitigation” címekkel: [MTMT: 35639548])

VI. 2024.12.03-04. ONLINE módon előadás tartása a brüsszeli „IDF Circularity in the Dairy Chain Symposium 2024” nemzetközi konferencián meghívott előadóként („Dairy wastewater treatment by advanced membrane separation techniques” címmel)

International Conference on Science, Technology, Engineering and Economy

ICOSTEE 2024

BOOK OF ABSTRACTS

31st May 2024
Faculty of Engineering University of Szeged
Building A Mars tér 7, Szeged, Hungary

Publisher:

University of Szeged Faculty of Engineering
Mars tér 7, H-6724 Szeged, Hungary

Responsible publisher:

Prof. Dr. István Bíró

Edited by:

Prof. Dr. István Bíró
Prof. Dr. Zsuzsanna László
Prof. Dr. József Sárosi
Réka Dobozi
Ákos Ferenc Fazekas
József Mihalkó

ISBN:

978-963-306-986-8

Scientific and Organization Committee

Joint organization with the Agricultural and Bioengineering Scientific Committee of Hungarian Academy of Sciences

International Conference on Science, Technology, Engineering and Economy

CASCADE MEMBRANE SYSTEM FOR SELECTIVE SEPARATION OF FUNCTIONAL COMPOUNDS FROM DAIRY BY-PRODUCTS

Adrienn Fejős[1], Zsuzsanna László[1], Gábor Veréb[1], József Csanádi[2], Sándor Beszédes[1], Edina Lendvai[3], Anikó Birkásné Nagypál[1], Dorottya Csenki[1], Imre Ábrahám[4], Nóra Garabné Ábrahám[4], Andrea Süveges-Gruber[4], Cecilia Hodúr[1], Szabolcs Kertész[1]

[1]Department of Biosystems Engineering, Faculty of Engineering, University of Szeged, Moszkvai krt. 9, H-6725 Szeged, Hungary
[2]Department of Food Engineering, Faculty of Engineering, University of Szeged, Moszkvai krt. 5-7, H-6725 Szeged, Hungary
[3]Department of Engineering Management and Economics, Faculty of Engineering, University of Szeged, Mars tér 7, H-6724 Szeged, Hungary
[4]Unichem Chemical, Manufacturing and Trading Ltd., Kistelek H-6760, Hungary
e-mail: kertesz@mk.u-szeged.hu

ABSTRACT

The utilization of low-pressure membrane separation processes, such as microfiltration (MF) and ultrafiltration (UF) can be very effective in the selective separation of valuable components from various dairy by-products such as whey or buttermilk. Whey, abundant in lactose and soluble proteins like β-lactoglobulin, α-lactalbumin, and immunoglobulins, poses risks for individuals with milk protein allergies. Our scope is to selectively separate compounds in addition to lactose in order to obtain an immunoglobulin (Ig)-rich, casein- and β-lactoglobulin-free concentrate with minimal lactose content.

In our study, we employ a cascade membrane system comprising several sequential steps, including: Milk fat separation step with 0.1/0.2/0.5 µm pore sizes MF membranes. Protein-selective UF with 100-150 kDa cut-off membranes. Protein concentration with 10 kDa UF.

Our further plan is to cooperate with the industrial partner to test special cleaning agents with multiple compositions for cleaning fouled membranes, manufactured by them in compliance with the strict rules of green chemistry principles. Our goal is that maximize the membranes can be used in as many cycles as possible, so adhering to the principles of circular economy.

Keywords: Cascade MF/UF Membrane System, Selective Separation, Functional Compounds, Whey, Soluble Proteins

Acknowledgements: The project is financed by The National Research, Development and Innovation Office Fund, 2022-1.2.6-TÉT-IPARI-TR-2022-00011.

INTERNATIONAL CONFERENCE ON SCIENCE, TECHNOLOGY, ENGINEERING AND ECONOMY – ICOSTEE 2024
Szeged, 31th of May, 2024

CASCADE MEMBRANE SYSTEM FOR SELECTIVE SEPARATION OF FUNCTIONAL COMPOUNDS FROM DAIRY BY-PRODUCTS

Adrienn Fejős[1], Zsuzsanna László[1], Gábor Veréb[1], József Csanádi[2], Sándor Beszédes[1], Edina Lendvai[3], Anikó Birkásné Nagypál[1], Dorottya Csenki[1], Imre Ábrahám[4], Nóra Garabné Ábrahám[4], Andrea Süveges-Gruber[4], Cecilia Hodúr[1], Szabolcs Kertész[1*]

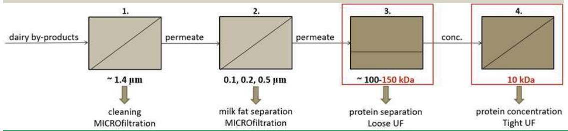
[1]Institute of Environmental Science and Technology, University of Szeged, Szeged, Hungary
[2]Department of Biosystems Engineering, Faculty of Engineering, University of Szeged, Szeged, Hungary
[3]Department of Engineering Management and Economics, Faculty of Engineering, University of Szeged, Szeged H-6724, Hungary
[4]Unichem Chemical, Manufacturing and Trading Ltd., Kistelek H-6760, Hungary
*E-mail: kertesz@mk.u-szeged.hu

INTRODUCTION

The utilization of low-pressure membrane separation processes, such as microfiltration (*MF*) and ultrafiltration (*UF*) can be very effective in the selective separation of valuable components from various dairy by-products such as whey or buttermilk. Whey, abundant in lactose and soluble proteins like β-lactoglobulin, α-lactalbumin, and immunoglobulins, poses risks for individuals with milk protein allergies. Our general scope is to selectively separate compounds in addition to lactose in order to obtain an immunoglobulin (Ig)-rich, casein- and β-lactoglobulin-free concentrate with minimal lactose content.
Our further plan is to cooperate with the industrial partner to test special cleaning agents with multiple compositions for cleaning fouled membranes, manufactured by them in compliance with the strict rules of green chemistry principles. Our goal is that maximize the membranes can be used in as many cycles as possible, so adhering to the principles of circular economy.

Cascade membrane system

In our study, we employ a cascade membrane system comprising several sequential steps, including: Milk fat separation step with 0.1/0.2/0.5 µm pore sizes *MF* membranes, protein-selective *UF* with 100-150 kDa cut-off loose membranes and protein concentration with 10 kDa tight *UF* membranes.

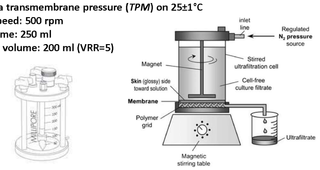


Scope of this study

The aim of this work is to investigate the effect of freezing. To this end, low-pressure membrane separation parameters of fresh whey and whey after one week of freezing (unfrozen) were examined and compared, primarily for permeate fluxes (1.), resistances (2.) and membrane retentions (3) with a tight, 10 kDa molecular weight cut-off (*MWCO*) *UF* membrane and a loose, 150 kDa *MWCO UF* membrane.

Membrane separation

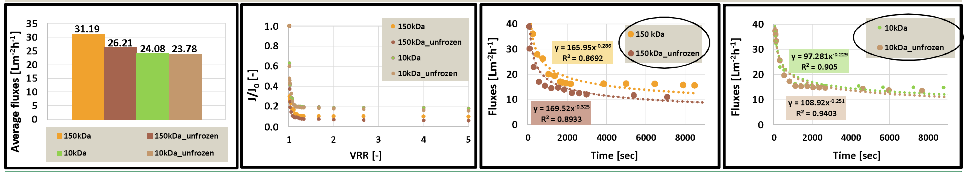
- ✓ Low-pressure membrane separation cell
- ✓ Ultrafiltrations were carried out at 0.4 MPa transmembrane pressure (*TPM*) on 25±1°C
- ✓ Stirring speed: 500 rpm
- ✓ Feed volume: 250 ml
- ✓ Permeate volume: 200 ml (VRR=5)



RESULTS AND DISCUSSION

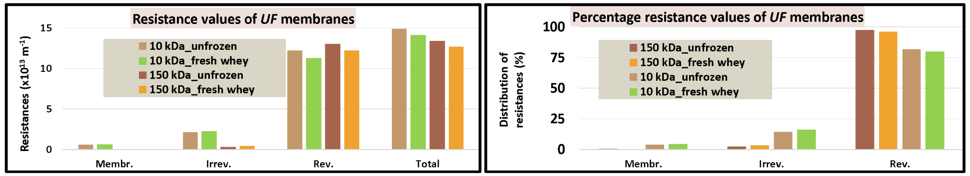
1. Permeate fluxes

The average permeate fluxes were 5% higher (31.19 vs. 26.21%) for the loose, 150 kDa *MWCO UF* membrane in the case of ultrafiltration of fresh whey.
With the tight, 10 kDa *MWCO UF* membrane there was no significant difference between the permeate fluxes performed with frozen and fresh whey (24.08 vs. 23.78%).



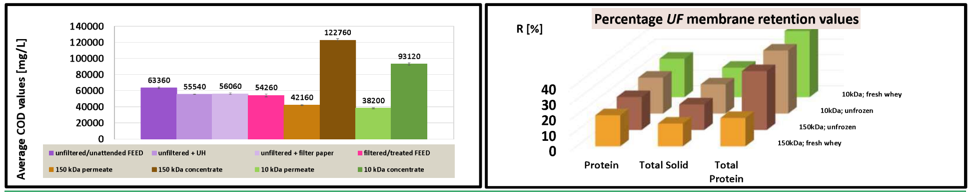
2. Resistances of membrane, irreversible and reversible

The total resistance values developed during ultrafiltration were higher for tight, 10 kDa *MWCO UF* membrane compare to 150 kDa and also higher for after one week of freezing (unfrozen) whey samples.
Furthermore, the largest part of these total resistances was given by the reversible resistance values in all cases.
Their distribution showed higher reversible percentages for the 150 kDa *MWCO UF* membrane and also for the unfrozen whey samples.



3. Membrane retentions

The retention values of the 10 kDa *MWCO UF* membrane were higher (except in chemical oxygen demand, *COD* case). For the 10 kDa membrane, the fresh whey, while for the 150 kDa membrane, the frozen samples had a higher retention values in general, but they do not differ significantly from each other (around 2% in all cases). However the ‚Total protein' retention was two times higher in the case of 150 kDa membrane with unfrozen sample.



ACKNOWLEDGEMENTS

PROJECT FINANCED FROM THE NRDI FUND

The project is financed by The National Research, Development and Innovation Office Fund, 2022-1.2.6-TÉT-IPARI-TR-2022-00011.

ICOSTEE 2024

International Conference on Science, Technology, Engineering and Economy

31st May 2024

Faculty of Engineering
University of Szeged

International Conference on Science, Technology,
Engineering and Economy

ICOSTEE 2024

BOOK OF ABSTRACTS

31st May 2024
Faculty of Engineering University of Szeged
Building A Mars tér 7, Szeged, Hungary

Publisher:
University of Szeged Faculty of Engineering
Mars tér 7, H-6724 Szeged, Hungary

Responsible publisher:
Prof. Dr. István Bíró

Edited by:
Prof. Dr. István Bíró
Prof. Dr. Zsuzsanna László
Prof. Dr. József Sárosi
Réka Dobozi
Ákos Ferenc Fazekas
József Mihalkó

ISBN:
978-963-306-986-8

Scientific and Organization Committee

Joint organization with the Agricultural and Bioengineering Scientific Committee of Hungarian Academy of Sciences

International Conference on Science, Technology, Engineering and Economy

ENHANCING MEMBRANE SEPARATION EFFICIENCY THROUGH THE UTILIZATION OF 3D-PRINTED TURBULENCE PROMOTERS DERIVED FROM RECYCLED PET BOTTLES, WITH INTEGRATION INTO FILTRATION MODULE

Gréta Gergely[1], Kevin Tóth[1], József Richárd Lennert[2], Szabolcs Kertész[1]

[1]Department of Biosystems Engineering, Faculty of Engineering, University of Szeged, Moszkvai krt. 9, H-6725 Szeged, Hungary
[2]Department of Power Electronics and E-Drives, Audi Hungaria Faculty of Automotive Engineering, Széchenyi István University, H-9026 Győr, Hungary
e-mail: kertesz@mk.u-szeged.hu

ABSTRACT

The food industry, by its nature, requires significant water consumption, especially the dairy industry, as one of the largest consumers and producers of wastewater. Additionally, the food industry is a primary contributor to the utilization of packaging materials, predominantly for polyethylene terephthalate (PET), which exhibits long-lasting degradation properties, thereby raising significant environmental problems. Given these considerations, it is recommended to accelerate efforts towards sustainable development, with innovative solutions for recycling packaging waste and modernizing wastewater treatment processes.

Through the integration of 3D-printed turbulence promoters within filtration cells, the filtration efficiencies can be enhanced solely through mechanical means, avoiding the need for chemical additives. In our research, we have observed that the integration of turbulence promoters into a low-pressure filtration cell, alongside reduced mixing speeds yielded comparable improvements in filtration efficiency to higher mixing speeds without turbulence promoters. Our scope was to research the effect of turbulence promoters printed from filament made from accumulated PET bottles on the filtration efficiency. By integrating these promoters into microfiltration and/or ultrafiltration modules, we aim not only to purify dairy wastewater, but also to selectively separate and concentrate valuable components present in other dairy by-products (e.g. whey, buttermilk).

Keywords: 3D-printed Turbulence Promoters, Dairy Wastewater Treatment, Low-pressure Membrane Separation, Ultrafiltration, Membrane Fouling Mitigation

Acknowledgements: The research is funded by the Hungarian National Research, Development and Innovation Office, NKFI-FK-142414 and 2022-1.2.6-TÉT-IPARI-TR-2022-00011 projects. G. Gergely is grateful for the financial support of the New National Excellence Program of the Ministry of Human Capacities (ÚNKP-23-2-SZTE-251).

ICOSTEE 2024-INTERNATIONAL CONFERENCE ON SCIENCE, TECHNOLOGY, ENGINEERING AND ECONOMY
Szeged, 31st MAY

ENHANCING MEMBRANE SEPARATION EFFICIENCY THROUGH THE UTILIZATION OF 3D-PRINTED TURBULENCE PROMOTERS DERIVED FROM RECYCLED PET BOTTLES, WITH INTEGRATION INTO FILTRATION MODULE

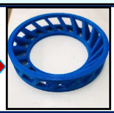
Gréta Gergely[1], Kevin Tóth[1], József Richárd Lennert[2], Szabolcs Kertész[1]*
[1]Department of Biosystems Engineering, Faculty of Engineering, University of Szeged, Szeged H-6725, Hungary
[2]Department of Power Electronics and E-Drives, Audi Hungaria Faculty of Automotive Engineering, Széchenyi István University, Győr H-9026, Hungary
Corresponding author: *kertesz@mk.u-szeged.hu

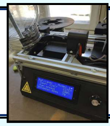
INTRODUCTION

Through the integration of **3D-printed turbulence promoters** within filtration cells, the filtration efficiencies can be enhanced solely through mechanical means, avoiding the need for chemical additives. In our research, we have observed that the integration of turbulence promoters into a low-pressure filtration cell, alongside reduced mixing speeds yielded comparable improvements in filtration efficiency to higher mixing speeds without turbulence promoters. Our scope was to research the effect of turbulence promoters printed from filament made from accumulated ***PET* bottles** on the filtration efficiency. By integrating these promoters into microfiltration and/or ultrafiltration modules, we aim not only to purify dairy wastewater, but also to selectively separate and concentrate valuable components present in other dairy by-products (e.g. whey, buttermilk).

MATERIALS AND METHODS

Dairy model wastewater: 5 gL^{-1} skimmed milk powder (Tutti Kft., Hungary) and 0.5 gL^{-1} anionic detergent (Chemipur Cl80, Szeged, Hungary) produced with tap water at 25°C; **Laboratory membrane filter cell**: (Merck Millipore, Germany); **3D printing of turbulence promoters for form testing:** The 1st promoter: *FDM* technology, Fusion 360 software; Ultimate Cure 5.0.0 program; Creality CR-10S Pro V2 type 3D printer (China), polylactic acid (*PLA*) based composite filament;The 2nd promoter: It was made using the same technology as the first one, but the filament was produced by recycling *PET* bottles with the ReFilamer (Hungary) equipment.


PLA



PET


3D printing of turbulence promoters for material testing:
The first 3D-printed turbulence promoter was made from *PLA*, while the second one was made from *PET*, or polyethylene terephthalate. In our previous research, we determined that the height of 3D-printed turbulence promoters does not significantly affect filtration properties. Considering these results and environmental protection, we removed the ring connecting the deflectors from the top of the *PET* 3D printed turbulence enhancing element.

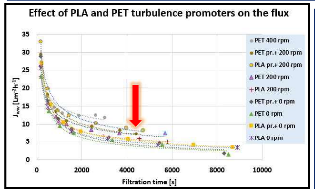
Operational parameters: **mixing speed:** 200 rpm; (400 rpm); **transmembrane pressure (TMP):** 2 bar (0.2 MPa) **cut off values** of ultrafiltration polymer *PES* membranes: 150 kDa
Additional analytics: pH meter (Thermo Scientific Orion 5-Star Plus Multifunction Benchtop Meter, United States); **Turbidity** determination (Hach 2100N Turbidimeter, United States); Chemical oxygen demand (***COD***) digester and photometer (Lovibond RD 125 and MD 200, Germany)

RESULTS AND DISCUSSION

Results of ultrafiltration of dairy wastewater

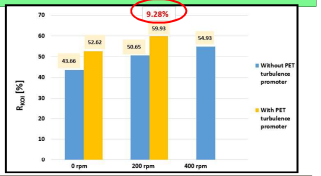
1. The laboratory measurements were carried out within the parameters that previously gave the best energetic results: ***200 rpm, 2 bar, 150 kDa***

2. After the measurements, we determined the **flux** value of the ultrafiltration membrane, which provides information on the filtration speed. After that, we compared the flux values obtained using the *PLA* 3D printed turbulence promoter.



Change in filtration time as a result of 3D printed turbulence enhancers		
	PLA turbulence promoter	*PET* turbulence promoter
0 rpm	8900 s	6872 s
200 rpm	4717 s	4345 s

3. We also determined membrane **retention** values for turbidity, total salinity and organic matter content, as well as the membrane **resistance** values. The turbidity retention values were above **99%** in all cases and the total salinity retention values ranged between **6-15%**.
For organic substances, the membrane retentions ranged from **43.7% to 59.9%.** The improvement achieved was **9.28%** with the 200 rpm *PET* turbulence promoter.



Future dairy by-product utilization possibilities

Furthermore, membrane separation processes with low pressure (*MF, UF*) are also suitable for the selective separation required for the utilization of dairy by-products. Most of the components of buttermilk and whey, which are produced in large quantities in the dairy industry, are heat-sensitive, therefore among **the non-thermal food processing technologies**, microfiltration (with polymer 0.1, 0.2, 0.45 µm membranes) and ultrafiltration (with 10, 100, **150 kDa** cut off) **are also examined in detail**. The aim is to reduce the initial microbial load and to enrich the functional components (mainly lactoglobulin G/membrane proteins/phospholipids/lipid fractions from whey and milk fat globule membrane constituents from buttermilk) and then selectively concentrate them. Afterwards, **the fouled membranes are cleaned with special cleaning agents**, mainly in order to take into account the principles of the circular economy.

ACKNOWLEDGEMENTS

The research is funded by the Hungarian National Research, Development and Innovation Office, NKFI-FK-142414 and 2022-1.2.6-TÉT-IPARI-TR-2022-00011 projects. G. Gergely is grateful for the financial support of the New National Excellence Program of the Ministry of Human Capacities (ÚNKP-23-2-SZTE-251).

NATIONAL RESEARCH, DEVELOPMENT AND INNOVATION OFFICE HUNGARY
PROJECT FINANCED FROM THE NRDI FUND

Tudományos, szakmai konferencia részvételek

Projektünk első éve alatt a projekthez szorosan kötődően 6 db tudományos konferencia részvétel történt, melyeken 10 db különböző anyaggal vettünk részt:

I. 2024.03.06-08. Balatonszárszón a XV. Környezetvédelmi Analitikai és Technológiai konferencián egy szóbeli előadás tartása („Innovatív módszerek alkalmazása a szennyvíztisztításban és tejipari szennyvíztisztításban” címmel: [MTMT közlemény azonosító: 35069466]) és egy poszter bemutatása („Ultraszűrések intenzifikálása az áramlási viszonyok megváltoztatásával” címmel: [MTMT: 35069477])

II. 2024.04.18. Hódmezővásárhelyen a „21st WELLMANN INTERNATIONAL SCIENTIFIC CONFERENCE” nemzetközi konferencián egy darab poszter bemutatása („Application possibilities of low-pressure membrane separation processes in the dairy industry” címmel: [MTMT: 35069492])

III. 2024.05.31. Szegeden az „International Conference on Science, Technology, Engineering and Economy (ICOSTEE 2024)” nemzetközi konferencián két darab poszter bemutatása („CASCADE MEMBRANE SYSTEM FOR SELECTIVE SEPARATION OF FUNCTIONAL COMPOUNDS FROM DAIRY BY-PRODUCTS” [MTMT: 35068257] és „ENHANCING MEMBRANE SEPARATION EFFICIENCY THROUGH THE UTILIZATION OF 3D-PRINTED TURBULENCE PROMOTERS DERIVED FROM RECYCLED PET BOTTLES, WITH INTEGRATION INTO FILTRATION MODULE” címekkel: [MTMT: 35069368])

IV. 2024.10.7-8. Szegeden az „30th International Symposium on Analytical and Environmental Problems (ISAEP 2024)” nemzetközi konferencián egy szóbeli előadás tartása („ANALYZING FLOW DYNAMICS WITH 3D PRINTED TURBULENCE PROMOTERS IN ULTRAFILTRATION UNIT TO MITIGATE MEMBRANE FOULING” címmel: [MTMT: 35465796]) és két darab poszter bemutatása („CASCADE MEMBRANE SYSTEM FOR EFFECTIVE COD REMOVAL FROM DAIRY BY-PRODUCT” [MTMT: 35465839] és „IMPACT OF SPACER GEOMETRY ON ULTRAFILTRATION PERFORMANCE IN A FILTER MODULE” címekkel: [MTMT: 35466592])

V. 2024.11.7-9. Debrecenben a „10th International Scientific Conference on Advances in Mechanical Engineering (ISCAME 2024)” nemzetközi konferencián két darab poszter bemutatása („Investigation of the Ultrafiltration Performance of Different Whey Solutions in a Dead-End Membrane Separation System” [MTMT: 35639572] és „Optimization of Ultrafiltration Parameters in a Laboratory-Scale Unit Using Dairy Model for Membrane Fouling Mitigation” címekkel: [MTMT: 35639548])

VI. 2024.12.03-04. ONLINE módon előadás tartása a brüsszeli „IDF Circularity in the Dairy Chain Symposium 2024” nemzetközi konferencián meghívott előadóként („Dairy wastewater treatment by advanced membrane separation techniques” címmel)

30th International Symposium on Analytical and Environmental Problems

UNIVERSITAS SCIENTIARUM SZEGEDIENSIS · SZEGEDI TUDOMÁNYEGYETEM

SZEGEDI AKADÉMIAI BIZOTTSÁG · SZAB•1961

PROCEEDINGS OF THE

30th International Symposium on Analytical and Environmental Problems

Szeged, Hungary

October 7-8, 2024

30th International Symposium on Analytical and Environmental Problems

University of Szeged

Edited by:
Tünde Alapi
Róbert Berkecz
István Ilisz

Publisher:
University of Szeged, H-6720 Szeged, Dugonics tér 13, Hungary

ISBN 978-963-688-009-5

2024.
Szeged, Hungary

The 30th International Symposium on Analytical and Environmental Problems

Organized by:
SZAB Kémiai Szakbizottság Analitikai és Környezetvédelmi Munkabizottsága

Supporting Organizations
Institute of Pharmaceutical Analysis, University of Szeged
Department of Inorganic and Analytical Chemistry, University of Szeged

Symposium Chairman:
István Ilisz, DSc

Honorary Chairman:
Zoltán Galbács, PhD

Organizing Committee:
István Ilisz, DSc
professor of chemistry
University of Szeged, Institute of Pharmaceutical Analysis
Tünde Alapi, PhD
assistant professor
University of Szeged, Department of Molecular and Analytical Chemistry
Róbert Berkecz, PhD
associate professor
University of Szeged, Institute of Pharmaceutical Analysis

Scientific Committee:
István Ilisz, DSc
Tünde Alapi, PhD
Róbert Berkecz, PhD
Daniela Sojic Merkulov, PhD
full professor
University of Novi Sad, Faculty of Sciences, Department of Chemistry, Biochemistry and Environmental Protection

Lecture Proceedings

ANALYZING FLOW DYNAMICS WITH 3D PRINTED TURBULENCE PROMOTERS IN ULTRAFILTRATION UNIT TO MITIGATE MEMBRANE FOULING

Aws N. Al-Tayawi[1*], Hajnalka Csott[2], József Richárd Lennert[3], Zsuzsanna Horváth Hovorka[4], Zsuzsanna László[2], Cecilia Hodúr[2], Tamás Szabó[5], Szabolcs Kertész[2]

[1] Doctoral School of Environmental Sciences, University of Szeged, Szeged H-6725, Hungary
[2] Department of Biosystems Engineering, Faculty of Engineering, University of Szeged, Szeged H-6725, Hungary
[3]Department of Power Electronics and E-Drives, Audi Hungaria Faculty of Automotive Engineering, Széchenyi István University, Győr H-9026, Hungary
[4]Department of Mechanical Engineering, Faculty of Engineering, University of Szeged, Szeged H-6725, Hungary
[5]Department of Physical Chemistry and Materials Science, University of Szeged, Rerrich Béla tér. 1, H-6720 Szeged, Hungary
e-mail: awsaltayawi@uomosul.edu.iq

Abstract
This study investigates the impact of various *3D* printed turbulence promoters (*3DPTP*) in a lab-scale low-pressure ultrafiltration membrane separation stirring unit using dairy model wastewater effluent. The research focuses on evaluating the performance of different *3DPTP* shapes; and identifying the optimal *3DPTP* material for the unit based on the best-performing shape. Multiple *3DPTP* designs were developed, fabricated, and tested using various materials to assess key membrane separation parameters, such as permeate flux, membrane retention, and total, reversible, and irreversible resistances. Specific *3DPTP* designs, particularly *PLA-UE* and *PLA-S*, significantly enhanced average permeates flux and reduced the total resistance. Among the tested materials, the resin material demonstrated superior performance by notably increasing permeate flux and reducing total resistance. Statistical analysis was employed to confirming the influence of *3DPTP* designs and materials on the separation performance.

Introduction
The escalating environmental challenges, driven by rapid population growth, have highlighted the importance of protecting natural water resources [1]. Within the food industry, particularly in dairy operations, substantial water use and wastewater management present significant issues [2]. The need for advanced technologies, such as hybrid/combined processes, for managing high-organic-content wastewater has become critical. Ultrafiltration, a membrane-based process, is increasingly utilized in industrial and wastewater treatment applications due to its effectiveness. However, membrane fouling and concentration polarization are persistent challenges in these processes [3]. Mitigating membrane fouling requires optimizing membrane parameters, including transmembrane pressure, stirring speed, and membrane cut-off values, as well as enhancing hydrophilicity to reduce fouling [4]. Additive manufacturing (*3D* printing) has emerged as a solution, enabling the fabrication of complex geometries and addressing various industrial challenges. The use of *3D* printed turbulence promoters (*3DPTP*) into the membrane filtration units has shown significant potential in reducing membrane fouling. Studies have demonstrated the effectiveness of *3DPTP* in improving energy efficiency and reducing fouling in membrane distillation processes. Optimizing the geometry of *3DPTP* has enhanced mixing and membrane performance. Moreover, the integration of *3DPTP* as led to superior fouling resistance and increased output flux compared to traditional spacers [5].

This study aims to examine the operational parameters of ultrafiltration membranes in a laboratory-scale dairy wastewater treatment model. After determining optimal parameters, the impact of *3DPTP* shapes on filtration efficiency and the effect of various materials on filtration performance were evaluated through comprehensive statistical analyses. The study uniquely addresses the shape and material analysis of *3DPTP* in small-scale membrane separation units.

Experimental

Model Wastewater Preparation

Model effluent simulating dairy wastewater was prepared using skimmed milk powder and anionic detergent dissolved in tap water at 25°C, achieving concentrations of 5 g/L and 0.5 g/L, respectively. Parameters such as chemical oxygen demand (*COD*) (5200 mg/L), turbidity (1150 NTU), conductivity (0.89 mS), and pH (8.7) were recorded.

Membrane Filtration Equipment

A static, stirred ultrafiltration system (Merck Millipore, Germany) was used in the laboratory. The apparatus utilized *PES* (polyethersulfone) membranes with various cut-off values, providing a total effective filtration area of 0.0036 m². Transmembrane pressure was controlled by nitrogen gas from a cylinder, regulated via a pressure valve. Filtrate was discharged through a tube at the base, maintaining a volume reduction ratio (*VRR*) of 2, reducing volumes from 100 mL to 50 mL. The mass of the permeate was continuously monitored using an electric balance (Kern EW, Germany).

Measurements for Shape and Material of 3DPTP

After selecting the optimal parameters, all variable settings associated with the equipment were documented. Measurements were then conducted using four different designs for shape testing (polylactic acid -unrestricted endstarting (*PLA-UE*), Polylactic acid-slim (*PLA-S*), polylactic acid thin barrier (*PLA-TB*) polyamide dual barrier (*PA-DB*)), and simultaneously, four identical designs were used for material testing (*PLA*, Resin, Metal, and thermoplastic polyurethane (*TPU*)), with *3DPTP* of various materials inserted along with control measurements, which were then repeated. The ultrafiltration measurements were carried out similarly to the initial series of experiments, except that the selected *3DPTP* was also directly placed on the membrane surface inside the device.

Results and discussion

The evaluations of various *3DPTP* designs showed differences in average flux. Figure 1 shows that the *PLA-UE* and *PLA-S* designs provide significant improvements in flux values compared to the control and the other designs. Additional testing with alternative printing materials demonstrated notable gains in average flux, particularly with resin material, which also contributed to decreased total resistance. Overall, the findings underscore the critical role of *3DPTP* in enhancing ultrafiltration performance.

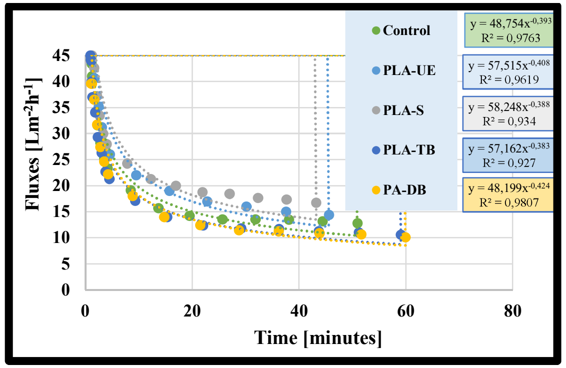


Figure 1. Variation of permeate fluxes as a function of time with different *3DPTP* (20 kDa *UF* membrane, T = 25°C, *TMP* = 3 bar, n = 400 rpm).

Conclusion

This study investigates the effects of 3D printed turbulence promoters (*3DPTP*) in a laboratory-scale ultrafiltration membrane separation unit using dairy model effluent. Various designs of *3DPTP* were tested, along with different materials, to evaluate key ultrafiltration parameters: permeate flux, membrane retention, and total resistance. The experiment with different 3D printed promoter designs revealed variations in average flux, with the *PLA-UE* and *PLA-S* designs showing notable improvements. Further assessments with alternative printing materials highlighted substantial gains in average flux, especially with resin material, which also decreased total resistance. The findings demonstrate the significant impact of *3DPTP* on ultrafiltration efficiency, with the *PLA-UE* design and resin material showing the most promising results in improving flow dynamics and overall performance.

Acknowledgements

This study was supported by the 142414 FK and 2022-1.2.6-TÉT-IPARI-TR-2022-00011 grants from the National Research, Development, and Innovation Office (NKFI), Hungary. Aws N. Al-Tayawi is grateful for the EKÖP-476 grant supported by University Research Fellowship Program of the University of Szeged.

References

[1] W. Musie, G. Gonfa, Fresh water resource, scarcity, water salinity challenges and possible remedies: A review, Heliyon. (2023).

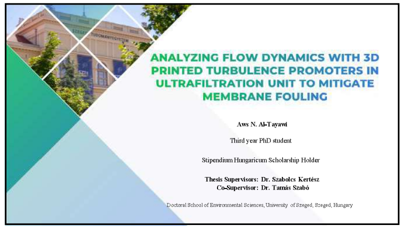
[2] L.K.S. Lima, L.N.L. Santana, H.L. Lira, M.A. Rodríguez, M.Y.M. Souza, M.G.S. Júnior, B.S. Lira, Development of asymmetric ceramic membranes for dairy wastewater treatment–A comparison between co-sintering and conventional firing process, J. Water Process Eng. 57 (2024) 104611.

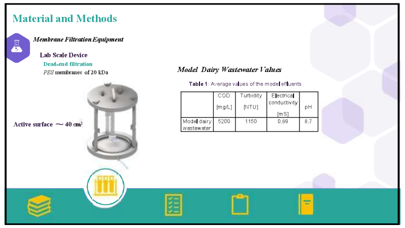
[3] L.N. Nthunya, M.F. Bopape, O.T. Mahlangu, B.B. Mamba, B. Van der Bruggen, C.A. Quist-Jensen, H. Richards, Fouling, performance and cost analysis of membrane-based water desalination technologies: A critical review, J. Environ. Manage. 301 (2022) 113922.

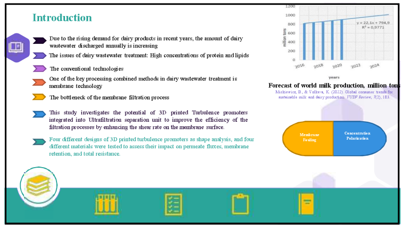
[4] S. Elhady, M. Bassyouni, R.A. Mansour, M.H. Elzahar, S. Abdel-Hamid, Y. Elhenawy, M.Y. Saleh, Oily wastewater treatment using polyamide thin film composite membrane technology, Membranes (Basel). 10 (2020) 84.

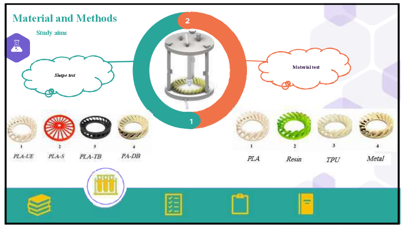
[5] N. Thomas, N. Sreedhar, O. Al-Ketan, R. Rowshan, R.K.A. Al-Rub, H. Arafat, 3D printed spacers based on TPMS architectures for scaling control in membrane distillation, J. Memb. Sci. 581 (2019) 38–49.

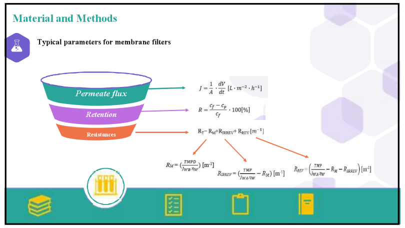
2025.02.11.

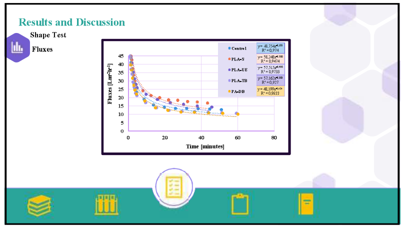


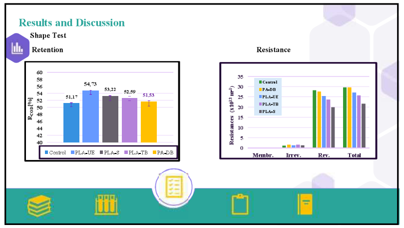


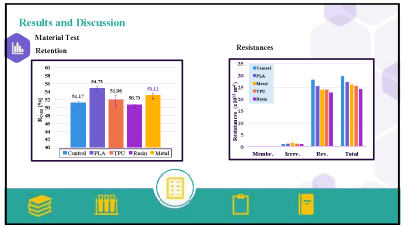




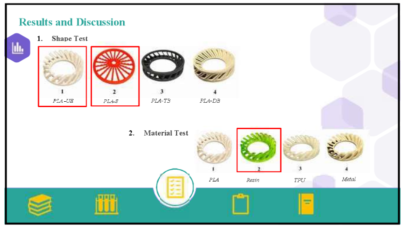


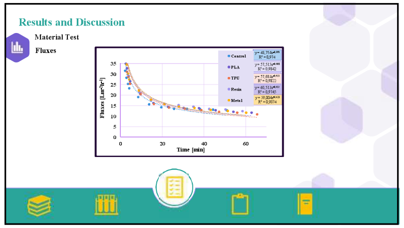


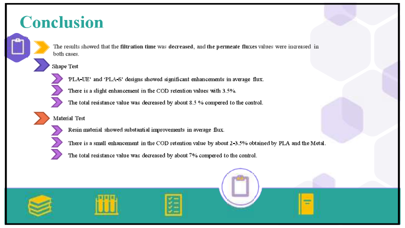

Results and Discussion
Shape Test
Retention
Resistance

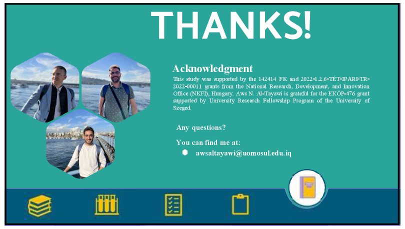

Results and Discussion
Material Test
Retention
Resistances


Results and Discussion
1. Shape Test
PLA-UE
PLA-S
PLA-TB
PLA-DB


Results and Discussion
1. Shape Test
PLA-UE
PLA-S
PLA-TB
PLA-DB
2. Material Test
PLA
Resin
TPU
Metal


Results and Discussion
Material Test
Fluxes
Time [min]


Conclusion
The results showed that the filtration time was decreased, and the permeate fluxes values were increased in both cases.
Shape Test
'PLA-UE' and 'PLA-S' designs showed significant enhancements in average flux.
There is a slight enhancement in the COD retention values with 3.5%.
The total resistance value was decreased by about 8.5 % compered to the control.
Material Test
Resin material showed substantial improvements in average flux.
There is a small enhancement in the COD retention value by about 2-3.5% obtained by PLA and the Metal.
The total resistance value was decreased by about 7% compered to the control.


THANKS!
Acknowledgment
This study was supported by the 142414 FK and 2022-1.2.6-TÉT-IPARI-TR-2022-00011 grants from the National Research, Development, and Innovation Office (NKFI), Hungary. Aws N. Al-Tayawi is grateful for the EKÖP-476 grant supported by University Research Fellowship Program of the University of Szeged.
Any questions?
You can find me at:
awsaltayawi@uomosul.edu.iq

PROCEEDINGS OF THE

30th International Symposium on Analytical and Environmental Problems

Szeged, Hungary
October 7-8, 2024

30th International Symposium on Analytical and Environmental Problems

University of Szeged

Edited by:
Tünde Alapi
Róbert Berkecz
István Ilisz

Publisher:
University of Szeged, H-6720 Szeged, Dugonics tér 13, Hungary

ISBN 978-963-688-009-5

2024.
Szeged, Hungary

The 30th International Symposium on Analytical and Environmental Problems

Organized by:
SZAB Kémiai Szakbizottság Analitikai és Környezetvédelmi Munkabizottsága

Supporting Organizations
Institute of Pharmaceutical Analysis, University of Szeged
Department of Inorganic and Analytical Chemistry, University of Szeged

Symposium Chairman:
István Ilisz, DSc

Honorary Chairman:
Zoltán Galbács, PhD

Organizing Committee:
István Ilisz, DSc
professor of chemistry
University of Szeged, Institute of Pharmaceutical Analysis
Tünde Alapi, PhD
assistant professor
University of Szeged, Department of Molecular and Analytical Chemistry
Róbert Berkecz, PhD
associate professor
University of Szeged, Institute of Pharmaceutical Analysis

Scientific Committee:
István Ilisz, DSc
Tünde Alapi, PhD
Róbert Berkecz, PhD
Daniela Sojic Merkulov, PhD
full professor
University of Novi Sad, Faculty of Sciences, Department of Chemistry, Biochemistry and Environmental Protection

30th International Symposium on Analytical and Environmental Problems

Poster Proceedings

CASCADE MEMBRANE SYSTEM FOR EFFECTIVE COD REMOVAL FROM DAIRY BY-PRODUCT

Hadid Sukmana, Adrienn Fejős, Anikó Birkásné Nagypál, Dorottya Csenki, József Csanádi, Szabolcs Kertész*

Faculty of Engineering, University of Szeged, H-6725 Szeged, Moszkvai krt. 9, Hungary
**e-mail: kertesz@mk.u-szeged.hu*

Abstract

The dairy industry is highly water-intensive, producing wastewater characterized by elevated organic loads, suspended solids, and a pH range of 7–8, which varies based on specific processes (e.g., milk processing, dairy products, cheese whey). Wastewater from both the dairy sector and chemical industries generally requires treatment before discharge to mitigate environmental impact. Dairy processing effluents are notably distinct from other industrial wastewaters, exhibiting high concentrations of chemical oxygen demand (COD), which can severely disrupt ecosystems. Membrane filtration technology has increasingly gained traction as an advanced method for water purification and to decrease COD to a desirable level.

This study provides a comparative analysis of ultrafiltration membranes for COD removal from dairy by-products. A cascade membrane system is utilized, incorporating several sequential stages: initial milk fat separation using microfiltration (MF) membranes with pore sizes of 0.1/0.2/0.5 µm, followed by protein-selective ultrafiltration (UF) with membranes of 100–150 kDa molecular weight cut-offs, and subsequent protein concentration using a 10 kDa UF membrane. The 150 kDa UF membrane exhibited superior performance, achieving higher flux and 33% COD removal. Meanwhile, the result showed that the COD removal of 10 kDa UF membrane was achieved at 40%. However, further investigation is necessary to evaluate long-term filtration performance and the effects of multiple cleaning cycles.

Keywords: Cascade membrane system, COD removal, Dairy by-product, Membrane filtration, UF membrane

Acknowledgments: This study was supported by the 2022-1.2.6-TÉT-IPARI-TR-2022-00011 grant from the National Research, Development, and Innovation Office (NKFI), Hungary.

30TH INTERNATIONAL SYMPOSIUM ON ANALYTICAL AND ENVIRONMENTAL PROBLEMS
SZEGED, 7-8 OCTOBER 2024

CASCADE MEMBRANE SYSTEM FOR EFFECTIVE COD REMOVAL FROM DAIRY BY-PRODUCT

Hadid Sukmana, Adrienn Fejős, Anikó Birkásné Nagypál, Dorottya Csenki, József Csanádi, Szabolcs Kertész*
Faculty of Engineering, University of Szeged, H-6725 Szeged, Moszkvai krt. 9, Hungary
*e-mail: kertesz@mk.u-szeged.hu

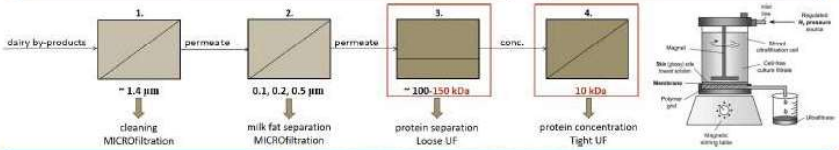
INTRODUCTION & OBJECTIVE

The dairy industry is highly water-intensive, producing wastewater characterized by elevated organic loads, suspended solids, and a pH range of 7–8, which varies based on specific processes (e.g., milk processing, dairy products, cheese whey). Wastewater from both the dairy sector and chemical industries generally requires treatment before discharge to mitigate environmental impact. Dairy processing effluents are notably distinct from other industrial wastewaters, exhibiting high concentrations of chemical oxygen demand (COD), which can severely disrupt ecosystems. Membrane filtration technology has increasingly gained traction as an advanced method for water purification and to decrease COD to a desirable level.
This study provides a comparative analysis of ultrafiltration membranes for COD removal from dairy by-products.

CASCADE MEMBRANE SYSTEM

A cascade membrane system is utilized, incorporating several sequential stages: initial milk fat separation using microfiltration (MF) membranes with pore sizes of 0.1/0.2/0.5 µm, followed by protein-selective ultrafiltration (UF) with membranes of 100–150 kDa molecular weight cut-offs, and subsequent protein concentration using a 10 kDa UF membrane.

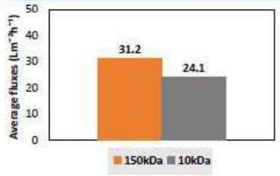
- Low-pressure membrane separation cell
- Ultrafiltrations at 0.4 MPa TPM, 25±1°C
- Stirring speed: 500 rpm
- Feed volume: 250 ml
- Permeate volume: 200 ml (VRR=5)

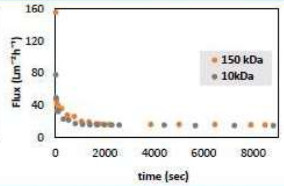


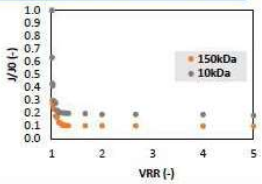
RESULTS AND DISCUSSIONS

1. Permeate fluxes

Flux and rejection are critical parameters in evaluating membrane performance. Flux measures the permeate volume and production rate, while rejection indicates the membrane's effectiveness in removing COD. These two factors together assess the membrane's ability to reduce COD levels. The average permeate fluxes for 150 kDa UF was 7% higher than 10 kDa UF.

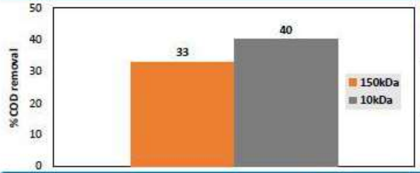






2. COD removal

Membrane separation is capable of lowering the COD in wastewater from various sources. COD levels are often a strong indicator of toxins in wastewater, with higher values signaling greater contamination. The result showed that the COD removal of 150 kDa and 10 kDa UF membranes was achieved at 33% and 40%, respectively.



Membrane	Final flux ($Lm^{-2}h^{-1}$)	Final COD (ppm)	% COD removal
150kDa UF	15.5	42160	33
10kDa UF	14.2	38200	40

Acknowledgments

This study was supported by the 2022-1.2.6-TÉT-IPARI-TR-2022-00011 grant from the National Research, Development, and Innovation Office (NKFI), Hungary.

PROCEEDINGS OF THE

30^{th} International Symposium on Analytical and Environmental Problems

Szeged, Hungary
October 7-8, 2024

30th International Symposium on Analytical and Environmental Problems

University of Szeged

Edited by:
Tünde Alapi
Róbert Berkecz
István Ilisz

Publisher:
University of Szeged, H-6720 Szeged, Dugonics tér 13, Hungary

ISBN 978-963-688-009-5

2024.
Szeged, Hungary

The 30th International Symposium on Analytical and Environmental Problems

Organized by:
SZAB Kémiai Szakbizottság Analitikai és Környezetvédelmi Munkabizottsága

Supporting Organizations
Institute of Pharmaceutical Analysis, University of Szeged
Department of Inorganic and Analytical Chemistry, University of Szeged

Symposium Chairman:
István Ilisz, DSc

Honorary Chairman:
Zoltán Galbács, PhD

Organizing Committee:
István Ilisz, DSc
professor of chemistry
University of Szeged, Institute of Pharmaceutical Analysis
Tünde Alapi, PhD
assistant professor
University of Szeged, Department of Molecular and Analytical Chemistry
Róbert Berkecz, PhD
associate professor
University of Szeged, Institute of Pharmaceutical Analysis

Scientific Committee:
István Ilisz, DSc
Tünde Alapi, PhD
Róbert Berkecz, PhD
Daniela Sojic Merkulov, PhD
full professor
University of Novi Sad, Faculty of Sciences, Department of Chemistry, Biochemistry and Environmental Protection

30th International Symposium on Analytical and Environmental Problems

Poster Proceedings

IMPACT OF SPACER GEOMETRY ON ULTRAFILTRATION PERFORMANCE IN A FILTER MODULE

Imre Vajk Fazekas[1], Aws N. Al-Tayawi[1], József Richárd Lennert[2], Sándor Beszédes[1], József Csanádi[3], Cecilia Hodúr[1], Gábor Veréb[1], Zsuzsanna László[1], Szabolcs Kertész[1*]

[1]Department of Biosystems Engineering, Faculty of Engineering, University of Szeged, Szeged H-6725, Hungary
[2]Department of Power Electronics and E-Drives, Audi Hungaria Faculty of Automotive Engineering, Széchenyi István University, Győr H-9026, Hungary
[3]Department of Food Engineering, Faculty of Engineering, University of Szeged, Szeged H-6725, Hungary
*Corresponding author: * kertesz@mk.u-szeged.hu*

Abstract

In our research, we aimed to explore how the filtration efficiency of a specialized membrane filtration device could be enhanced using custom-made, 3D-printed spacers with various geometric designs. We performed experiments using model dairy wastewater with an average load, a polyethersulfone (PES) ultrafiltration membrane, and a membrane filtration device. The tests were performed with (and without) different spacer configurations.
During the experiments, we evaluated several factors, including the permeate flux, membrane retentions, resistances, and specific energy consumption. Our measurements clearly showed that the use of 3D-printed spacers significantly improved the filtering efficiency, with some geometric configurations yielding better results.

Introduction

In today's world, wastewater management poses a significant challenge due to limited resources, making it essential to treat and recycle as much waste as possible. Among the various wastewater treatment methods, membrane filtration holds the most potential [1]. This process uses semi-permeable membranes to filter water, allowing water molecules to pass through while retaining solid particles [2]. In our research, we focused on ultrafiltration (*UF*), a pressure-driven filtration process. *UF* effectively removes suspended particles, bacteria, and viruses, but cannot filter out sugars or mono- and multivalent ions. A key drawback of membrane filtration is the inevitable fouling of the membranes. As filtered solids accumulate on the membrane's surface and within its pores, permeate flux decreases, and energy consumption rises [3]. To address this, several mitigation strategies exist, such as backwashing, chemical cleaning, and the use of module vibrations or flow diverter spacers [4]. Our study focused on the impact of the last method. We conducted tests with flow diverter spacers, which were designed based on our own plans using reference models and produced via *FDM* (Fused Deposition Modeling) 3D printing. This manufacturing method was ideal for our research, as 3D printing technology has seen rapid advancements in recent years and is now widely applied not only in industry but also in everyday life [5]. Additionally, 3D printing allowed us to quickly modify and produce new models based on insights gained from previous tests and experiences.

Experimental

The tests were conducted on a 10 liters of a model dairy wastewater solution consisting of skimmed milk powder, with a mass concentration of 5 g/L, cleaning detergent, with 0.5 g/L and room temperature tap water. A *VSEP* Series L membrane filtration module was employed,

maintaining two constant parameters: a transmembrane pressure of 8 bars and a volumetric flow rate of 4 *GPM* (approximately 15.14 L/min) (New Logic Research, Inc., USA).
Throughout 5 experiments, we analyzed various factors, including permeate flux, membrane retention, resistance, and specific energy consumption. The experiments used four variations of spacers: Sp.1-4. (Table 1.) The spacers were 3D-printed using *PETG* and *PCTG* plastic filaments on our in-house 3D printer (filaments: Filatikum, Hungary; *FDM* printer: Creality CR-10S Pro V2, China).
During the 2-hour experiment processes, 9 samples were collected in each case at different time intervals (2 feed solutions, 4 permeates, and 3 concentrates). Each sample was analyzed for total dissolved solids (*TDS*), pH level, conductivity, and turbulence. The final permeates and concentrate samples were also tested for chemical oxygen demand (*COD*), milk fat, protein, lactose with an infrared device (Bentley Instruments, Inc., USA), and protein values with Kjeldahl method (Foss, Britain).

Results and discussion

In figure 1. the permeate fluxes and in figure 3. the specific energy consumption results were plotted. Values were compared over time and over volume reduction ratio (VRR). First, it can be concluded that the use of spacers produced better results compared to the control measurements. One of the designs, Sp.1 yielded the best overall performance across all parameters, including permeate flux, retention, resistance, and specific energy consumption.

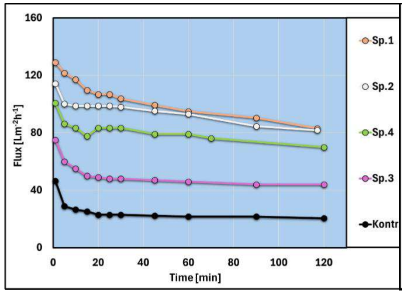


Figure 1. Permeate fluxes as a function of time (TMP=0.8MPa, q_{vrec}=15.14L/min, T=25±1°C)

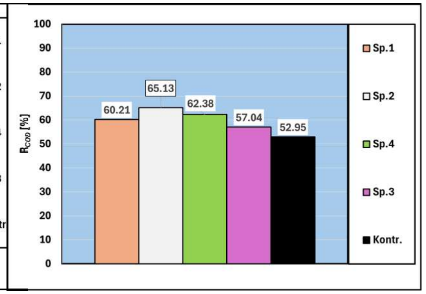


Figure 2. Retentions compared within each spacer (TMP=0.8MPa, q_{vrec}=15.14L/min, T=25±1°C)

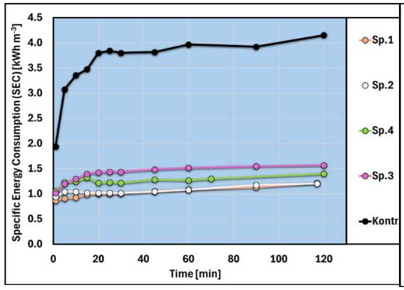


Figure 3. Specific energy consumption as a function of time (TMP=0.8MPa, q_{vrec}:4, T=25±1°C)

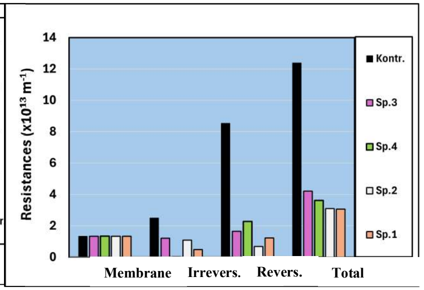


Figure 4. Irreversible and reversible resistances compared to total resistance (TMP=0.8MPa, q_{vrec}:4, T=25±1°C)

Differences between the geometric spacer designs were observed. The first two designs (Sp.1 and Sp.2) significantly outperformed the latter two (Sp.3 and Sp.4) based on the flux results. However, it's important to highlight that Sp.3 and Sp.4 required considerably less plastic for the printings. Furthermore, it can be seen from Figure 3 that the use of spacers reduced the specific energy consumption values by about one third. The fourth figure shows that the value of the total
resistances have also been greatly reduced compared to the control measurements. In addition, the first two designs gave better results than the third and fourth, as the resistances were the lowest.

Sp.1 *– First design*
Sp.2 *– First design, cone variant*
Sp.3 *– Tesla-valve inspired design*
Sp.4 *– Strengthened Tesla-valve inspired design*

Table 1. Spacer designs meanings

Conclusion

The key finding from our results is that to achieve optimal performance, a spacer with a certain geometry should be used. This approach significantly boosts the initial flux and extends the time before a substantial drop in performance occurs. As a result, the filtration process becomes more efficient, reducing the time required to treat a given volume of wastewater and lowering overall energy consumption. The average of flux values taken with the best spacer indicate a staggering 309% improvement when compared to the average of the control measurements. In the case of energy consumption, an 70% decrease is observable, when compared to the control values.

Given the lower resource and energy demands of the latter designs, it warrants further investigation to determine whether their reduced performance is offset by these savings. Future studies should assess whether the decreased performance of Sp.3 and Sp.4 can be justified by their more efficient material and energy use, particularly for large-scale applications.

Further research should also explore the combination of using multiple anti-fouling techniques, such as using spacers and module vibrations simultaneously. Our preliminary experiments in

this area have shown highly promising results, warranting continued investigation. Future studies will focus on further examining this approach.

Acknowledgements

This study was supported by the 142414 FK and 2022-1.2.6-TÉT-IPARI-TR-2022-00011 grants from the National Research, Development, and Innovation Office (NKFI), Hungary.

References

[1] J. F. J. Chimuca, C. S. A. do Canto, J. T. de Sousa, V. D. Leite, and W. S. Lopes, "Anaerobic dynamic membrane bioreactor applied to wastewater treatment: a review," *Afinidad*, vol. 80, no. 598, pp. 20–34, 2022, doi: 10.55815/413319.

[2] S. Mulyati *et al.*, "Enhancing the Anti-Fouling Property of Polyethersulfonebased Membrane using Chitosan Additive from Golden Snail (Pomacea canaliculata) Shell Waste for Water Purification," *ASEAN J. Chem. Eng.*, vol. 23, no. 2, pp. 224–239, 2023, doi: 10.22146/ajche.79643.

[3] M. S. Amiraftabi, N. Mostoufi, M. Hosseinzadeh, and M. R. Mehrnia, "Reduction of membrane fouling by innovative method (injection of air jet)," *J. Environ. Heal. Sci. Eng.*, vol. 12, no. 1, pp. 1–8, 2014, doi: 10.1186/s40201-014-0128-0.

[4] S. G. Szerencsés *et al.*, "Effect of vibration on the efficiency of ultrafiltration," *Analecta Tech. Szeged.*, vol. 15, no. 1, pp. 37–44, 2021, doi: 10.14232/analecta.2021.1.37-44.

[5] T. Templom, T. I. Erdei, and G. Husi, "Delta tripod robot FDM típusú 3D nyomtató tervezése Open-Source Arduino fejlesztőplatform felhasználásával," *Recent Innov. Mechatronics*, vol. 5, 2018, doi: 10.17667/riim.2018.si/10.

ISAEP 2024 – INTERNATIONAL SYMPOSIUM ON ANALYTICAL AND ENVIROMENTAL PROBLEMS

7th–8th OCTOBER 2024 – SZEGED

Impact of spacer geometry on ultrafiltration performance in a filter module

Imre Vajk Fazekas[1], Aws N. Al-Tayawi[1], József Richárd Lennert[2], Sándor Beszédes[1], József Csanádi[3], Cecilia Hodúr[1], Gábor Veréb[1], Zsuzsanna László[1], Szabolcs Kertész[1*]

[1]Department of Biosystems Engineering, Faculty of Engineering, University of Szeged, Szeged H-6725, Hungary

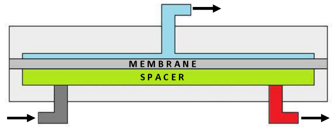
[2]Department of Power Electronics and E-Drives, Audi Hungaria Faculty of Automotive Engineering, Széchenyi István University, Győr H-9026, Hungary

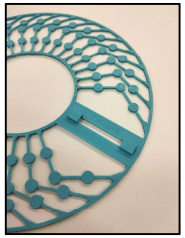
[3]Department of Food Engineering, Faculty of Engineering, University of Szeged, Szeged H-6725, Hungary

Corresponding author: *kertesz@mk.u-szeged.hu

OVERVIEW

In our research, we aimed to explore how the filtration efficiency of a specialized membrane filtration device could be enhanced using custom-made, 3D-printed spacers with various geometric designs. We performed experiments using model dairy wastewater made from skimmed milk powder, cleaning detergent and room temperature (25°C) tap water, a polyethersulfone (PES) ultrafiltration membrane with a 30 kDa cut-off value, and a VSEP Series L membrane filtration device. The tests were performed with (and without) different spacer configurations, with a transmembrane pressure of 0.8 MPa and a recirculation volume flow of approximately 15.14 L/min.
During the experiments, we evaluated several factors, including the flux of the filtrates (permeate), membrane retention, resistance, and specific energy consumption. Our measurements clearly showed that the use of 3D-printed spacers significantly improved the filtering efficiency, with some geometric configurations yielding better results.





Sp.1

Sp.4

Designing the spacers

The initial spacer prototypes were made using PLA plastic. However, PLA proved inadequate in durability when exposed to alkaline cleaning agents, prompting the need for a more robust material. We switched to PETG and PCTG, as they offer greater resilience under extreme conditions, including high pressure and exposure to highly acidic or alkaline cleaning chemicals. Our initial geometric design was relatively simple, incorporating cylinders and cones to disrupt the uniform flow inside the module. The second-generation, however, is more advanced, inspired by the Tesla valve concept. The key improvement in the new design is that it not only disrupts the flow but also channels it along a specific path, potentially promoting a more uniform flow across the membrane surface.

Spacer top-view in the module

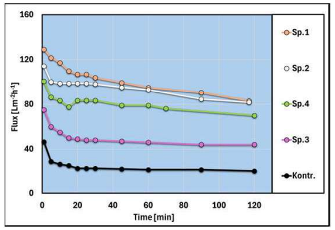


Figure 1. Permeate fluxes as a function of time (TMP=0.8MPa, q_{vrec}=15.14L/min, T=25±1°C)

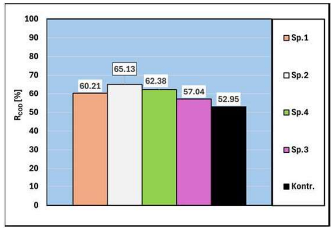


Figure 2. Retentions compared within each spacer (TMP=0.8MPa, q_{vrec}=15.14L/min, T=25±1°C)

Spacer name	Printing time [min]	Plastic used [g]
Sp.1 – First design	470	47
Sp.2 – First design cone variant	484	46
Sp.3 – Tesla-valve inspired design	340	36
Sp.4 – Strengthened Tesla-valve inspired design	362	38

Table 1. Spacer designs meanings and manufacturing parameters

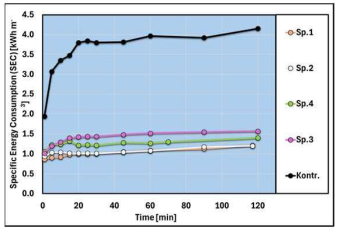


Figure 3. Specific energy consumption as a function of time (TMP=0.8MPa, q_{vrec}=15.14L/min, T=25±1°C)

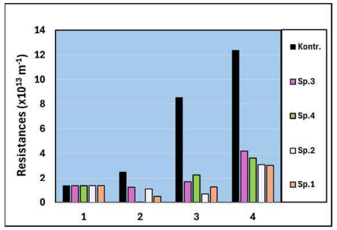


Figure 4. Irreversible and reversible resistances compared to total resistance (TMP=0.8MPa, q_{vrec}=15.14L/min, T=25±1°C)

Series LP VSEP system

Findings and conclusion

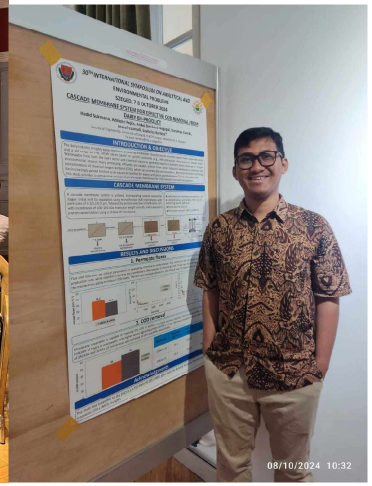
- It can be confidently stated that the use of spacers led to better results compared to the control measurements. Sp.1 demonstrated the best overall performance across most parameters, including permeate flux, resistance, and specific energy consumption.
- Significant differences were observed among the spacer designs, with Sp.1 and Sp.2 performing notably better than Sp.3 and Sp.4. However, Sp.3 and Sp.4 required 20% less plastic and 30% less printing time.
- Further research should explore combining multiple anti-fouling techniques, such as spacers and module vibrations, as preliminary experiments have shown promising results.

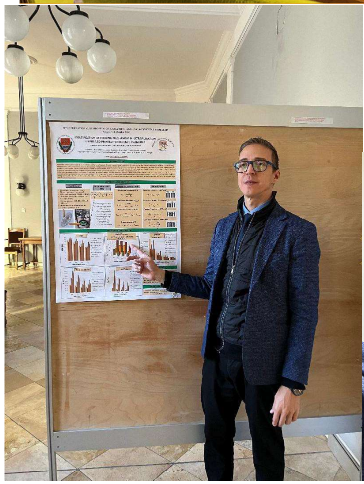
ACKNOWLEDGEMENTS

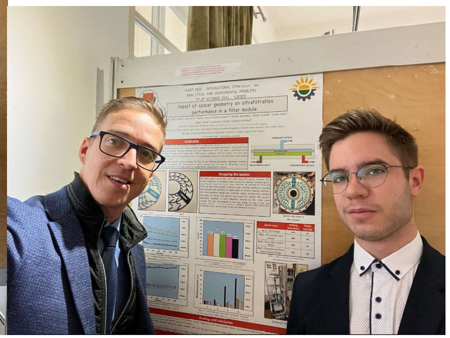
NATIONAL RESEARCH, DEVELOPMENT AND INNOVATION OFFICE HUNGARY

PROJECT FINANCED FROM THE NRDI FUND

This study was supported by the 142414 FK and 2022-1.2.6-TÉT-IPARI-TR-2022-00011 grants from the National Research, Development, and Innovation Office (NKFI), Hungary.







Tudományos, szakmai konferencia részvételek

Projektünk első éve alatt a projekthez szorosan kötődően 6 db tudományos konferencia részvétel történt, melyeken 10 db különböző anyaggal vettünk részt:

I. 2024.03.06-08. Balatonszárszón a XV. Környezetvédelmi Analitikai és Technológiai konferencián egy szóbeli előadás tartása („Innovatív módszerek alkalmazása a szennyvíztisztításban és tejipari szennyvíztisztításban” címmel: [MTMT közlemény azonosító: 35069466]) és egy poszter bemutatása („Ultraszűrések intenzifikálása az áramlási viszonyok megváltoztatásával” címmel: [MTMT: 35069477])

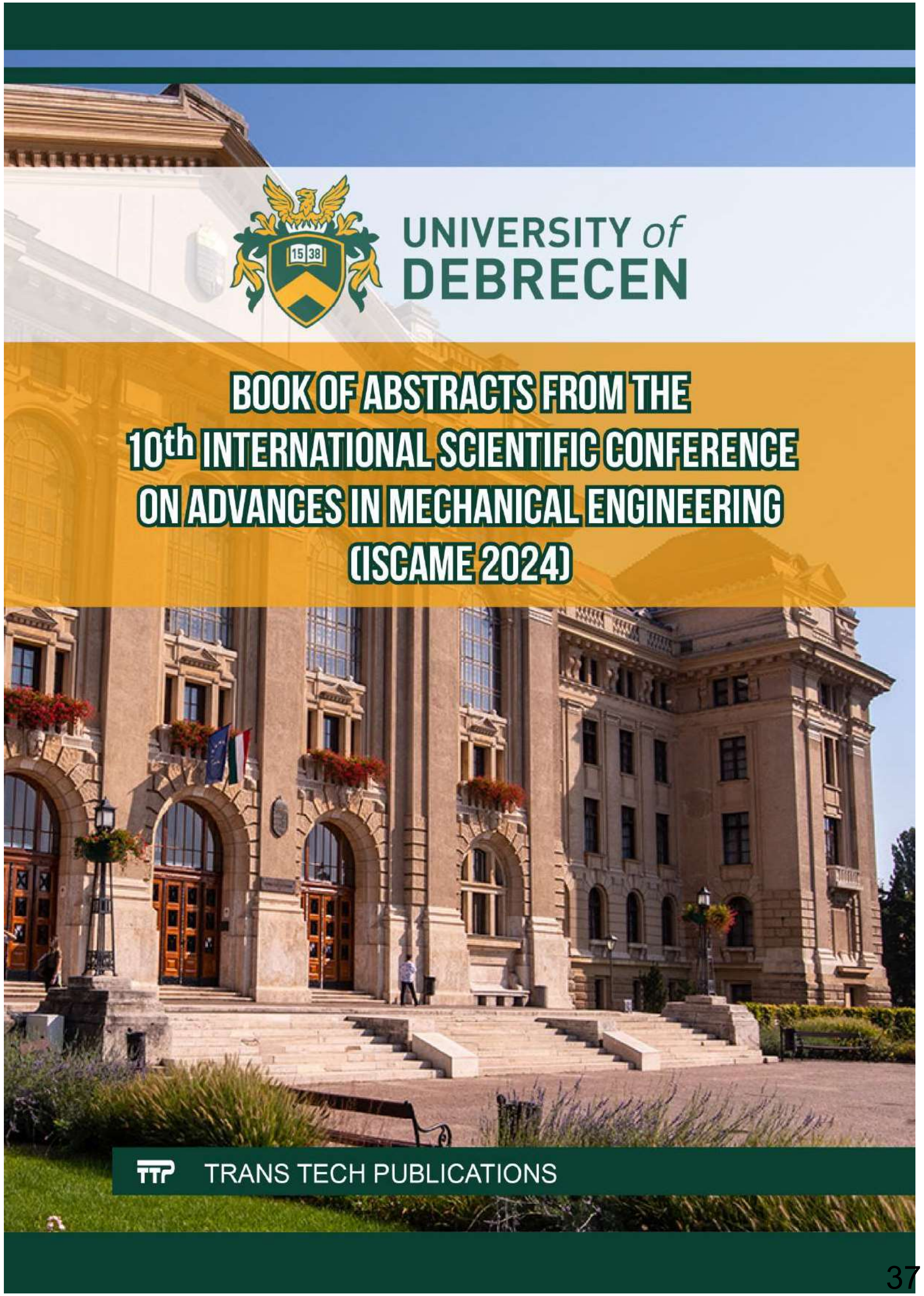
II. 2024.04.18. Hódmezővásárhelyen a „21st WELLMANN INTERNATIONAL SCIENTIFIC CONFERENCE” nemzetközi konferencián egy darab poszter bemutatása („Application possibilities of low-pressure membrane separation processes in the dairy industry” címmel: [MTMT: 35069492])

III. 2024.05.31. Szegeden az „International Conference on Science, Technology, Engineering and Economy (ICOSTEE 2024)” nemzetközi konferencián két darab poszter bemutatása („CASCADE MEMBRANE SYSTEM FOR SELECTIVE SEPARATION OF FUNCTIONAL COMPOUNDS FROM DAIRY BY-PRODUCTS” [MTMT: 35068257] és „ENHANCING MEMBRANE SEPARATION EFFICIENCY THROUGH THE UTILIZATION OF 3D-PRINTED TURBULENCE PROMOTERS DERIVED FROM RECYCLED PET BOTTLES, WITH INTEGRATION INTO FILTRATION MODULE” címekkel: [MTMT: 35069368])

IV. 2024.10.7-8. Szegeden az „30th International Symposium on Analytical and Environmental Problems (ISAEP 2024)” nemzetközi konferencián egy szóbeli előadás tartása („ANALYZING FLOW DYNAMICS WITH 3D PRINTED TURBULENCE PROMOTERS IN ULTRAFILTRATION UNIT TO MITIGATE MEMBRANE FOULING” címmel: [MTMT: 35465796]) és két darab poszter bemutatása („CASCADE MEMBRANE SYSTEM FOR EFFECTIVE COD REMOVAL FROM DAIRY BY-PRODUCT” [MTMT: 35465839] és „IMPACT OF SPACER GEOMETRY ON ULTRAFILTRATION PERFORMANCE IN A FILTER MODULE” címekkel: [MTMT: 35466592])

V. 2024.11.7-9. Debrecenben a „10th International Scientific Conference on Advances in Mechanical Engineering (ISCAME 2024)” nemzetközi konferencián két darab poszter bemutatása („Investigation of the Ultrafiltration Performance of Different Whey Solutions in a Dead-End Membrane Separation System” [MTMT: 35639572] és „Optimization of Ultrafiltration Parameters in a Laboratory-Scale Unit Using Dairy Model for Membrane Fouling Mitigation” címekkel: [MTMT: 35639548])

VI. 2024.12.03-04. ONLINE módon előadás tartása a brüsszeli „IDF Circularity in the Dairy Chain Symposium 2024” nemzetközi konferencián meghívott előadóként („Dairy wastewater treatment by advanced membrane separation techniques” címmel)



Faculty of Engineering
Department of Mechanical Engineering

Book of Abstracts from the 10th International Scientific Conference on Advances in Mechanical Engineering (ISCAME 2024)

7-9 November, 2024 Debrecen, Hungary

organized by

Department of Mechanical Engineering
Faculty of Engineering, University of Debrecen
and
Working Commission in Mechanical Engineering
Specialized Committee in Engineering
Regional Committee in Debrecen, Hungarian Academy of Sciences
and
Scientific Association of Mechanical Engineers

Project no. MEC_SZ_149279 has been implemented with the support provided by the Ministry of Culture and Innovation of Hungary from the National Research, Development and Innovation Fund, financed under the Mecenatúra funding scheme.

NATIONAL RESEARCH, DEVELOPMENT AND INNOVATION OFFICE HUNGARY

PROGRAM FINANCED FROM THE NRDI FUND

Trans Tech Publications Ltd
Seestrasse 24c
CH-8806 Baech
Switzerland
https://www.scientific.net

Scientific Books of Abstracts

Full text available online at *https://www.scientific.net*

***Distributed** worldwide by*

Trans Tech Publications Ltd
Seestrasse 24c
CH-8806 Baech
Switzerland

Phone: +41 (44) 922 10 22
e-mail: sales@scientific.net

Table of Contents

Scientific Books of Abstracts
Vol. 8, pp 17-17
© 2024 Trans Tech Publications Ltd, All Rights Reserved

Submitted: 2024-10-30
Accepted: 2024-10-31
Online: 2024-11-25

Investigation of the Ultrafiltration Performance of Different Whey Solutions in a Dead-End Membrane Separation System

Hadid Sukmana[a*], Adrienn Fejős, Anikó Birkásné Nagypál, Dorottya Csenki, József Csanádi, Cecilia Hodúr, László Zsuzsanna, Gábor Veréb, Szabolcs Kertész[b]

Faculty of Engineering, University of Szeged, H-6725 Szeged, Moszkvai krt. 9, Hungary

[a]sukmanahadid@gmail.com, [b]kertesz@mk.u-szeged.hu

Keywords: COD removal, Dairy by-product, Membrane filtration, MF membrane, UF membrane, Whey.

Abstract. The dairy industry is highly water-intensive, producing wastewater characterized by elevated organic loads, suspended solids, and a pH range of 7–8, which varies based on specific processes (e.g., milk processing, dairy products, cheese whey). Wastewater from both the dairy sector and chemical industries generally requires treatment before discharge to mitigate environmental impact. Dairy processing effluents are notably distinct from other industrial wastewaters, exhibiting high concentrations of chemical oxygen demand (COD), which can severely disrupt ecosystems. Membrane filtration technology has increasingly gained traction as an advanced method for water purification and to decrease COD to a desirable level.

This study presents a comparative analysis of microfiltration (MF) and ultrafiltration (UF) membranes for chemical oxygen demand (COD) removal from different whey solutions. In experiments using fresh whey, a sequential filtration approach was implemented, beginning with milk fat separation via MF membranes with pore sizes of 0.1, 0.2, and 0.5 µm. This was followed by protein-selective ultrafiltration using UF membranes with molecular weight cut-offs of 100–150 kDa and then protein concentration using a 10 kDa UF membrane. For synthetic whey, membrane separation was performed with MF membranes of 0.1, 0.2, and 0.5 µm pore sizes, incorporating variations in parameters such as temperature and stirring speed. The 150 kDa UF membrane showed superior performance, achieving a higher flux and 33% COD removal, while the 10 kDa UF membrane reached 40% COD removal. Optimal conditions were identified during the synthetic whey experiments. However, further research is required to assess long-term filtration performance and the impacts of multiple cleaning cycles.

UNIVERSITY of DEBRECEN

ISCAME - 10th International Scientific Conference on Advances in Mechanical Engineering

Investigation of The Ultrafiltration Performance of Different Whey Solutions in A Dead-End Membrane Separation System

Hadid Sukmana, Adrienn Fejős, Anikó Birkásné Nagypál, Dorottya Csenki, József Csanádi, Cecilia Hodúr, László Zsuzsanna, Gábor Veréb, Szabolcs Kertész*

Faculty of Engineering, University of Szeged, H-6725 Szeged, Moszkvai krt. 9, Hungary

*kertesz@mk.u-szeged.hu

Introduction

The dairy industry is highly water-intensive, producing wastewater characterized by elevated organic loads, suspended solids, and a pH range of 7–8, which varies based on specific processes (e.g., milk processing, dairy products, cheese whey). Wastewater from both the dairy sector and chemical industries generally requires treatment before discharge to mitigate environmental impact. Dairy processing effluents are notably distinct from other industrial wastewaters, exhibiting high concentrations of chemical oxygen demand (COD), which can severely disrupt ecosystems. Membrane filtration technology has increasingly gained traction as an advanced method for water purification and to decrease COD to a desirable level.

This study presents a comparative analysis of microfiltration (MF) and ultrafiltration (UF) membranes for chemical oxygen demand (COD) removal from different whey solutions.

Material and Methods

- A sequential filtration approach was implemented in experiments using fresh whey, beginning with milk fat separation via MF membranes with pore sizes of 0.1, 0.2, and 0.5 µm. This was followed by protein-selective ultrafiltration using UF membranes with molecular weight cut-offs of 100–150 kDa and then protein concentration using a 10 kDa UF membrane.
- For synthetic whey, membrane separation was performed with MF membranes of 0.1, 0.2, and 0.45 µm pore sizes, incorporating variations in parameters such as temperature (15 and 25 °C) and stirring speed (300 and 500 rpm)

Results

Flux and rejection are critical parameters in evaluating membrane performance. Flux measures the permeate volume and production rate, while rejection indicates the membrane's effectiveness in removing COD. These two factors together assess the membrane's ability to reduce COD levels. The average permeate fluxes for 150 kDa UF was 7% higher than 10 kDa UF. Meanwhile, under conditions of 500 rpm and 25 °C, the 0.45 µm membrane demonstrates a higher average permeate flux compared to the 0.1 µm and 0.2 µm membranes.

Membrane separation is capable of lowering the COD in wastewater from various sources. COD levels are often a strong indicator of toxins in wastewater, with higher values signaling greater contamination. The results showed that COD rejection for fresh whey reached 40% with 10 kDa UF membranes. In contrast, COD rejection for synthetic whey reached 79% across all membrane types under conditions of 300 rpm and 25 °C.

Fluxes

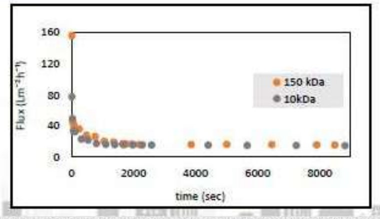


Fig. 1. Variation of the permeate fluxes from fresh whey with the function of time at 4 bar and 500rpm, T=25° C).

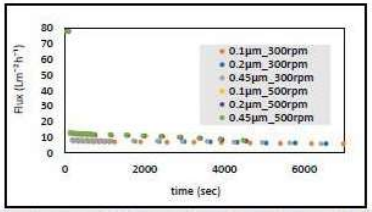


Fig. 2. Variation of the permeate fluxes from synthetic whey with the function of time at different stirring speeds (T=25° C).

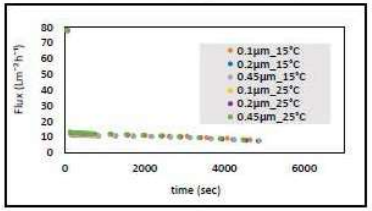


Fig. 3. Variation of the permeate fluxes from synthetic whey with the function of time at different temperatures (stirring speed=500rpm).

Rejection

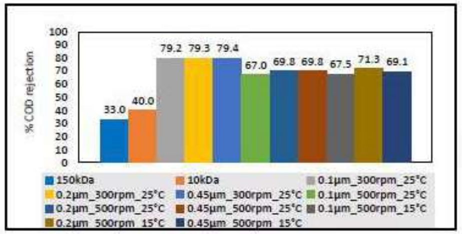


Fig. 4. COD rejection from fresh and synthetic whey

Resistances

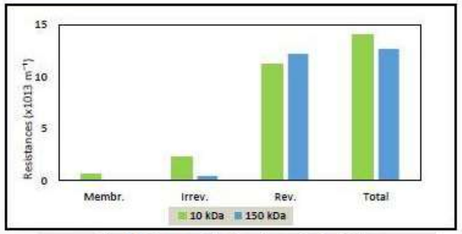
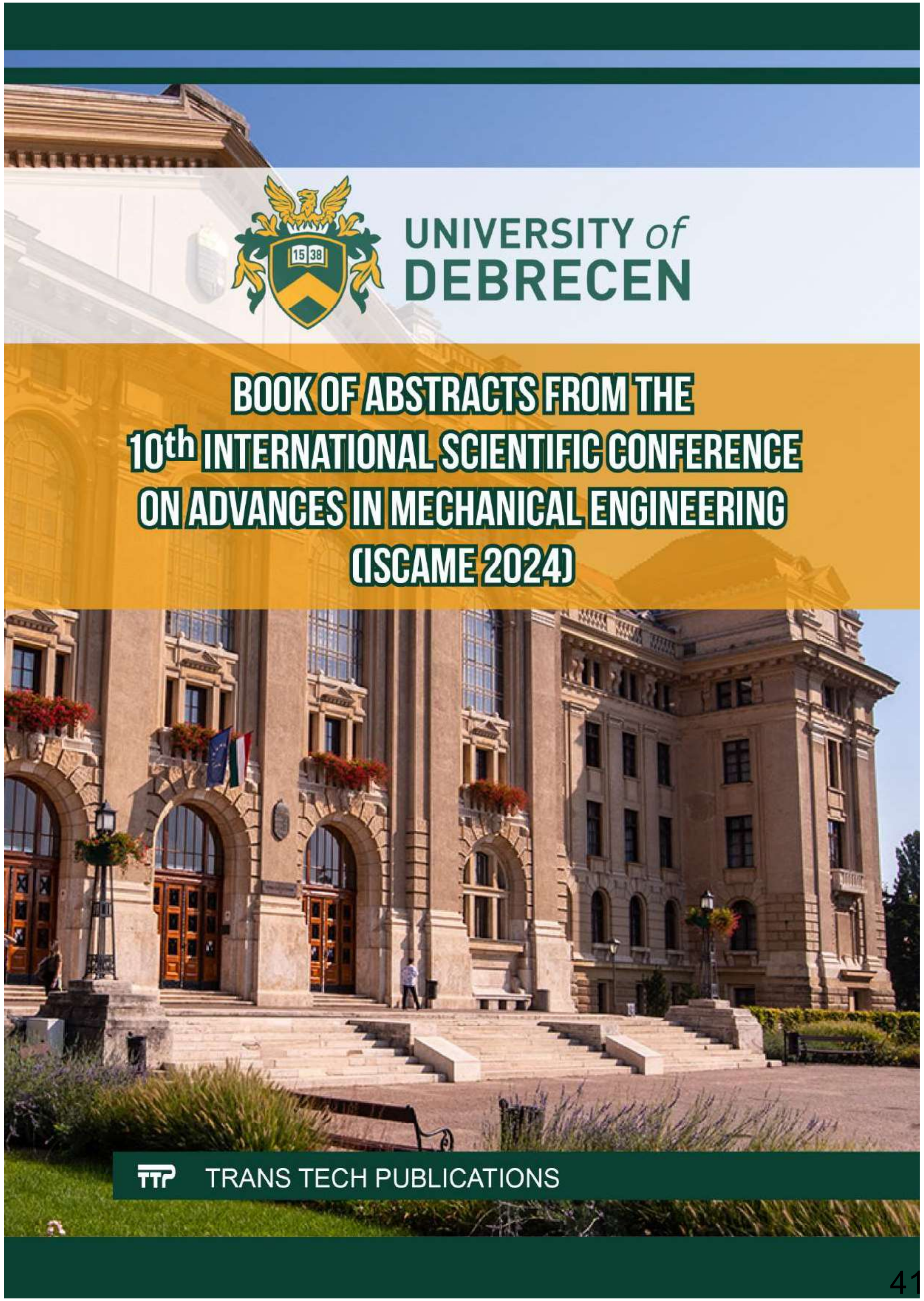


Fig. 5. Resistances value of membranes for fresh whey

Acknowledgment

This study was supported by the 2022-1.2.6-TÉT-IPARI-TR-2022-00011 grant from the National Research, Development, and Innovation Office (NKFI), Hungary.



Faculty of Engineering
Department of Mechanical Engineering

Book of Abstracts from the 10th International Scientific Conference on Advances in Mechanical Engineering (ISCAME 2024)

7-9 November, 2024 Debrecen, Hungary

organized by

Department of Mechanical Engineering
Faculty of Engineering, University of Debrecen
and
Working Commission in Mechanical Engineering
Specialized Committee in Engineering
Regional Committee in Debrecen, Hungarian Academy of Sciences
and
Scientific Association of Mechanical Engineers

Project no. MEC_SZ_149279 has been implemented with the support provided by the Ministry of Culture and Innovation of Hungary from the National Research, Development and Innovation Fund, financed under the Mecenatúra funding scheme.

NATIONAL RESEARCH, DEVELOPMENT AND INNOVATION OFFICE HUNGARY
PROGRAM FINANCED FROM THE NRDI FUND

Trans Tech Publications Ltd
Seestrasse 24c
CH-8806 Baech
Switzerland
https://www.scientific.net

Scientific Books of Abstracts

Full text available online at *https://www.scientific.net*

***Distributed** worldwide by*

Trans Tech Publications Ltd
Seestrasse 24c
CH-8806 Baech
Switzerland

Phone: +41 (44) 922 10 22
e-mail: sales@scientific.net

Table of Contents

Scientific Books of Abstracts
Vol. 8, pp 18-20

Submitted: 2024-10-18
Revised: 2024-11-05
Accepted: 2024-11-05
Online: 2024-11-25

Optimization of Ultrafiltration Parameters in a Laboratory-Scale Unit Using Dairy Model for Membrane Fouling Mitigation

Aws N. Al-Tayawi[1,a*], Hajnalka Csott[2], József Richárd Lennert[3], Zsuzsanna Horváth Hovorka[4], Zsuzsanna László[2], Cecilia Hodúr[2], Szabolcs Kertész[2]

[1]Doctoral School of Environmental Sciences, University of Szeged, Szeged H-6725, Hungary

[2]Department of Biosystems Engineering, Faculty of Engineering, University of Szeged, Szeged H-6725, Hungary

[3]Department of Power Electronics and E-Drives, Audi Hungaria Faculty of Automotive Engineering, Széchenyi István University, Győr H-9026, Hungary

[4]Department of Mechanical Engineering, Faculty of Engineering, University of Szeged, Szeged H-6725, Hungary

[a]awsaltayawi@uomosul.edu.iq

Keywords: Ultrafiltration; Membrane Fouling Mitigation; Dairy.

Abstract. This study focuses on optimizing ultrafiltration membrane parameters, including transmembrane pressure, stirring speed, and molecular weight cut-off values, to mitigate membrane fouling during dairy wastewater treatment. Adjusting operational parameters are key strategies to reduce the fouling. Increased pressure generally improves permeate quality but exacerbates fouling, while optimal cut-off values directly influence fouling severity. A laboratory-scale model was used to investigate the effects of these parameters, and statistical analysis was performed to determine the optimal conditions for permeate flux, membrane retention, and resistance. Results showed that higher stirring speeds with 400 rpm improved average flux, organic matter retention, and total resistance, whereas changes in membrane pore size had minimal effect except for flux improvement. Increasing pressure to 4 bar significantly boosted flux but also increased total resistance. Statistical validation at $p<0.005$ and a 95% confidence interval confirmed the most suitable parameter combinations for efficient filtration.

Introduction

The escalating environmental challenges confronting humanity today, stemming from rapid population growth, have underscored the critical importance of safeguarding natural water resources. One pivotal sector, particularly within the food industry, is the dairy industry, which not only utilizes substantial water volumes in its daily operations but also grapples with the intricate management of generated wastewater [1]. The contemporary necessity of employing advanced, dependable technologies like hybrid/combined processes for more effective disposal of high-organic-content wastewater is undeniable. Within this realm, the utilization of ultrafiltration, a membrane-based process, emerges as a promising solution increasingly integrated into diverse industrial and wastewater treatment technologies [2].

The prevailing challenges in membrane-based processes are membrane fouling and concentration polarization. Membrane fouling is a significant problem as it diminishes flux rates, compromises rejection efficiency, and increases energy consumption [3]. It occurs when foulants such as particulate matter, colloidal particles, biomacromolecules, and various organic, inorganic, and biological substances adhere to the membrane surface or within membrane pores. This attachment to the membrane obstructs or drastically reduces membrane pores, leading to reduced permeation flux or to changed separation efficiency. Polymer membrane fouling is categorized as irreversible when

foulants adhere to the membrane's pores and reversible when foulants form a cake layer on the membrane surface, hindering permeate movement. Membrane fouling consistently leads to decreased flux, thereby impeding membrane performance and reducing overall productivity. This reduction in active surface area, filtration efficiency, and membrane effectiveness shortens the membrane's lifespan and increases operating and replacement costs [4].

To mitigate membrane fouling, optimizing membrane parameters such as transmembrane pressure, stirring speed, and membrane cut-off values is crucial. Modifying membrane properties to enhance hydrophilicity can reduce fouling formation [5]. Adjusting this operational parameters can impact fouling behavior; for instance, increasing pressure can lead to higher fouling but improved permeate quality. Moreover, optimizing the membrane cut-off values is essential as it directly influences the severity of fouling. This study aims to meticulously examine the operational parameters, including stirring speed, transmembrane pressure, and molecular weight cut-off values, of ultrafiltration membranes within a laboratory-scale model simulating dairy wastewater treatment. Upon determining the optimal parameters. Comprehensive statistical analyses were conducted on the data to optimize the specified parameters.

Materials and Methods

A static, stirred laboratory ultrafiltration system (Merck Millipore, Germany) was utilized. PES (polyether sulfone) membranes of varied cut-off values, collectively offering an effective filtration area of 0.0036 m2, were used in the apparatus. Nitrogen gas control from the bottle and a pressure regulator valve managed the transmembrane pressure. Filtrate was released through a tube on the bottom plate, maintaining a compression ratio of 2 (VRR=2, volumes reduced from 100 mL to 50 mL). Continuous permeate mass measurements were recorded by an electric balance (Kern EW, Germany). The experiments were conducted with different transmembrane pressures (2 bar and 4 bar), stirring speeds (0 rpm, 200 rpm, and 400 rpm), and different cut-off values (10 kDa, 20 kDa, and 50 kDa). All possible pairings were combined to obtain the most detailed statistical evaluations (using Statistica), and the optimum was selected based on filtration time, quality, and economy.

Results and Discussion

Different ultrafiltration operation parameters (stirring speed, pressure, and membrane cut-off values) were investigated. The optimum filtration constants were selected by varying the filtration speed (permeate flux), quality (membrane retention), and economy (resistance), taking into account three aspects. The results were subjected to statistical analysis at a significance level of $p<0.005$ and a confidence interval of 0.95, thus helping to confirm the most appropriate choice.

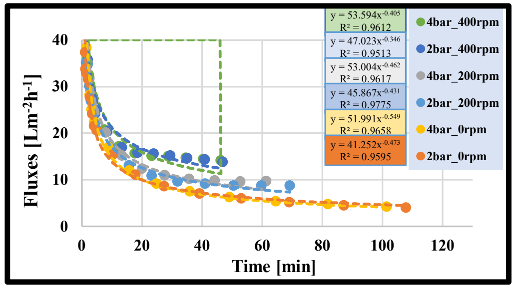


Fig. 1. Variation of the permeate fluxes with the function of time at different pressures and stirring speeds (MWCO=20 kDa; T=25°C).

The results demonstrated that increasing stirring speed enhanced average flux (Fig.1), organic matter retention, and total resistance. Altering membrane pore sizes had a limited impact on most parameters, with the exception of a notable improvement in average flux. In contrast, increasing pressure resulted in a significant rise in average flux, accompanied by a pronounced increase in total resistance.

Conclusion

This study aimed to analyze flow modifications in detail and optimize ultrafiltration by varying operating parameters such as pressure, stirring speed, and membrane cut-off values. Overall, it was found that increasing the stirring speed improved both the average flux, organic matter retention, and the total resistance values. Changing the pore sizes of the membrane did not show much difference in the other values except for the improvement in the average flux values. With increasing pressure, the average flux values increased spectacularly, while the total resistance values increased dramatically.

Acknowledgements

This study was supported by the 142414 FK and 2022-1.2.6-TÉT-IPARI-TR-2022-00011 grants from the National Research, Development, and Innovation Office (NKFI), Hungary. Aws N. Al-Tayawi is grateful for the EKÖP-476 grant supported by University Research Fellowship Program of the University of Szeged.

References

[1] L.K.S. Lima, L.N.L. Santana, H.L. Lira, M.A. Rodríguez, M.Y.M. Souza, M.G.S. Júnior, B.S. Lira, Development of asymmetric ceramic membranes for dairy wastewater treatment–A comparison between co-sintering and conventional firing process, J. Water Process Eng. 57 (2024) 104611.

[2] E.S. Mansor, E.A. Ali, A.M. Shaban, Tight ultrafiltration polyethersulfone membrane for cheese whey wastewater treatment, Chem. Eng. J. 407 (2021) 127175.

[3] A.N. Al-Tayawi, N.S. Gulyás, G. Gergely, Á.F. Fazekas, B. Szegedi, C. Hodúr, J.R. Lennert, S. Kertész, Enhancing ultrafiltration performance for dairy wastewater treatment using a 3D printed turbulence promoter, Environ. Sci. Pollut. Res. (2023) 1–10.

[4] C. Niu, X. Li, R. Dai, Z. Wang, Artificial intelligence-incorporated membrane fouling prediction for membrane-based processes in the past 20 years: A critical review, Water Res. (2022) 118299. https://doi.org/10.1016/j.watres.2022.118299 (accessed January 17, 2023).

[5] S. Elhady, M. Bassyouni, R.A. Mansour, M.H. Elzahar, S. Abdel-Hamid, Y. Elhenawy, M.Y. Saleh, Oily wastewater treatment using polyamide thin film composite membrane technology, Membranes (Basel). 10 (2020) 84.

UNIVERSITY of DEBRECEN

ISCAME - 10th International Scientific Conference on Advances in Mechanical Engineering

Optimization of Ultrafiltration Parameters in a Laboratory-Scale Unit Using Dairy Wastewater Model For Membrane Fouling Mitigation

Aws N. Al-Tayawi[1*], Hajnalka Csott[2], József Richárd Lennert[3], Zsuzsanna Horváth Hovorka[4], Zsuzsanna László[2], Cecilia Hodúr[2], Szabolcs Kertész[2]

[1]Doctoral School of Environmental Sciences, University of Szeged, Szeged H-6725, Hungary
[2]Department of Biosystems Engineering, Faculty of Engineering, University of Szeged, Szeged H-6725, Hungary
[3]Department of Power Electronics and E Drives, Audi Hungaria Faculty of Automotive Engineering, Széchenyi István University, Győr H 9026, Hungary
[4]Department of Mechanical Engineering, Faculty of Engineering, University of Szeged, Szeged H-6725, Hungary

1 Introduction

The prevailing challenges in membrane-based processes are membrane fouling and concentration polarization. Membrane fouling is a significant problem as it diminishes flux rates, compromises rejection efficiency, and increases energy consumption. To mitigate membrane fouling, optimizing membrane parameters such as transmembrane pressure, stirring speed, and membrane cut-off values is crucial. Modifying membrane properties to enhance hydrophilicity can reduce fouling formation. Adjusting these operational parameters can impact fouling behavior; for instance, increasing pressure can lead to higher fouling but improved permeate quality. Moreover, optimizing the membrane cut-off values is essential, as it directly influences the severity of fouling.

This study examines the operational parameters of ultrafiltration membranes, including stirring speed, transmembrane pressure, and molecular weight cut-off values, within a laboratory-scale model simulating dairy wastewater treatment, upon determining the optimal parameters. Comprehensive statistical analyses were conducted on the data to optimize the specified parameters.

2 Material and Methods

- The ultrafiltration experiments were carried out using a Millipore Solvent Resistant Stirred Micro- and Ultrafiltration Cell.
- The experiments were conducted with different transmembrane pressures (2 bar and 4 bar), stirring speeds (0 rpm, 200 rpm, and 400 rpm).), and different cut-off values (10 kDa, 20 kDa, and 50 kDa).

3 Results

Different ultrafiltration operation parameters (stirring speed, pressure, and membrane cut-off values) were investigated. The optimum filtration constants were selected by varying the filtration speed (permeate flux), quality (membrane retention), and economy (resistance), taking into account three aspects. The results were subjected to statistical analysis at a significance level of p<0.005 and a confidence interval of 0.95, thus helping to confirm the most appropriate choice.

Fluxes

The significant results for the fluxes value was obtained with (20 kDa, 4 bar and 400 rpm)

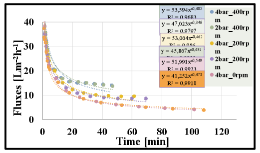


Fig. 1. Variation of the permeate fluxes with the function of time at different pressures and stirring speeds (*MWCO*=20 kDa; T=25° C).

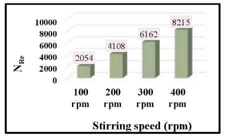


Fig.2. Reynolds number values as a result of increasing stirring speed.

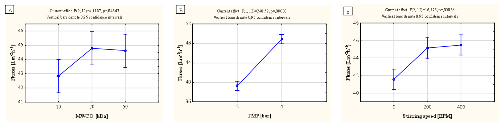


Fig. 3. Results of ANOVA: average of flux values as a function of membrane cut-off value (a), pressure (b), and stirring speed (c).

Retention

The significant results for the retention value was obtained with (20 kDa, 2 bar and 400 rpm)

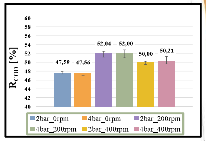


Fig. 4. Retention values of the 10 kDa membrane as a function of organic matter content, based on *COD* measurements (T=25°C).

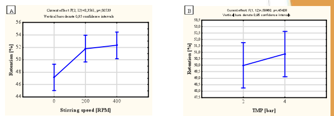


Fig. 5. Results of ANOVA: average of retention values as a function of stirring speed (a), pressure (b).

Resistances

The significant results for the total resistance value was obtained with (20 kDa, 2 bar and 400 rpm)

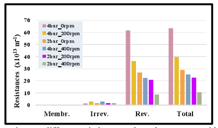


Fig. 6. Changes in resistance values at different stirring speeds and pressures with the 20 kDa membrane (T=25°C).

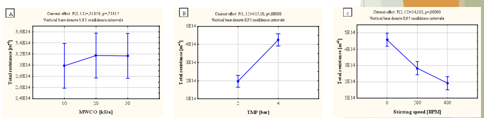


Fig. 7. Result of ANOVA: average of total resistance values as a function of membrane cut-off value (a), pressure (b), and stirring speed (c).

Conclusion

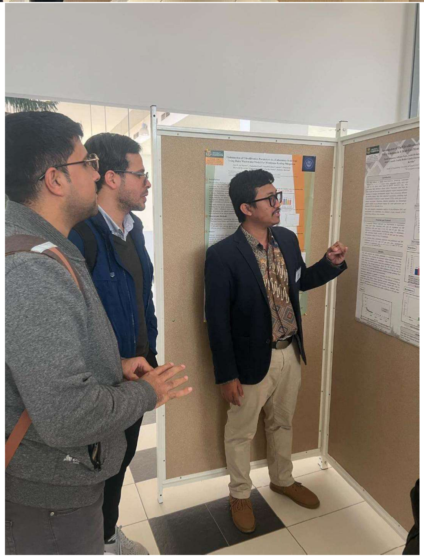
This study aimed to analyze flow modifications in detail and optimize ultrafiltration by varying operating parameters such as pressure, stirring speed, and membrane cut-off values. Overall, it was found that increasing the stirring speed improved both the average flux, organic matter retention, and the total resistance values. Changing the pore sizes of the membrane did not show much difference in the other values except for the improvement in the average flux values. With increasing pressure, the average flux values increased spectacularly, while the total resistance values increased dramatically.

Acknowledgment

This study was supported by the 142414 FK and 2022-1.2.6-TÉT-IPARI-TR-2022-00011 grants from the National Research, Development, and Innovation Office (NKFI), Hungary. Aws N. Al-Tayawi is grateful for the EKÖP-476 grant supported by University Research Fellowship Program of the University of Szeged.

Dr. Szabolcs Kertész
kertesz@mk.u-szeged.hu

PhD Candidate. Aws Al-Tayawi
awsaltayawi@uomosul.edu.iq



Tudományos, szakmai konferencia részvételek

Projektünk első éve alatt a projekthez szorosan kötődően 6 db tudományos konferencia részvétel történt, melyeken 10 db különböző anyaggal vettünk részt:

I. 2024.03.06-08. Balatonszárszón a XV. Környezetvédelmi Analitikai és Technológiai konferencián egy szóbeli előadás tartása („Innovatív módszerek alkalmazása a szennyvíztisztításban és tejipari szennyvíztisztításban” címmel: [MTMT közlemény azonosító: 35069466]) és egy poszter bemutatása („Ultraszűrések intenzifikálása az áramlási viszonyok megváltoztatásával” címmel: [MTMT: 35069477])

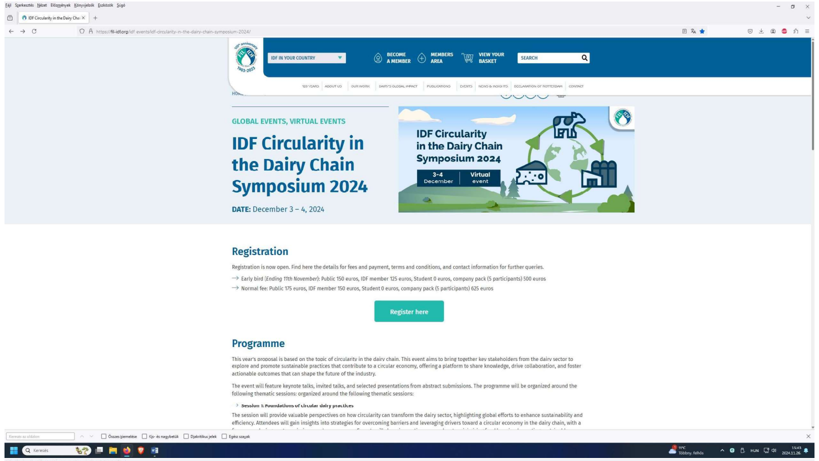
II. 2024.04.18. Hódmezővásárhelyen a „21st WELLMANN INTERNATIONAL SCIENTIFIC CONFERENCE” nemzetközi konferencián egy darab poszter bemutatása („Application possibilities of low-pressure membrane separation processes in the dairy industry” címmel: [MTMT: 35069492])

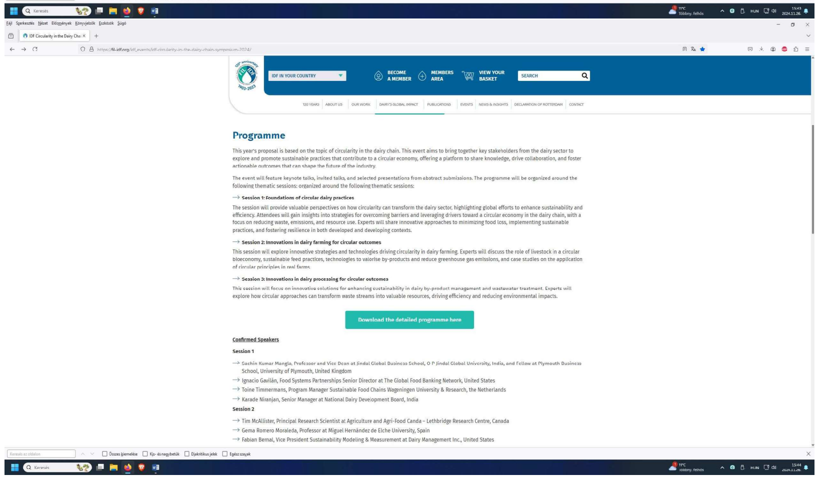
III. 2024.05.31. Szegeden az „International Conference on Science, Technology, Engineering and Economy (ICOSTEE 2024)” nemzetközi konferencián két darab poszter bemutatása („CASCADE MEMBRANE SYSTEM FOR SELECTIVE SEPARATION OF FUNCTIONAL COMPOUNDS FROM DAIRY BY-PRODUCTS” [MTMT: 35068257] és „ENHANCING MEMBRANE SEPARATION EFFICIENCY THROUGH THE UTILIZATION OF 3D-PRINTED TURBULENCE PROMOTERS DERIVED FROM RECYCLED PET BOTTLES, WITH INTEGRATION INTO FILTRATION MODULE” címekkel: [MTMT: 35069368])

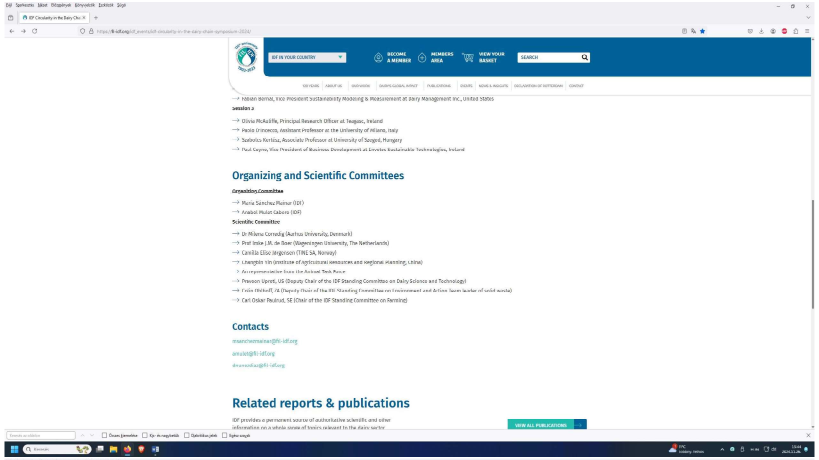
IV. 2024.10.7-8. Szegeden az „30th International Symposium on Analytical and Environmental Problems (ISAEP 2024)” nemzetközi konferencián egy szóbeli előadás tartása („ANALYZING FLOW DYNAMICS WITH 3D PRINTED TURBULENCE PROMOTERS IN ULTRAFILTRATION UNIT TO MITIGATE MEMBRANE FOULING” címmel: [MTMT: 35465796]) és két darab poszter bemutatása („CASCADE MEMBRANE SYSTEM FOR EFFECTIVE COD REMOVAL FROM DAIRY BY-PRODUCT” [MTMT: 35465839] és „IMPACT OF SPACER GEOMETRY ON ULTRAFILTRATION PERFORMANCE IN A FILTER MODULE” címekkel: [MTMT: 35466592])

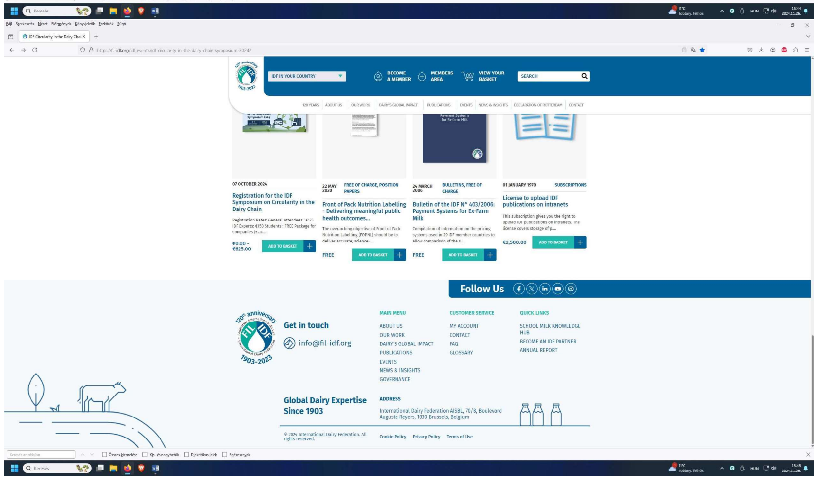
V. 2024.11.7-9. Debrecenben a „10th International Scientific Conference on Advances in Mechanical Engineering (ISCAME 2024)” nemzetközi konferencián két darab poszter bemutatása („Investigation of the Ultrafiltration Performance of Different Whey Solutions in a Dead-End Membrane Separation System” [MTMT: 35639572] és „Optimization of Ultrafiltration Parameters in a Laboratory-Scale Unit Using Dairy Model for Membrane Fouling Mitigation” címekkel: [MTMT: 35639548])

VI. 2024.12.03-04. ONLINE módon előadás tartása a brüsszeli „IDF Circularity in the Dairy Chain Symposium 2024” nemzetközi konferencián meghívott előadóként („Dairy wastewater treatment by advanced membrane separation techniques” címmel)

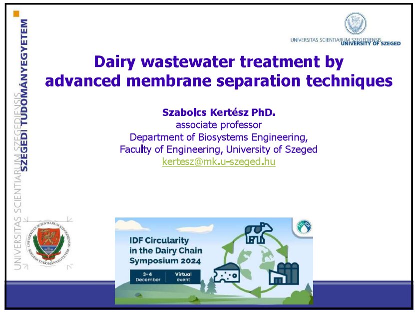





Organizing and Scientific Committees
Contacts
Related reports & publications

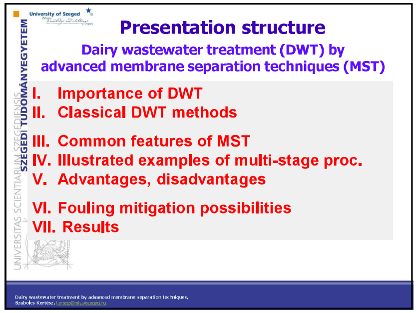

Follow Us
Get in touch
Global Dairy Expertise Since 1903

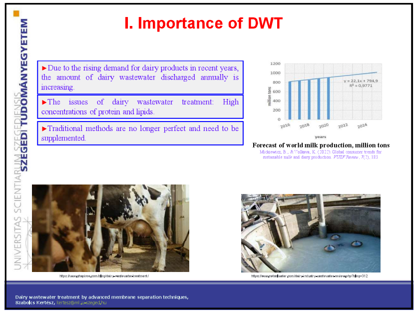

IDF Circularity in the Dairy Chain Symposium 2024
3-4 December
Virtual event

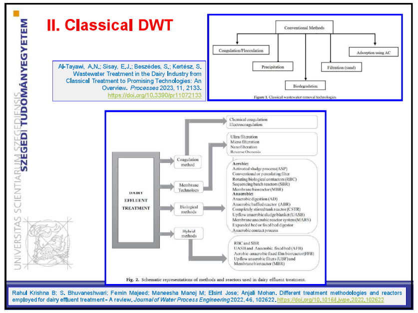

SZEGEDI TUDOMÁNYEGYETEM
Dairy wastewater treatment by
advanced membrane separation techniques
Szabolcs Kertész PhD.
associate professor
Department of Biosystems Engineering,
Faculty of Engineering, University of Szeged
kertesz@mk.u-szeged.hu
IDF Circularity in the Dairy Chain Symposium 2024

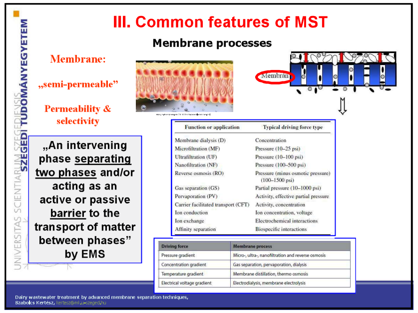

Warming up: ‚Behind us'
Hungary
Szeged
„City of Sunshine"
USZ
QS 500
12 faculties
19 doctoral schools
6000 staff
25 000 students

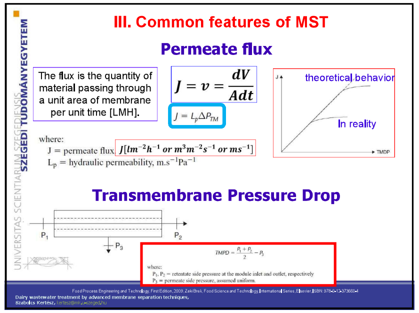

Warming up: ‚Behind us'
Hungarians have won
15 Nobel Prizes since 1905.
Year
Winner
Field
Contribution
1937
Albert Szent-Györgyi
Physiology or Medicine
2023
Katalin Karikó
Physiology or Medicine
2023
Ferenc Krausz
Physics

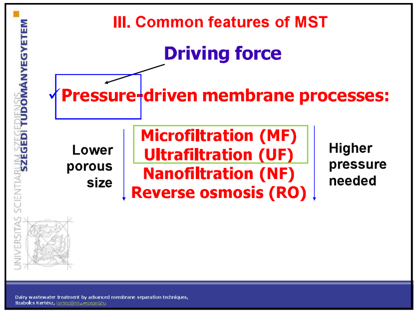

Presentation structure
Dairy wastewater treatment (DWT) by
advanced membrane separation techniques (MST)
I. Importance of DWT
II. Classical DWT methods
III. Common features of MST
IV. Illustrated examples of multi-stage proc.
V. Advantages, disadvantages
VI. Fouling mitigation possibilities
VII. Results

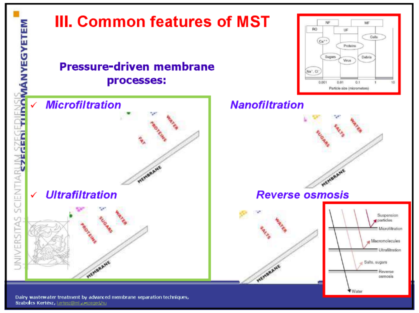

I. Importance of DWT
Due to the rising demand for dairy products in recent years, the amount of dairy wastewater discharged annually is increasing.
The issues of dairy wastewater treatment: High concentrations of protein and lipids
Traditional methods are no longer perfect and need to be supplemented
Forecast of world milk production, million tons

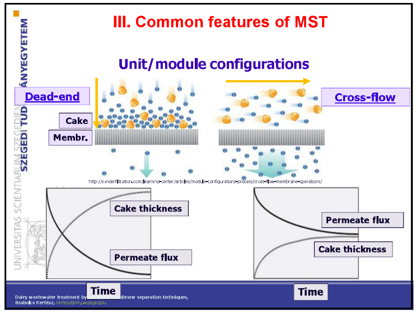

II. Classical DWT

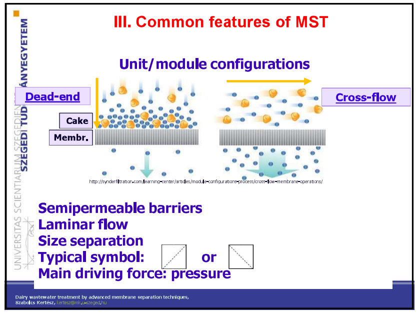

III. Common features of MST
Membrane processes
Membrane:
„semi-permeable"
Permeability & selectivity
„An intervening phase separating two phases and/or acting as an active or passive barrier to the transport of matter between phases" by EMS

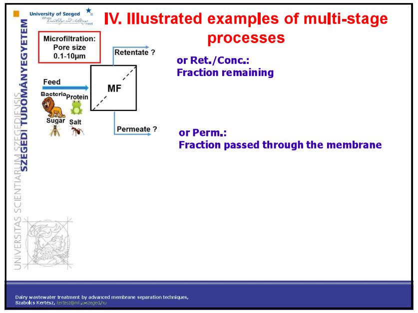

III. Common features of MST
Permeate flux
The flux is the quantity of material passing through a unit area of membrane per unit time [LMH].
theoretical behavior
In reality
Transmembrane Pressure Drop

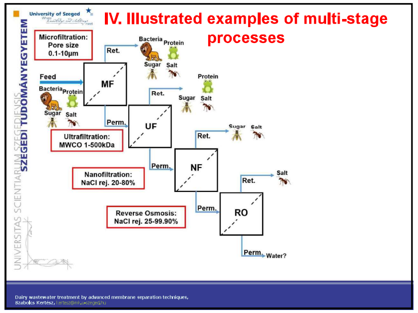

III. Common features of MST
Driving force
Pressure-driven membrane processes:
Microfiltration (MF)
Ultrafiltration (UF)
Nanofiltration (NF)
Reverse osmosis (RO)
Lower porous size
Higher pressure needed

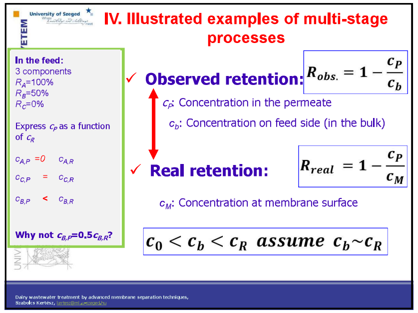

III. Common features of MST
Pressure-driven membrane processes:
Microfiltration
Nanofiltration
Ultrafiltration
Reverse osmosis

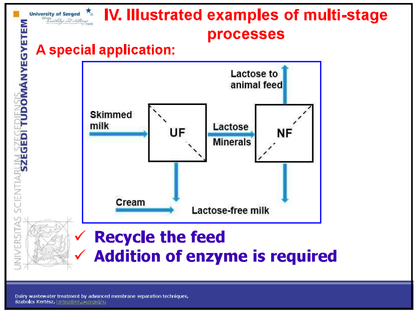

III. Common features of MST
Unit/module configurations
Dead-end
Cross-flow
Cake
Membr.
Cake thickness
Permeate flux
Time

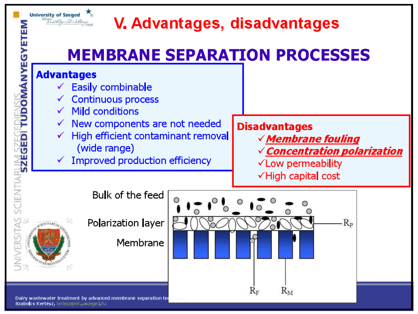

III. Common features of MST
Unit/module configurations
Dead-end
Cross-flow
Cake
Membr.
Semipermeable barriers
Laminar flow
Size separation
Typical symbol: or
Main driving force: pressure

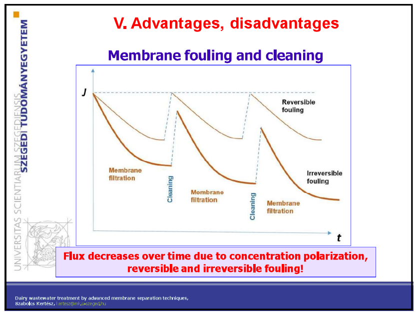

IV. Illustrated examples of multi-stage processes
Microfiltration: Pore size 0.1-10μm
Retentate ?
or Ret./Conc.: Fraction remaining
Feed
Bacteria
Protein
Sugar
Salt
MF
Permeate ?
or Perm.: Fraction passed through the membrane


IV. Illustrated examples of multi-stage processes
Microfiltration: Pore size 0.1-10μm
Ultrafiltration: MWCO 1-500kDa
Nanofiltration: NaCl rej. 20-80%
Reverse Osmosis: NaCl rej. 25-99.90%
Feed
MF
UF
NF
RO
Ret.
Perm.
Water?

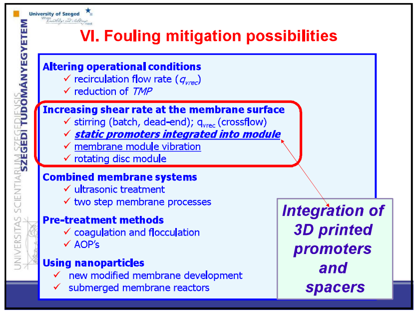

IV. Illustrated examples of multi-stage processes
In the feed: 3 components
R_A=100%
R_B=50%
R_C=0%
Express c_p as a function of c_R
Why not $c_{B,P}$=0.5$c_{B,R}$?
Observed retention: $R_{obs.} = 1 - \frac{c_P}{c_b}$
c_P: Concentration in the permeate
c_b: Concentration on feed side (in the bulk)
Real retention: $R_{real} = 1 - \frac{c_P}{c_M}$
c_M: Concentration at membrane surface
$c_0 < c_b < c_R$ assume $c_b \sim c_R$

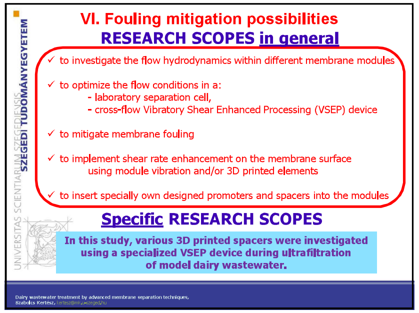

IV. Illustrated examples of multi-stage processes
A special application:
Skimmed milk
UF
Lactose Minerals
NF
Lactose to animal feed
Cream
Lactose-free milk
Recycle the feed
Addition of enzyme is required

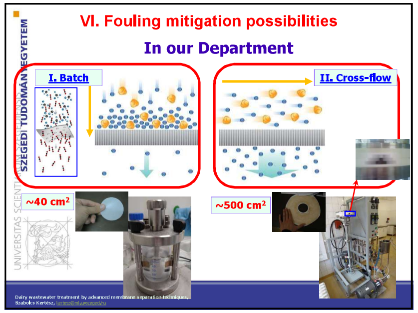

V. Advantages, disadvantages
MEMBRANE SEPARATION PROCESSES
Advantages
Easily combinable
Continuous process
Mild conditions
New components are not needed
High efficient contaminant removal (wide range)
Improved production efficiency
Disadvantages
Membrane fouling
Concentration polarization
Low permeability
High capital cost
Bulk of the feed
Polarization layer
Membrane


V. Advantages, disadvantages
Membrane fouling and cleaning
Reversible fouling
Irreversible fouling
Membrane filtration
Cleaning
Flux decreases over time due to concentration polarization, reversible and irreversible fouling!

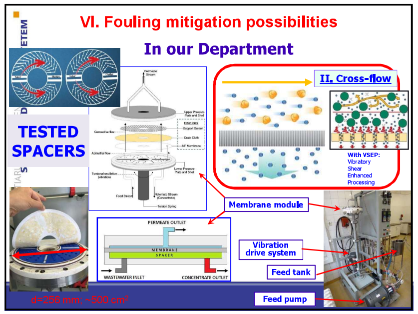
2025.02.11.

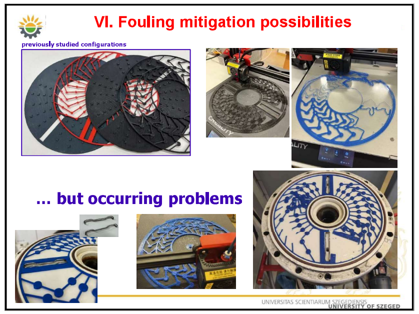

VI. Fouling mitigation possibilities
Altering operational conditions
recirculation flow rate
reduction of TMP
Increasing shear rate at the membrane surface
stirring (batch, dead-end); (crossflow)
static promoters integrated into module
membrane module vibration
rotating disc module
Combined membrane systems
ultrasonic treatment
two step membrane processes
Pre-treatment methods
coagulation and flocculation
AOP's
Using nanoparticles
new modified membrane development
submerged membrane reactors
Integration of 3D printed promoters and spacers

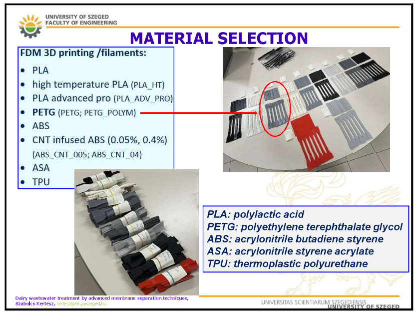

VI. Fouling mitigation possibilities
RESEARCH SCOPES in general
to investigate the flow hydrodynamics within different membrane modules
to optimize the flow conditions in a:
- laboratory separation cell,
- cross-flow Vibratory Shear Enhanced Processing (VSEP) device
to mitigate membrane fouling
to implement shear rate enhancement on the membrane surface using module vibration and/or 3D printed elements
to insert specially own designed promoters and spacers into the modules
Specific RESEARCH SCOPES
In this study, various 3D printed spacers were investigated using a specialized VSEP device during ultrafiltration of model dairy wastewater.

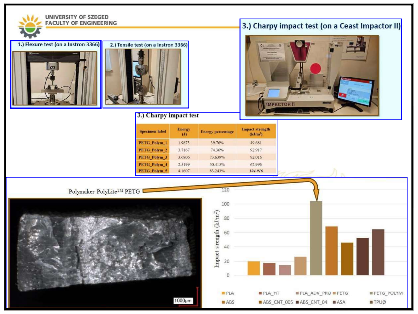

VI. Fouling mitigation possibilities
In our Department
I. Batch
II. Cross-flow
~40 cm²
~500 cm²

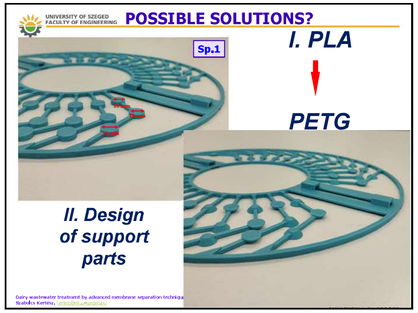

VI. Fouling mitigation possibilities
I. Batch
previously studied configurations
~40 cm²

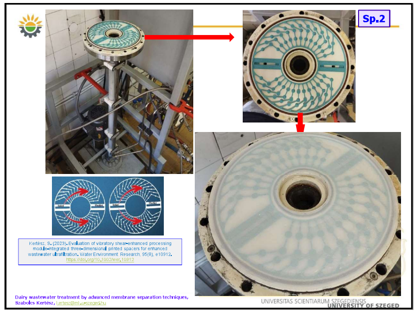

VI. Fouling mitigation possibilities
In our Department
TESTED SPACERS
II. Cross-flow
Membrane module
Vibration drive system
Feed tank
Feed pump

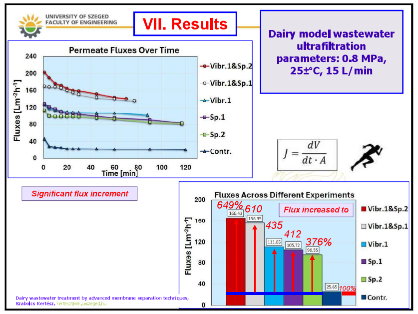

VI. Fouling mitigation possibilities
previously studied configurations
... but occurring problems

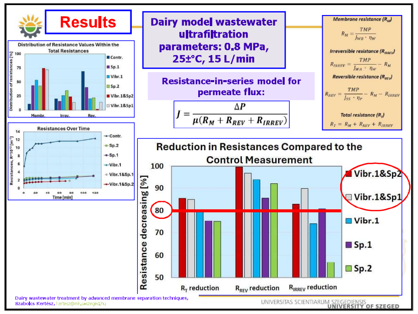

UNIVERSITY OF SZEGED FACULTY OF ENGINEERING
MATERIAL SELECTION
FDM 3D printing /filaments:
PLA
high temperature PLA (PLA_HT)
PLA advanced pro (PLA_ADV_PRO)
PETG (PETG; PETG_POLYM)
ABS
CNT infused ABS (0.05%, 0.4%) (ABS_CNT_005; ABS_CNT_04)
ASA
TPU
PLA: polylactic acid
PETG: polyethylene terephthalate glycol
ABS: acrylonitrile butadiene styrene
ASA: acrylonitrile styrene acrylate
TPU: thermoplastic polyurethane

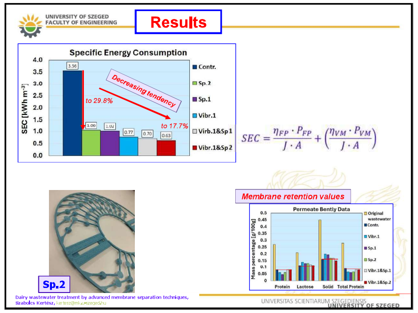

UNIVERSITY OF SZEGED FACULTY OF ENGINEERING
1.) Flexure test (on a Instron 3366)
2.) Tensile test (on a Instron 3366)
3.) Charpy impact test (on a Ceast Impactor II)
3.) Charpy impact test
Polymaker PolyLite PETG

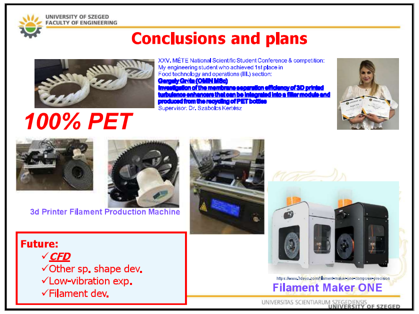

UNIVERSITY OF SZEGED FACULTY OF ENGINEERING
POSSIBLE SOLUTIONS?
Sp.1
I. PLA
PETG
II. Design of support parts

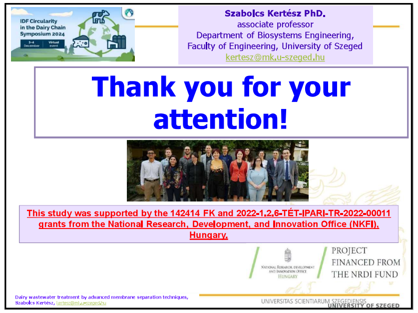

Sp.2


UNIVERSITY OF SZEGED FACULTY OF ENGINEERING
VII. Results
Dairy model wastewater ultrafiltration parameters: 0.8 MPa, 25±°C, 15 L/min
Permeate Fluxes Over Time
Vibr.1&Sp.2
Vibr.1&Sp.1
Vibr.1
Sp.1
Sp.2
Contr.
Time [min]
Fluxes [L m⁻² h⁻¹]
$J = \frac{dV}{dt \cdot A}$
Significant flux increment
Fluxes Across Different Experiments
Flux increased to
649%
610
435
412
376%


Results
Dairy model wastewater ultrafiltration parameters: 0.8 MPa, 25±°C, 15 L/min
Resistance-in-series model for permeate flux:
$J = \frac{\Delta P}{\mu (R_M + R_{REV} + R_{IRREV})}$
Reduction in Resistances Compared to the Control Measurement
Resistance decreasing [%]
Vibr.1&Sp2
Vibr.1&Sp1
Vibr.1
Sp.1
Sp.2


UNIVERSITY OF SZEGED FACULTY OF ENGINEERING
Results
Specific Energy Consumption
Decreasing tendency
to 29.8%
to 17.7%
Contr.
Sp.2
Sp.1
Vibr.1
Virb.1&Sp1
Vibr.1&Sp2
SEC [kWh m⁻³]
Membrane retention values
Permeate Bently Data
Sp.2


UNIVERSITY OF SZEGED FACULTY OF ENGINEERING
Conclusions and plans
100% PET
3d Printer Filament Production Machine
Future:
✓CFD
✓Other sp. shape dev.
✓Low-vibration exp.
✓Filament dev.
Filament Maker ONE


Szabolcs Kertész PhD,
associate professor
Department of Biosystems Engineering,
Faculty of Engineering, University of Szeged
kertesz@mk.u-szeged.hu
Thank you for your attention!
This study was supported by the 142414 FK and 2022-1.2.6-TÉT-IPARI-TR-2022-00011 grants from the National Research, Development, and Innovation Office (NKFI), Hungary.
PROJECT FINANCED FROM THE NRDI FUND