

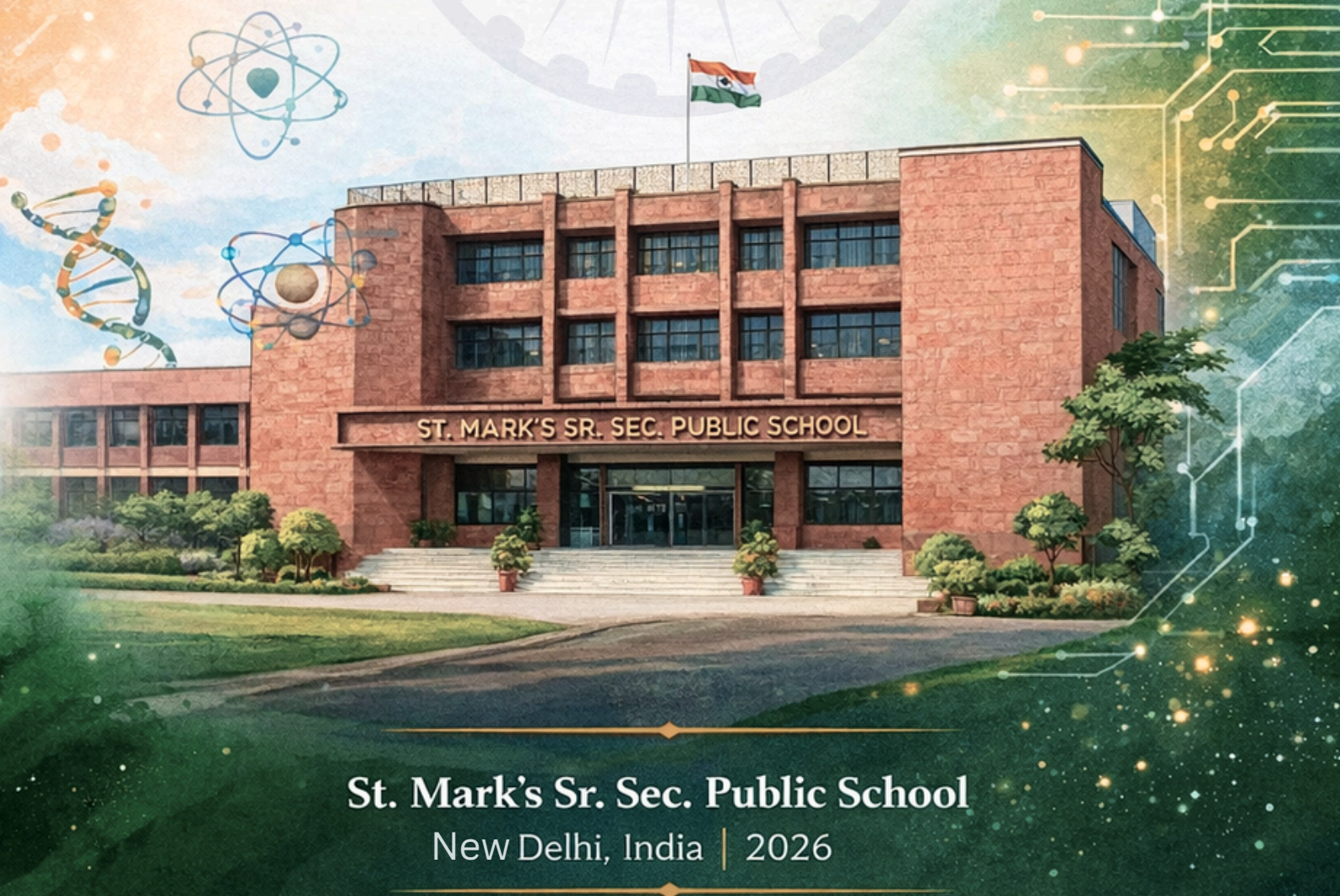


ABSTRACT & GUIDEBOOK

THE 32nd
INTERNATIONAL CONFERENCE
OF YOUNG SCIENTISTS

— **NEW DELHI, INDIA** —

Real Minds. Real Intelligence.



St. Mark's Sr. Sec. Public School
New Delhi, India | 2026

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International Conference Of Young Scientists

Real Minds. Real Intelligence.

TRIBUTE TO THE FOUNDER PRINCIPAL



ST MARK'S SR SEC PUBLIC SCHOOL, MEERA BAGH

'Some leaders light a path for others; a rare few become the light that guides generations.'

Ms. Anjali Aggarwal, our revered Founder Principal and a truly inspiring mentor, leaves behind a legacy that beautifully blends academic excellence with innovation and a deep-rooted spirit of scientific enquiry. To many of us, she was not just a leader, but a guiding light who believed that education must go beyond the pages of a book.

Her vision was clear and powerful—she wished to see every child think independently, question confidently, and create fearlessly. She constantly



encouraged students to step forward, to participate, to experiment, and to discover their potential. Be it exhibitions, Olympiads, research platforms, or STEM competitions, her unwavering support gave students the confidence to express their ideas and face challenges with courage.

What made her truly special was her belief in learning by doing. She championed the integration of technology and hands-on experiences, making education meaningful and memorable. Today, as we see our alumni making their mark in science and research, we are reminded of the strong foundation she helped build. Her presence may no longer be with us in the same way, but her influence continues to echo in our classrooms, our thoughts, and our aspirations. In every question a child dares to ask, in every idea that takes shape, and in every dream that soars high, her spirit lives on.

Ms. Aggarwal did not just build an institution—she built a culture of curiosity, courage, and continuous learning that will inspire generations to come.



MESSAGES



THE CHAIRPERSON



ST MARK'S SR SEC PUBLIC SCHOOL, MEERA BAGH

It gives me immense pleasure and a deep sense of pride to welcome you all to the 32nd edition of the International Conference of Young Scientists (ICYS), hosted by St. Mark's Senior Secondary Public School, Meera Bagh, New Delhi.

"Education is not the filling of a pail, but the lighting of a fire." – a thought beautifully advocated by William Butler Yeats.

As the Founder and Chairman of the St. Mark's Senior Secondary Public School, Meera Bagh,

my journey has always been guided by a simple yet powerful vision—to create learning spaces where every child is empowered to grow not only academically, but also creatively, emotionally, and ethically.

Over the years, my experiences in the world of arts, cinema, and leadership across national and international platforms have broadened my understanding of education. They have taught me the importance of storytelling, collaboration, and cultural exchange in shaping young minds.

At St. Mark's, we view education as a journey of transformation. It is not limited to the acquisition of knowledge, but extends to nurturing empathy, integrity, and a global outlook. The theme of ICYS 32 reflects this very spirit, bringing together young innovators and educators from across the world on a shared platform of inquiry, creativity, and collaboration.

To our young scientists, I encourage you to embrace this experience with curiosity and confidence—ask questions, explore ideas, and express yourselves without hesitation. You are the thinkers and changemakers of tomorrow. To our mentors, judges, and distinguished guests, your guidance and presence will undoubtedly inspire and enrich this journey.

We are honoured to have you in India, at St. Mark's Sr Sec Public School, for ICYS 32. May this experience inspire you, challenge you, and stay with you for years to come.



Warm regards,

Mr. T. P. Aggarwal

Founder St. Mark's Group of Schools

Chairperson SMS Meera Bagh



THE CHAIRPERSON

ICYS 2026



It is with great warmth and enthusiasm that I welcome all participants to the 32nd International Conference of Young Scientists (ICYS). The future belongs to those who dare to question, explore and turn ideas into meaningful change. It is truly a proud moment for us to host such a distinguished global gathering of changemakers at St. Mark's Senior Secondary Public School, Meera Bagh, New Delhi, and to witness the coming together of bright, curious minds from around the world.



As Director, I strive to create a future-ready learning environment that blends education with emerging technologies and real-world application. I believe in empowering students with the skills, mindset, and adaptability needed to lead in an ever-evolving digital world. To me, education is not just about knowledge—it is about shaping individuals who think deeply, act compassionately, and lead with confidence in an ever-changing world.

As we come together for ICYS 32, we celebrate more than academic achievement—we celebrate ideas, values, and the spirit of global unity. This platform reflects the very essence of what we strive for: a world where knowledge is shared, cultures are respected, and innovation is driven by purpose. Over the course of this conference, you will witness inspiring projects and presentations that go beyond scientific exploration—they represent passion, perseverance, and a genuine desire to make a difference.

This edition of ICYS invites each one of you to contribute to a larger vision—one where science serves humanity with integrity and inclusiveness, and where collaboration shapes a future filled with promise and possibility. May the connections you build, the ideas you exchange, and the experiences you gather here stay with you long after the conference concludes.

This conference is not just an event—it is a celebration of talent, diversity, and aspiration. May your time here be filled with discovery, inspiration, and joyful learning. We look forward to witnessing your brilliance and celebrating the remarkable potential each one of you brings. Welcome to a journey towards the future—shaped by vision, driven by passion, and enriched by limitless possibilities.



Warm regards,
Mr. Rahul Aggarwal
Chairperson - ICYS 2026
Director-S.M.S Group of Schools

THE PRESIDENT

ICYS 2026



It is with immense pride and heartfelt warmth that I extend a sincere welcome to our dear students, educators, and mentors from across the globe to the 32nd International Conference of Young Scientists (ICYS), hosted at St. Mark's Senior Secondary Public School, Meera Bagh, New Delhi.

As the President of ICYS 2026 and Principal of the host institution, I feel privileged to be part of a learning community that believes in nurturing curiosity, encouraging creativity, and building meaningful collaborations—values that lie at the very heart of ICYS.



Our association with ICYS began in 2016, and over the past decade, it has grown into a truly enriching and meaningful collaboration, reflecting our commitment to nurturing scientific minds and fostering global academic excellence. My journey as an educational leader and Physics educator has strengthened my belief that education must be research-oriented, equipping learners to analyze, innovate, and adapt in an ever-evolving world. I feel privileged to have been part of the jury for the Poster Presentation at the 31st ICYS held in Thailand, an experience that enriched this association. Echoing Albert Einstein, “The true sign of intelligence is not knowledge but imagination,” we continue to nurture minds that dare to dream and innovate.

In today's dynamic world, it is inspiring to see young minds engaging with emerging fields such as artificial intelligence, machine learning, and cloud computing. What sets them apart is their ability to blend knowledge with ethics, imagination, and purpose, empowering them not just to adapt to the future, but to shape it. This edition of ICYS reflects the spirit of holistic education—where knowledge transcends boundaries, ideas are shared, and cultures unite. It provides a platform to present research, build connections, and grow into confident global citizens.

To our young participants—you inspire us with your curiosity and determination. May this experience deepen your love for discovery and empower you to become thoughtful leaders of tomorrow.

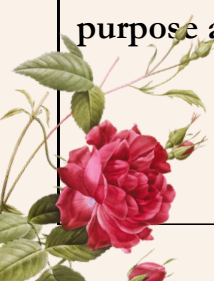
India greets you. St. Mark's embraces you. ICYS 32 brings us together—where science meets purpose and the future begins to unfold.

Warm regards,

Ms. Ritika Anand

President - ICYS 2026

Principal- S.M.S Meera Bagh



MESSAGE FROM THE PRESIDENT OF ICYS



Dear Participants of the International
Conference of Young Scientists (ICYS)!

Nelson Rockefeller said: “You can’t leave
footprints in the sand as long as you sit down”

During the last 32nd years these students and
teachers, team leaders, jury members leave
footprints in the sand through their
participation in various scientific activities.

We believe this conference will be beneficial
for the students and will contribute to their professional and personal
development.

It is a profound privilege to stand before you today in New Delhi—a city that for
millennia has served as a crossroads of civilization, philosophy, and profound
intellectual inquiry. As we convene here for the 32nd edition of the International
Conference of Young Scientists, we are not merely opening a competition; we are
reaffirming a legacy of excellence that has spanned more than three decades.
Thirty-two years ago, ICYS was born from a visionary belief: that the spark of
scientific genius does not wait for a university degree to ignite. It believed that
curiosity, when paired with the rigorous application of the scientific method,
could allow a young student to contribute meaningfully to the global body of
knowledge.

However, the true essence of ICYS transcends the laboratory and the lecture hall.
We are living in an era often characterized by fragmentation and borders. Yet,
science remains a universal language—a bridge built on the foundations of
empirical truth and shared reason.

We wish you all to have a wonderful time and happy days under the umbrella of
knowledge and friendship which we will all share.



Good luck for all participants!

Professor Dr. Adelhaida KEREKES

President of the International Conference of Young Scientists (ICYS)



MESSAGE FROM THE HONORARY PRESIDENT OF ICYS



Dear ICYS Community, dear
Participants and Organizers,

I sincerely wish this competition,
ICYS2026 in India may be a great
success!

I wish you:

many interesting presentations in the
different sections,

successful discussions with the jury
members,

beautiful and meaningful posters, rich leisure and cultural programs
and many-many new friends!

I am sure that the Local Organizers have done and will continue to
do everything to ensure the smooth and memorable running of the
conference. They are doing a great job, for which everybody has to
be very grateful. A big thank you to Them for this hard work!

I am with you in spirit during the conference, I follow every detail of
the competition on the website and I am cheering for everyone.

I am convinced that everyone will return home from this competition
with pleasant memories and experiences.



Kind regards,
Dr. Zsuzsanna Rajkovits
Honorary President



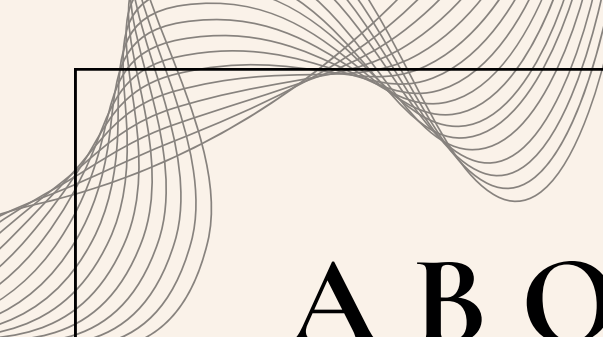


International Conference Of Young Scientists

Real Minds. Real Intelligence.

GENERAL INFORMATION

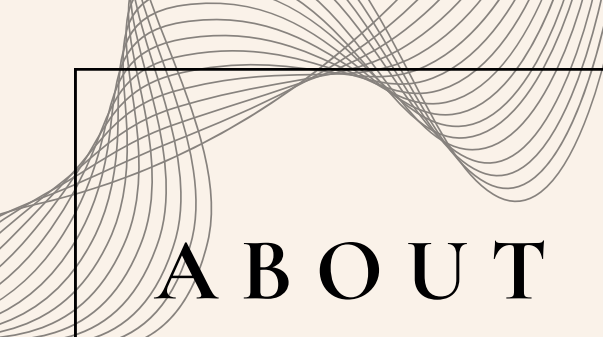




ABOUT ICYS

The International Conference of Young Scientists (ICYS) was established in 1993 by representatives of Eötvös Loránd University in Budapest and the State University of Belarus in Minsk. It was created for students aged 14–18 to introduce them to scientific research, from selecting a topic to presenting results in a foreign language. The conference provides young participants with an opportunity to receive feedback and compete internationally.

Over the years, students from many countries across Europe, Asia, and the USA have participated. The first conference was held in Visegrád in 1994 with 70 lectures from 5 countries, and it gradually expanded in scale and reputation. The event has been hosted in multiple countries and continues to grow, attracting more participants and diverse topics. ICYS plays an important role in encouraging interest in science among youth and can significantly influence their future academic and research careers.



ABOUT THE 32ND ICYS

The 32nd International Conference of Young Scientists (ICYS) 2026 is a prestigious global event that brings together talented secondary school students aged 14–18 who have a strong interest in scientific research. Organized under the International Conference of Young Scientists, ICYS provides a unique platform for students to present independent research projects in disciplines such as Physics, Mathematics, Computer Science, and Ecology. Unlike conventional competitions, ICYS emphasizes originality, critical thinking, and scientific inquiry, where participants showcase their work through presentations and discussions before an international panel of experts. The 32nd edition continues this legacy by fostering collaboration among young minds from different countries, encouraging the exchange of ideas, and promoting cultural understanding. It not only enhances scientific knowledge but also develops essential skills such as communication, creativity, and problem-solving. Overall, the conference plays a vital role in nurturing future scientists and innovators by offering them exposure to global standards of research and learning.

STEERING COMMITTEE



**DR.ADELHAIDA KEREKEŞ
(PRESIDENT)**



**DR.CSABA
KIRCHKESZNER
(MEMBER)**



**MS.MONIKA RAHARTI
(MEMBER)**



**MR.ALEXANDER URBAN
(MEMBER)**



**MR. SERGEI SERGEEV
(MEMBER)**



**MR. LEONID MARKOVICH
(MEMBER)**

WORLD FEDERATION OF PHYSICS COMPETITIONS



MR.GOLCEA SANDU MIREL
PRESIDENT



MR.STEFAN PETERSEN
VICE PRESIDENT



MR.PAUNESCU VICTOR
CHAIRMAN



MR.KAREL KOLÁŘ
SECRETARY



MR.SYAMIL BIN AHMAD SHAKIR
MEMBER

LOCAL ORGANISING COMMITTEE



**MR. RAHUL AGGARWAL
(CHAIRPERSON)**



**MS. RITIKA ANAND
(PRESIDENT)**



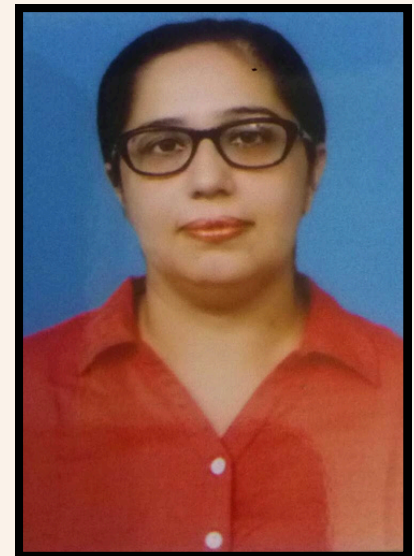
**MS. GEETA RAJAN
(COUNTRY
REPRESENTATIVE)**



**MS. ADIT KAUR
(MEMBER)**



**MR. SACHIN ARORA
(MEMBER)**



**MS. SARANPREET KAUR
(MEMBER)**

KEYNOTE SPEAKER

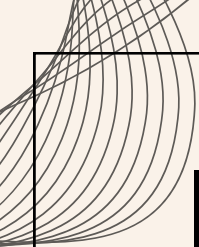
"To the young scientists shaping tomorrow: You hold the keys to the future of healthcare. The next era of medicine will not just be discovered it will be engineered. I challenge you to step outside traditional boundaries and not just study biology, but actively



innovate it. By combining relentless curiosity with the power of artificial intelligence and computational modeling, you can turn your boldest hypotheses into real-world therapeutics. Never let your research stay confined to the laboratory. Keep questioning the status quo, and remember that the greatest breakthroughs happen when we bridge the gap between complex benchtop data and the bedside reality of the patients who need it most. The world is waiting for what you will build."

Regards

Dr. Bharat Kwatra



IMPORTANT CONTACTS

For your safety, convenience, and immediate assistance, please keep the following contact numbers readily accessible at all times. Our team and emergency support services are available to ensure a smooth and secure experience throughout the programme.

**ST. MARK'S SR. SEC. PUBLIC SCHOOL, MEERA BAGH
011-25262056, 11-25266056, 011-25289194, 011-25289195**

NEAREST HOSPITAL TO SCHOOL

Sehgal Neo Hospital

Emergency No: 011-45565600, +91-8800297600

NEAREST HOSPITAL TO ACCOMODATION

Arya Hospital

Emergency No: 011-45066244

POLICE – 100

FIRE – 101

AMBULANCE – 102

MS. GEETA RAJAN - +91 9811798565

MS. SARANPREET - +91 9212436608

EVENTS AT A GLANCE



Scan me!

OR

CLICK HERE >

DAILY SCHEDULE

SUNDAY, 19 APRIL 2026 (DAY 1)

Programme Details	Time	Venue
Arrival of delegates	Flight timings	Airport
Registration of delegates	13:00 onwards	Kitchen District-2
Jury Meeting	16:00-16:30	PDR(Private Dining Room)
ICYS briefing	17:00-17:15	Kitchen District-2
Ice-breaking activity for students	17:15-18:15	Kitchen District-2
Dinner	19:00-20:00	Kitchen District-1
Team Leaders' Meeting	20:30-21:00	Kitchen District-2

MONDAY, 20 APRIL 2026 (DAY 2)

Programme Details	Time	Venue
Breakfast/Registration	07:00-08:00	Kitchen District-1 and 2
Bus boarding for School	08:30	
Welcome and Opening Ceremony	09:00-10:30	Auditorium
Tea /Coffee	10:30-11:30	Exhibition hall(Ground floor)
Poster Presentations	11:30-13:00	Class rooms(Ground Floor)
Lunch	13:00-14:00	Exhibition hall(Ground floor)
World federation of physics	14:00-15:30	Conference Room(Ground Floor)
Poster Presentations	14:00-16:00	Class rooms(Ground Floor)
Tea/Coffee	16:00-16:30	Exhibition hall(Ground floor)
Jury meeting	16:30-17:00	Conference Room(Ground Floor)
Departure to hotel	17:00	
Dinner	19:00-21:00	Kitchen District-1

TUESDAY, 21 APRIL 2026 (DAY 3)

Programme Details	Time	Venue
Breakfast	7:00-8:00	Kitchen District-1
Bus boarding for School	8:30	
Jury presentations	9:00-11:30	Labs,Activity room(4th floor)
Tea/Coffee	11:30-12:00	Exhibition hall(Ground floor)
Jury presentations	12:00-13:30	Labs,Activity room(4th floor)
Lunch	13:30 -14:30	Exhibition hall(Ground floor)
Jury presentations	14:30-16:00	Labs,Activity room(4th floor)
Tea/Coffee	16:00-16:30	Exhibition hall(Ground floor)
Submission of Jury Results to organising Committee	16:30	Conference Room(Ground Floor)
Gift Presentation and Cultural Fair	16:30-17:30	Activity Room(4th floor)
Departure to hotel	17:30	
Dinner	19:00-21:00	Kitchen District-1

WEDNESDAY, 22 APRIL 2026 (DAY 4)

Programme Details	Time	Venue
Breakfast	7:00-8:00	Kitchen District-1
Bus boarding for Sightseeing	8:30	Gandhi Smriti,Indira Gandhi Museum,Dilli Haat
Delhi Darshan		Packed boxes
Lunch		Dilli Haat
Dinner		
Departure to hotel	19:00	

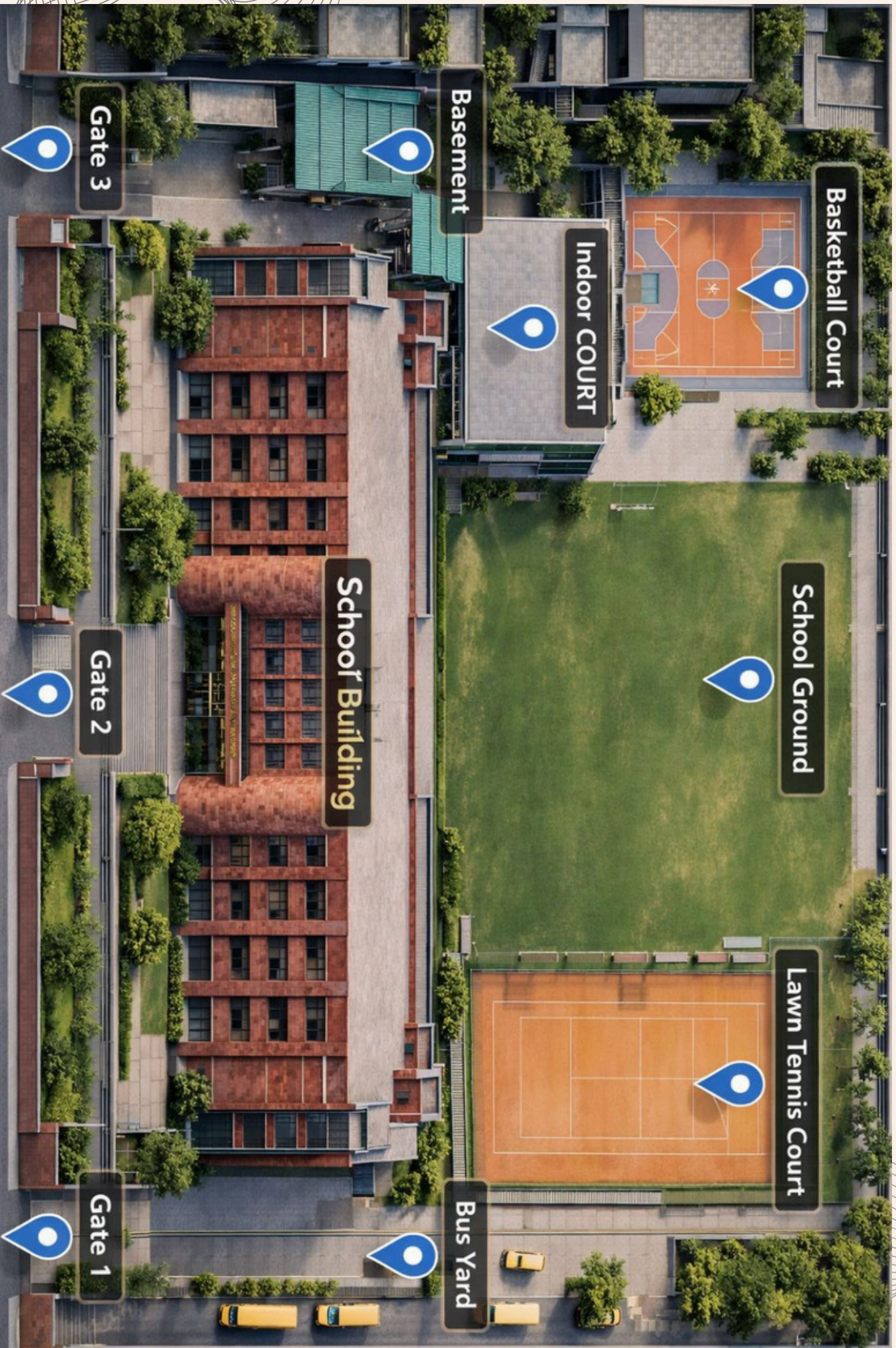
THURSDAY, 23 APRIL 2026 (DAY 5)

Programme Details	Time	Venue
Breakfast	7:00-8:00	Kitchen District-1
Bus boarding for School	8:30	
Team Activities for Students	9:00-11:30	Activity room,Bio lab,Home Science Lab(4th Floor) Music Room(3rd Floor)
Educator Sharing Session for Teachers	9:00-11:30	Conference Room(Ground Floor)
Tea/Coffee	11:30-12:00	Exhibition hall(Ground floor)
Lunch	12:00-13:00	Exhibition hall(Ground floor)
Cultural Performances	13:00-15:00	Activity Room(4th floor)
Tea/Coffee	15:00	Exhibition hall(Ground floor)
To Auditorium	15:30	
Award and Closing Ceremony	16:30-18:30	Auditorium
Departure to hotel	18:30	
Dinner	19:00	Kitchen District-1

FRIDAY, 24 APRIL 2026 (DAY 6)

Programme Details	Time	Venue
Departure of Delegates		

MAIN BUILDING





PARTICIPANTS



PARTICIPATING COUNTRIES



Federative Republic of Brazil

Czech Republic (officially: Czechia)

Federal Republic of Germany

Guam

Hungary

Mongolia

Republic of Poland

Malaysia

Republic of India

Russian Federation (Moscow)

Russian Federation (St. Petersburg)

Kingdom of Thailand

Republic of Türkiye

Republic of Indonesia

Republic of Serbia

Romania

Georgia

Republic of Belarus



PARTICIPANTS

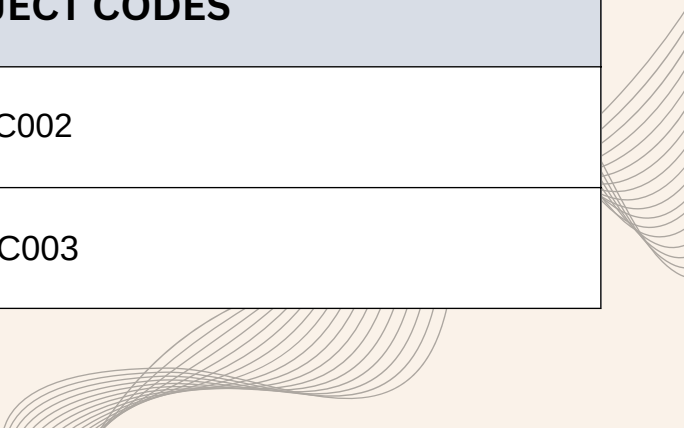
THE 32ND INTERNATIONAL CONFERENCE OF YOUNG
SCIENTISTS (THE 32ND ICYS)

REPUBLIC OF BELARUS

NAME	POSITION
MR. LEONID MARKOVICH (SC)	TEAM LEADER
MR. DAVID ZMIAIKOU	TEAM LEADER
STUDENT	PROJECT CODE
YAHOR BIARHOVIN	PHYS002
SABRYNA BREL	ENVSC001
DZIANIS VISTUNOU	MATH001
ARSENI HOHANAU	ENVSC002
ALIAKSANDR SAKALOU	PHYS001
RYHOR KALBANAU	CSC001

CZECHIA (CZECH REPUBLIC)

NAME	POSITION
MR.BARBER WAYNE	TEAM LEADER
STUDENTS	PROJECT CODES
VALASEK TOMAS	LIFESC002
STRITESKA ANNA	LIFESC003



REPUBLIC OF HUNGARY

NAME	POSITION
DR.CSABA KIRCHKESZNER(SC)	TEAM LEADER
DR.PETRA VARRÓ	TEAM LEADER
STUDENT	PROJECT CODE
ÁRMIN VÁMI	ENVSC007
JOHANNA MÁRTA KLASSON	PHYS004
PETRA SZÜCS	PHYS005
NATALI JÚLIA HAJSZ	LIFESC006
RÓBERT NAGY	LIFESC007

REPUBLIC OF INDONESIA

NAME	POSITION
MS.MONIKA RAHARTI(SC)	TEAM LEADER
STUDENT	PROJECT CODE
CALVIN NICHOLAS SETIADI	LIFESC011
REUBEN PRABASWARA WINDUKUSUMA	MATH005
JESHUA JOYFULL TORIE	MATH006
BRYAN KWAN	ENVSC010
KAI AKIRA ANGKADJAJA	PHYS008

FEDERAL REPUBLIC OF GERMANY

NAME	POSITIONS
MR.ALEXANDER URBAN(SC)	TEAM LEADER
MS.ANNE SPANKE	TEAM LEADER
MR.TOBIAS REINSCH	TEAM LEADER
STUDENTS	PROJECT CODES
AVANEESH JAWALKAR	MATH002
NATALIE HORVAT	ENVSC004
BENNET EISFELD	PHYS003
LAURA SCHÄFER	LIFESC004
EMIL FRÖSCHL	ENVSC005
EMMA BÜRGEL	ENG003

TERITORRY OF GUAM (USA)

NAME	POSITIONS
Ms.ARLENE CHUA	TEAM LEADER
Mr.IVAN PINEDA	TEAM LEADER
STUDENTS	PROJECT CODES
ALWYN LIN	LIFESC005
MING YEN TSAI	CSC002
SEAN SUNGWON LEE	ENVSC006

REPUBLIC OF INDIA

NAME	POSITION
MS.GEETA RAJAN(COUNTRY REPRESENTATIVE)	TEAM LEADER
MS.ADIT KAUR	TEAM LEADER
MR.SACHIN ARORA	TEAM LEADER
STUDENT	PROJECT CODE
AYYAN SHIVOGAN	PHYS006
SHAARAV AYACHIT	PHYS007
ARNAV DHIMAN	CSC003
SARTHAK DHOLE	LIFESC009
SAANIKA JAIN	LIFESC008
SAANVI RAGHAVENDRAN	MATH003
AADYA KANCHAN	ENG005
SHIVEN UPPAL	MATH004
HARSHIL JINDAL	ENVSC009
RANVEER ARORA	ENVSC009
DIVIT BAJPAI	ENG006
PUNYA KOCHAR	LIFESC010
SARAH ANSARI	ENVSC008
LAVANYA GANDHI	ENVSC008
MIHIR NARULA	CSC004
AARAV BANSAL	CSC004

MONGOLIA

NAME	POSITION
MR.GANBAT ATARSAIKHAN	LEADER
STUDENT	PROJECT CODE
GARYET BRYUS KHARRIS	PHYS009
URANBAT BATMUNKH	PHYS009
MUNKHSOYOL CHINZORIG	ENG007
MUNGUNSOR GANBOLD	CSC005

ROMANIA

NAME	POSITION
DR.ADELHAIDA KEREKEŞ(PRESIDENT)	TEAM LEADER
MS.BOAR FELICIA	TEAM LEADER
MS.FELICA FLOAREA	TEAM LEADER
MR.KOVÁCS ZOLTAN ZSOLT	TEAM LEADER
STUDENT	PROJECT CODE
CHIRICĂ MIHAI-ŞTEFAN	ENVSCO11
PANĂ COSTIN ADRIAN	MATH007
VÂTCĂ PETRA-MIRUNA	LIFESCO13
POP ALEXANDRU	LIFESCO12
CHELM TEODOR-IOAN	CSC006
ȚIPLEA OANA-AUGUSTA	LIFESCO13
CIOROSLAN DORU ANDREI	PHYS011
FOLEA MATEI	ENG009
JIGANIE BOGDAN	ENG009
DUMITRAŞCU FLAVIUS-CRISTIAN	CSC006

RUSSIAN FEDERATION - (ST. PETERSBERG)

NAME	POSITION
MR.ANDREI POTEKIN	TEAM LEADER
MR.ILIA CHISTIakov	TEAM LEADER
STUDENT	PROJECT CODE
PAVEL ZINOVEV	MATH009
IVAN LIPIN	MATH013
ANDREI CHURAKOV	MATH011
SAVVA VINNIKOV	MATH010
FEDOR CHURILIN	MATH012

RUSSIAN FEDERATION - (MOSCOW)

NAME	POSITION
MR.ASTAPOV ARTEM	TEAM LEADER
MR.TOKAREV MIKHAIL	TEAM LEADER
MR. SERGEI SERGEEV(SC)	TEAM LEADER
STUDENT	PROJECT CODE
KARPOV ANTON	CSC009
MEDVEDEV SEMEN	CSC008
MOKEEV EGOR	ENVSC013
SEMASHKO IRINA	ENVSC012
DOLGOV VLADISLAV	LIFESC016
DERIUGIN NIKITA	CSC009
ADAMIAN ARTUR	MATH008
PRISICH VIKTORIIA	PHYS012
SOROKINA DARIA	LIFESC015
SURNACHEV ARKHIP	CSC007
KUTSOVA ANNA	PHYS013
BATRAKOVA MARIIA	LIFESC014

REPUBLIC OF SERBIA

NAME	POSITION
MR.MATEJA OPAČIĆ	TEAM LEADER
MR.NIKOLA SRZENTIĆ(VICE PRESIDENT)	TEAM LEADER
STUDENT	PROJECT CODE
TARA KOLDŽIĆ	LIFESCO17
HELENA GRUJIĆ	PHYS014
NIKOLA JOVIĆ	LIFESCO18
NATALIJA ARSIĆ	ENVSCO14

REPUBLIC OF TÜRKİYE

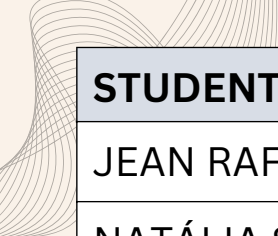
NAME	POSITION
MR.SÜLEYMAN ATILLA	TEAM LEADER
MS.SEZEN UZER	TEAM LEADER
STUDENT	PROJECT CODE
DEMIRHAN MERT ÖZGÜL	LIFESCO23
YAĞIZ KAAAN BEDİR	LIFESCO22
ZEYNEP IRMAK GÜR	ENVSCO16

THAILAND

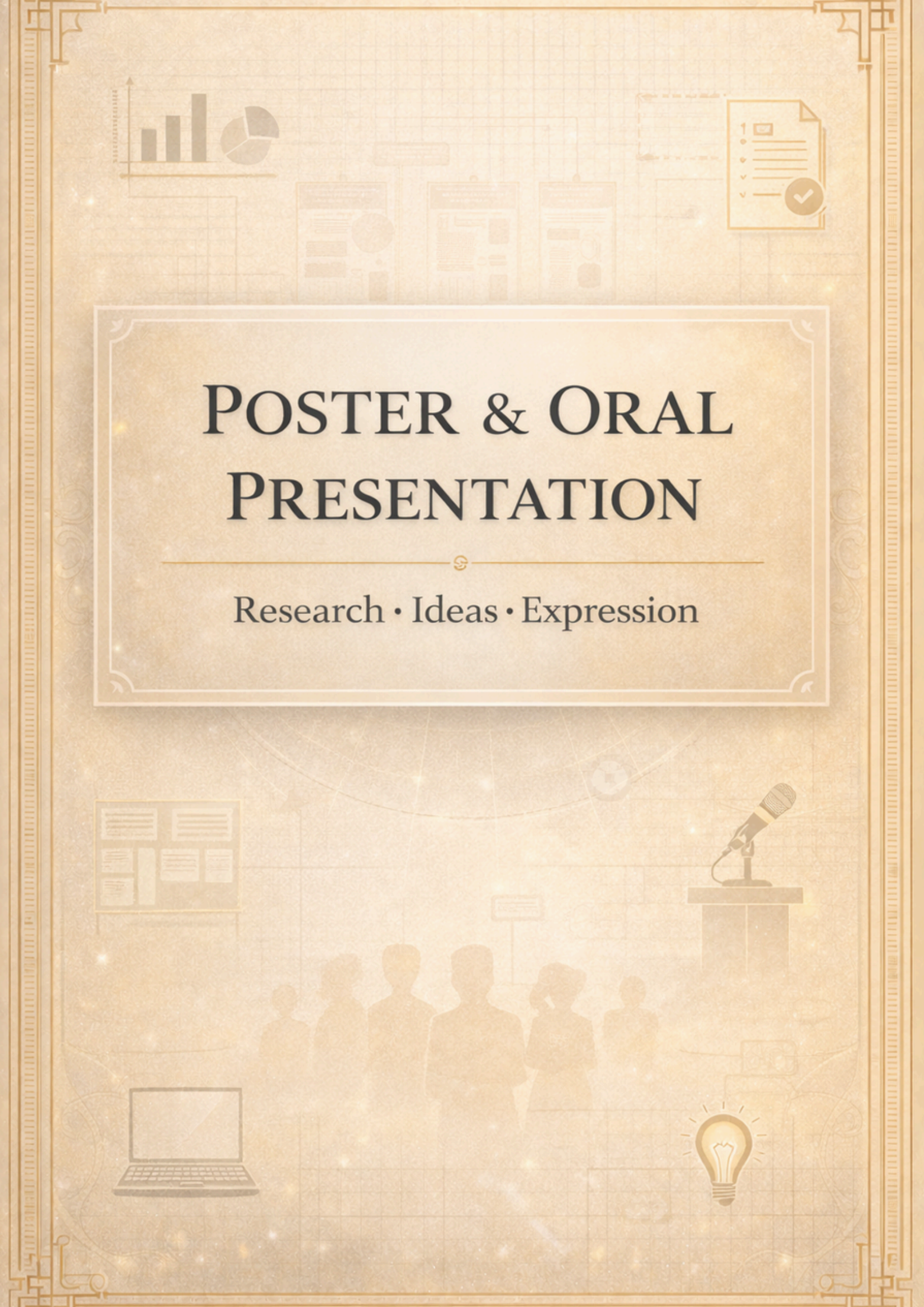
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MR.SONTHI PHONCHAIYA	TEAM LEADER
MS.THIDAPORN SUPAPAKORN	TEAM LEADER
STUDENT	PROJECT CODE
THANAKRIT JIRATANACHIT	LIFESCO19
PIMPNAPAT WATCHARAPREMPANT	ENVSCO15
PICHAYA RATTANABUNDARIK	LIFESCO19, LIFESCO20
SUPISARA CHOMPUNOI	LIFESCO21
THAWEEWATANA NGEAMVIJAWATANA	ENG010
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NATÁLIA SLOGO FAGUNDES	ENVSC003
BIANCA ELISA DIAS OLIVEIRA E SILVA	ENG002
LARISSA THOMAS MARTINS DE SIQUEIRA	ENG002

The background is a warm, golden-brown grid with various faint icons related to research and presentations. In the top left, there is a bar chart and a pie chart. In the top right, there is a checklist with a checkmark. In the center, there are three posters on a wall. In the bottom left, there is a laptop. In the bottom right, there is a lightbulb. In the center bottom, there is a group of silhouettes of people standing in front of a presentation board. A microphone on a stand is also visible on the right side.

POSTER & ORAL PRESENTATION

Research • Ideas • Expression

COMPUTER SCIENCE

ORDER	PROJECT CODE	TOPICS
1	CSC001	Secux Linux: a hardened security-focused operating system Ryhor Kalbanau Belarus
2	CSC002	Detecting Financial Fake News and Quantifying Psychological & Market Impact Using Machine Learning Models (FinBERT, etc.) Ming Yen (Austin) Tsai Guam (USA)
3	CSC003	Saddle Escape Efficiency: A novel metric to benchmark learning rates in non convex optimisation Arnav Dhiman India
4	CSC004	Streamlining CDSS: Minimising Fatigue via User defined alerts Mihir Narula , Aarav Bansal India
5	CSC005	Experimental Study of a Smart System for Monitoring Sitting Habits in an Office Environment G. Mungunsor Mangolia
6	CSC006	Cordis: Intelligent System for Cognitive Assistance and Social Reintegration for Patients with Alzheimer's Dumitraşcu Flavius-Cristian, Chelm Teodor-loan Romania
7	CSC007	Development of a Processor Architecture for Accelerated Cryptocurrency Mining Arhip Surnacher Russia
8	CSC008	Development of a Custom 3D Engine and Algorithmic Complex for Hybrid N-Body and Solid Mechanics Simulation Semen Medvedev Russia
9	CSC009	An online learning platform for Linux-based operating systems Nikita Deriugin, Anton Karpov Russia
10	CSC010	Wasserstein-Jacobian Regulatory Perturbation Atlas (WJRPA): A Six-Pillar Mathematical Framework for AlphaGenome-Driven Parkinson's Disease Regulatory Genomics Wirunrak Radsadonsak Thailand

ENGINEERING		
ORDER	PROJECT CODE	TOPICS
1	ENG001	Vaccine Control : The Development Of An Electro-Electronic Device For Analyzing And Measuring A Controlled Environment For Vaccine Storage Jean Rafael Kot Brazil
2	ENG002	Stabiluva: active control device for tremor attenuation in Parkinson's disease Bianca Elisa Dias Oliveira e Silva; Larissa Thomas Martins de Siqueira Brazil
3	ENG003	Braille-Math: an adapted calculator as an alternative assistive resource for people with visual impairment and low vision Paola Mileny Batista, Raquel Emanuely Ferreira Knakievicz Brazil
4	ENG004	UK-LA-2 Intelligent Laser Weeding Emma Bürgel Germany
5	ENG005	Microfluidic Point-of-Care Device for Rapid Lipid Screening Using Optical Sensing AADYA KANCHAN India
6	ENG006	Fabrication and Characterization of Lignin-ZnO Hybrid Nanoparticles for Omniphobic Divit Bajpai India
7	ENG007	DEXORA: A Smart Device for Correct Finger Placement in Typing Munkhsoyol Chinzorig Mongolia
8	ENG008	The Human Body as a Transmission Channel for Industrial Systems Tymoteusz Feja Poland
9	ENG009	Study on the Modeling and Educational Integration of Aramid Fibers (Kevlar) via an Interactive 3D Platform Folea Matei, Jiganie Bogdan Romania
10	ENG010	The Design and Development of a Low-Cost UV-Vis Spectrophotometer Using a Microcontroller for Light Absorption Analysis Thaweewatana Ngeamvijawatana, Tunwa Phetyawa, Sorrakom Sawettarat Thailand

ENVIRONMENTAL SCIENCE

ORDER	PROJECT CODE	TOPICS
1	ENVSC001	New environmentally friendly biopreparation creation for the control of agricultural plant's fusariosis Brel Sabryna, Belitskaya Marya Belarus
2	ENVSC002	Creation of a photosorption-catalytic installation for air purification from harmful odorous gases and microorganisms at agricultural enterprises Arseni Hohanau Belarus
3	ENVSC003	Stratfish: Use of Sludge from Excavated Tanks Combined with Commercial Substrate for Vegetable Cultivation Natália Slongo Fagundes Brazil
4	ENVSC004	To what extent do dietary supplements influence catalytic activity? Natalie Horvat Germany
5	ENVSC005	"Attachment not permitted!" - Colonization Experiments on the Quagga Mussel Emil Fröschl Germany
6	ENVSC006	Enhancing Anodic Reaction Selectivity in Seawater Electrolysis Systems Sean Lee Guam
7	ENVSC007	Infrared Spectroscopic Analysis of Solid-Phase Carbonic Acid Ármin Vámi Hungary
8	ENVSC008	Enhanced Bioremediation of Textile Waste Using Calcium Alginate Immobilized <i>Pleurotus ostreatus</i> LAVANYA GANDHI, SARAH ANSARI India
9	ENVSC009	Pine Needle Valorisation: From Fire Hazard to Green Resource HARSHIL JINDAL ,RANVEER ARORA India
10	ENVSC0010	Colorimetric Detection of Mercury in Bengkulu City River Waters Using AgNPs Synthesized via Green Synthesis from <i>Citrofortunella microcarpa</i> Extract Bryan Kwan Indonesia

ENVIRONMENTAL SCIENCE

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11	ENVSC011	Sustainable Foam – an Affordable Alternative of Car Seat Recycling Chirică Mihai Ștefan, Radu Codrin Elian Romania
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13	ENVSC013	Mine-derived fungi as a tool for environmental biotechnology: protease production for degradation of environmental protein waste Mokeyev Egor Russia
14	ENVSC014	Response of green alga Tetrademus obliquus (Turpin) M.J. Wynne 2016 to eutrophication Natalija Arsić Serbia
15	ENVSC015	Study of Microplastics Removal Efficiency in Water Samples Using Chitosan Solution and Film Forms Pimnapat Watcharaprempant, Tamon Bamrungsalee, Kittipob Chuaychookull Thailand
16	ENVSC016	Sustainable Removal of Heavy Metals and Textile Dyes Using Verbascum as a Natural Adsorbent Zeynep Irmak Gür Turkey

LIFE SCIENCE

ORDER	PROJECT CODE	TOPICS
1	LIFESC001	DOMICONNECT – Home Care Solution with AI for Monitoring Multiple Patients Lucas Kazuo Nonose Brazil
2	LIFESC002	Chemical Modification of Hyaluronic Acid Tomáš Valášek Czech Republic
3	LIFESC003	Breast Cancer in Young Women: Correlation of Molecular Genetic, Clinical and Morphological Features Anna Strítěská Czech Republic
4	LIFESC004	Yeast from the supermarket for applications in biotechnology Laura Schäfer Germany

LIFE SCIENCE		
ORDER	PROJECT CODE	TOPICS
5	LIFESC005	Computational Pixel-Level Analysis of Plantar Pressure Fields for Quantitative Differentiation of Foot Morphology Using Image-Based Sensor Data Alwyn Lin Guam
6	LIFESC006	Personalized, partially absorbable band-aid Natali Júlia Hajsz Hungary
7	LIFESC007	Development of Mn ²⁺ based MRI contrast agent candidates Investigation of structure-activity relationships of new bispidine derivatives Róbert Nagy Hungary
8	LIFESC008	Targeting the SCN9A Gene in Congenital Insensitivity to Pain: Genetic Insights and Therapeutic Approaches Saanika Jain India
9	LIFESC009	A Hybrid AI System for Distinguishing Alopecia Areata from Trichotillomania and Automating Disease Severity Assessment Sarthak Dhole India
10	LIFESC010	Synergistic Toxicity of Chlorinated Water and Sunscreen-Derived Compounds: An Allium fistulosum and Yeast Bioassay Study Punya Kochar India
11	LIFESC011	Potential of Glycyrrhizin (Glycyrrhiza glabra) as an Inhibitor of Tropomyosin (Lit v 1) Induced Shellfish Allergy in Litopenaeus vannamei Calvin Nicholas Setiadi Indonesia
12	LIFESC012	A Bio-Responsive Gold Nanoparticle Platform with Machine Learning Integration for Intelligent Cysteine Detection Pop Alexandru Romania
13	LIFESC013	Sustainable Valorisation of Black Chokeberry (Aronia melanocarpa) and Sea Buckthorn (Hippophae rhamnoides) By-Products through the Development of An Antimicrobial Sticker Țiplea Oana Augusta, Vâtcă Petra Miruna Romania
14	LIFESC014	Polymorphism of the PER3 gene and its association with sleep-wake preference Batrakova Mariia Russia (Moscow)

LIFE SCIENCE		
ORDER	PROJECT CODE	TOPICS
15	LIFESC015	A study of the ability of birds to visual categorical learning on a «bead floor»: the effect of the size of the visual insentives Sorokina Daria Russia (Moscow)
16	LIFESC016	Asymmetric triarylantimony dicarboxylates as potential antileishmanial agents: synthesis and structure Dolgov Vladislav Russia (Moscow)
17	LIFESC017	Effects of intermittent theta burst stimulation on neuron-like SH-SY5Y cell phenotype Tara Kodzic Serbia
18	LIFESC018	Examination of the antibacterial activity of the homeopathic preparation "Antisept M" against ESKAPE pathogens Nikola Jovic Serbia
19	LIFESC019	Colloidal Stability and Response-Surface Modeling of Laser-Induced Heating in Quercetin-Loaded Hollow Porous Iron Oxide Nanoparticles Thanakrit Jiratanachit, Pichaya Rattanabundarik Thailand
20	LIFESC020	Preparation of Cannabidiol-Loaded Transethosomes for Improved Transdermal Delivery in Psoriasis Treatment Pichaya Rattanabundarik, Teeravee Seubsuksunwong, Yanawut Manee Thailand
21	LIFESC021	Saliva Pops: Development of Artificial Saliva from Okra Mucilage Enhanced with Antimicrobial Efficacy of Chrysanthemum Extract Using Spherification Technique Supisara Chompunoi, Panisara Junjareon Thailand
22	LIFESC022	Smart Chemotherapy Strategy: Engineering a Dual-Stimuli Responsive (pH and Temperature) Doxorubicin Delivery System Using Layer-by-Layer (LbL) Polymer Films Yağız Kaan Bedir Turkey
23	LIFESC023	Toward Sustainable Plastics: Bioplastic (PHB) Production Using Genetically Engineered Bacteria Demirhan Mert Özgül Turkey

MATHEMATICS		
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1	MATH001	On asymptotic density of certain sets with pseudo-linear closure Dzianis Vistunou Belarus
2	MATH002	At the Highest Degree : a new approach to solving differentisl equation Avaneesh Jawalkar Germany
3	MATH003	Cross - Cultural Music Generation Using Markov Chains 'Blending Indian Raga And Western Melodic Styles SAANVI RAGHVENDRAN India
4	MATH004	Polyominies With Maximum Number Of Deep Holes SHIVEN UPPAL India
5	MATH005	An Error-Minimized Nonlinear Analytical Approximant for the Catenary Arc Length Reuben Prabaswara Windukusuma Indonesia
6	MATH006	Mathematical Modeling Based on Genetic Biomarkers for the Predictive Diagnosis of Pancreatic Cancer: Analysis and Validation Using Hypothesis Testing with Python Jeshua Joyfull Torie Indonesia
7	MATH007	Analysis Of Convex Combinations Of Dependent Bernoulli Variables : A Bivariate Distribution Approach. Application In Health Insurance Portfolio Pană Costin Adrian Romania
8	MATH008	On a Property of a Triangle Arthur Adamyman Russia
9	MATH009	Curried Functional Spaces Pavel Zinovev Russia
10	MATH010	Noncommutative Error-Correcting Codes Savva Vinnikov Russia

MATHEMATICS		
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11	MATH011	On an Automorphic Representation of Multivirtual Braid Group Andrei Churakov Russia
12	MATH012	Diagonal Oriented Graphs of Diameter Two Fedor Churilin Russia
13	MATH013	Quasi-injective Functions Ivan Lipin Russia

PHYSICS		
ORDER	PROJECT CODE	TOPICS
1	PHYS001	The Research Of Electrophysical Properties If Planar Structures With Percolation Conductivity on Paper Substrates Aliaksandr Sakalou Belarus
2	PHYS002	Artificial Pneumatic Muscle: Design, Theory, and Applications Yahor Biarhovin Belarus
3	PHYS003	Decoding Starlight – Stellar Analysis via Spectroscopy Bennet Eisfeld Germany
4	PHYS004	Flipo Flip: The Physics of a Toy Johanna Klasson Hungary
5	PHYS005	Ring Fountain Dynamics Petra Szücs Hungary

PHYSICS		
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6	PHYS006	Periodic Motion of The Weighted Double Pendulum Ayaan Shivogan India
7	PHYS007	Effects of Non-Gaussian Wave Packets on Interference and Their Implications for Electron Wave Packet Simulation in Next-Generation Semiconductors Shaarav Ayachit India
8	PHYS008	Early Epileptic Seizure Prediction Using Welch's Power Spectral Density and Machine Learning Kai Akira Angkadjaja Indonesia
9	PHYS009	Investigation of Voltage and Phase Effects in an Ultrasonic Levitation System Gareth Bruce Harris, Uranbat Batmunkh Mongolia
10	PHYS010	Dynamics of a Parametrically Excited Pendulum with Finite-Range Impacts Zofia Makowska Poland
11	PHYS011	The evaluation of physiochemical properties and biocompatibility of alginate-collagen hydrogels for tissue regeneration Cioroslan Doru Andrei Romaniaa
12	PHYS012	Synthesis and characterization of CFO@BTO nanoparticles Prisich Victoriaa Russia
13	PHYS013	Research Of Diclofenac Adsorption On Charcoal Obtained From Rice Husk Ash, With The Aim Of Industrial Waste Utilization And The Production Of A Low-Cost Sorbent For Wastewater Treatment Anna Kutsova Russia
14	PHYS014	Desing of Fresnel Lenses Helena Grujic Serbia

Computer Science

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Secux Linux: a hardened security-focused operating system

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1. INTRODUCTION

While dominating server infrastructures, standard Linux endpoints remain vulnerable to physical and runtime attacks. Mainstream Linux leaves the initramfs unsigned, exposing systems to Evil Maid attacks [1]. Furthermore, standard FDE tools implicitly trust the TPM, allowing fault injection (faulTPM [2]) to extract encryption keys regardless of PIN complexity. While hypervisor defenses (e.g., Qubes OS) address some issues, they impose significant overhead. This work presents Secux Linux – a bare-metal hardened OS built on Zero Trust principles [3] to counter both network and physical adversaries without virtualization.

2. AIMS

The primary aim of this project is to implement and evaluate a security-focused operating system that mitigates vulnerabilities in standard Linux deployments. Instead of relying on isolated countermeasures, this work seeks to integrate authenticated boot, hardware-enforced protections, and Secux Integrity Runtime Attestation (SIRA) into a cohesive environment. A specific objective is to develop and evaluate In-Depth Protection (IDP) – a new, TPM-resilient full disk encryption mechanism designed to withstand physical hardware attacks and coercion.

3. METHODS AND MATERIALS

The threat model assumes remote adversaries and local adversaries with unrestricted physical access. Debian 13.4 serves as the baseline.

Vulnerability Demonstration. XIntercept injects a payload into Debian's unverified exfiltrating LUKS key. A swtpm-based PoC emulates a faulTPM attack – full TPM storage access – extracting systemd-cryptenroll's sealed key despite PIN protection.

Authenticated Boot & IDP. Secux enforces UKI Secure Boot, rejecting modified components within the verified boot chain. IDP splits the LUKS secret across two TPM NVRAM indices using Argon2id key derivation and AES-256-GCM blob encryption, incorporating Anti-Rollback protection. An optional decoy PIN triggers irreversible key destruction with plausible deniability: attacker cannot determine the presence of decoy PIN or tamper that function.

Kernel Hardening. A custom LLVM/Clang-compiled kernel integrates special Linux kernel patches alongside GrapheneOS and KSPP patchsets. It enforces hardware CFI, Shadow Stack, and minimizes attack surface by restricting runtime parameters. ThinLTO/AVX2 optimizations offset overhead.

Runtime attestation. Leveraging IMA, SIRA attests all executed binaries – including dynamic libraries and fileless payloads, issuing signed JWTs for zero-trust network integration.

4. RESULTS

XIntercept extracted LUKS keys from Debian; Secux rejected all tampered components. The swtpm PoC extracted systemd-cryptenroll's key; under IDP, TPM compromise yielded only partial secrets, insufficient without PIN knowledge. Decoy PIN resulted in NVRAM erasure and LUKS header destruction in 600 ms. Hardened kernel incurred 4% memory overhead with 0.24% CPU overhead (sysbench, 16 threads). Kernel optimizations improved AES XTS performance by 12%. SIRA generated JWTs with 765 ms mean latency across 2200+ binaries.

5. DISCUSSION

IDP fundamentally shifts the FDE trust model by storing an encrypted blob in TPM NVRAM rather than the actual key, making TPM compromise alone insufficient for disk unlock. Unlike Qubes OS, Secux achieves strict bare-metal attack surface reduction without virtualization overhead. Assuming IOMMU mitigates DMA attacks, a Cold-Boot vulnerability theoretically remains. As full memory encryption imposes significant performance overhead and TSME lacks universal hardware support, future work will implement selective per-page SME to secure key-holding memory while preserving near-native speed. Integrating FIDO2 tokens into IDP is also planned.

6. CONCLUSIONS

Secux Linux provides a comprehensive bare-metal solution for enterprise Zero Trust compliance [3] and individual coercion resistance by integrating authenticated boot, TPM-resilient encryption, hardware-enforced memory protections, and runtime attestation – at bare-metal performance.

7. ACKNOWLEDGEMENT

Special thanks to my research leader, Elena Belousova (Associate Professor, Department of Information Security, BSUIR), for her supervision and expert advice in developing this project.

8. REFERENCES

1. Rutkowska, J. “The 'Evil Maid' attack on TrueCrypt”. The Invisible Things Lab
2. Jacob, Weling, Buhren, Seifert “faulTPM: Exposing AMD fTPMs' Deepest Secrets”. TU Berlin
3. Rose, Borchert, Mitchell, Connelly, “Zero Trust Architecture”. NIST Special Publication 800-207.

Detecting Financial Fake News and Quantifying Psychological & Market Impact Using Machine Learning Models (FinBERT, etc.)

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1. INTRODUCTION

Financial misinformation exploits two cognitive system reactions, System 1 (fast, emotional) responses trigger System 2 analytical evaluation, particularly when headlines use overstatements or personalized pronouns. These linguistic patterns were identified as the strongest predictors of fake news (Bachate & S, 2025). The 2013 AP Twitter hack erased \$130 billion in equity value in minutes, demonstrating how fake financial news bypasses rational decision making and triggers automated market responses before verification is possible. In the current age, computational detection systems use general-purpose language models which aren't specifically suited for financial discourse, and no prior work has truly simultaneously utilized both detection accuracy and psychological factors to measure market impact of financial misinformation.

2. AIMS

There are two objectives for this research. (1) develop a high-precision financial fake news classifier by fine-tuning FinBERT (a transformer pre-trained on 4.9 billion words of financial text) showing its advantage over general and traditional ML baselines (Khan et al., 2021). (2) Show the dual impact pathway shown in Fig. 1, from psychological vulnerability through fake news exposure, cognitive response, and behavioral change to measurable market disruption.

3. METHODS AND MATERIALS

Dataset for Training Ahmed et al. (2017) 6,335 balanced articles (Reuters real; PolitiFact fake). Split 80/10/10 stratified by class.

ML Model. ProsusAI/FinBERT fine-tuned with 2-class classification head. Targeted differential learning rates; lower rate (2e-5) for pre-trained BERT layers to preserve financial language knowledge; higher rate (1e-4) for the new classification layer to learn fake news signals. AdamW optimizer with linear warmup across 3 epochs on T4 GPU. Combined loss function: weighted sum of binary cross-entropy (news classification) + mean squared error (volatility) + codebook commitment loss (representation alignment). All of this is done through Google Colab.

Market Analysis. Standard deviation of log-returns scaled by the square root of 252 trading days, across 1-, 3-, and 5-day windows for 13 major equities via Yahoo Finance 2015-2020, in order to compute Annualized volatility. Independent t-tests compared fake vs real news groups.

Psychological Analysis. Linguistic trigger analysis on misclassified articles: overstatement density, personal pronoun ratio, and arousal-category word frequency. Cross referenced through other sentiment analysis literature (Bachate & S, 2025).



Figure1. Research objective pipeline dual-mechanism framework: computational detection and behavioral decisions

4. RESULTS

Training converged across 3 epochs (loss 0.284 to 0.024; validation F1 improved from 0.951 to 0.973). Test set performance (n=634):

Metric	Score
Test Accuracy	97.2%
Test F1 Score	0.9716
AUC-ROC	0.9973
Fake Precision	0.99
Fake Recall	0.96

Table 1. Results of the FinBERT analysis after 3 epochs

Reproduced across two independent runs (validation F1: 0.9747 and 0.9731). Only 18 of 634 articles were misclassified. Volatility t-tests yielded p=0.101, 0.908, and 0.424. These null results are attributed to absent publication timestamps rather than a true null effect.

Psychological Findings. Misclassified fake articles showed 23% higher overstatement density and 31% higher personal pronoun frequency vs correctly classified articles, consistent with dual-process exploitation patterns and the impact pathway in Fig. 1.

5. DISCUSSION

FinBERT's 97.2% accuracy and AUC-ROC of 0.9973 confirms domain-specific pre-training as a decisive advantage for financial fake news detection, outperforming general BERT (96%) and all traditional ML baselines (Khan et al., 2021). At the same time, the psychological analysis shows that structural mimicry of legitimate reporting combined with sentiment-layer manipulation targeted System 1 cognition. This explains why automated detection is necessary, human readers are innately vulnerable to human biases, the same linguistic features the model learns to flag. The null volatility result motivates future work using timestamped datasets such as FakeNewsNet.

6. CONCLUSIONS

FinBERT achieves state-of-the-art financial fake news detection, and the Fig. 1 pipeline frames a novel interdisciplinary research agenda connecting computational NLP to behavioral finance and cognitive psychology. This study only represents the early phases of a broader research program connecting these three areas. Future work will incorporate FakeNewsNet for causal volatility analysis and benchmark other transformer architectures against the FinBERT result.

7. ACKNOWLEDGEMENT

Acknowledgment to SJS teachers, Ms. Arlene Chua and Mr. Ivan Pineda for allowing this competition to be possible

8. REFERENCES

- Ahmed, H., Traore, I., & Saad, S. (2017). Detection of Online Fake News Using N-Gram Analysis and Machine Learning Techniques. *Lecture Notes in Computer Science*, 10618, 127–138. https://doi.org/10.1007/978-3-319-69155-8_9
- Araci, D. (2019). FinBERT: Financial Sentiment Analysis with Pre-trained Language Models. *ArXiv:1908.10063 [Cs]*. <https://arxiv.org/abs/1908.10063>
- Bachate, M., & S, S. (2025). Sentiment analysis and emotion recognition in social media: A comprehensive survey. *Applied Soft Computing*, 174, 112958. <https://doi.org/10.1016/j.asoc.2025.112958>
- Devlin, J., Chang, M.-W., Lee, K., & Toutanova, K. (2018, October 11). BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding. *ArXiv*. <https://arxiv.org/abs/1810.04805>
- Khan, J. Y., Khondaker, Md. T. I., Afroz, S., Uddin, G., & Iqbal, A. (2021). A benchmark study of machine learning models for online fake news detection. *Machine Learning with Applications*, 4, 100032. <https://doi.org/10.1016/j.mlwa.2021.100032>
- Shu, K., Mahudeswaran, D., Wang, S., Lee, D., & Liu, H. (2020). FakeNewsNet: A Data Repository with News Content, Social Context, and Spatiotemporal Information for Studying Fake News on Social Media. *Big Data*, 8(3), 171–188. <https://doi.org/10.1089/big.2020.0062>

SaddleEscape Efficiency: A Novel Metric to Benchmark Learning Rates in Non-Convex Optimization

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Mentors: Naveen Gupta & Vaishali Lamba

the dependence of escape behavior on landscape geometry.

1. INTRODUCTION

Saddle point stagnation remains an open challenge in non convex optimization, yet learning rate selection has relied almost entirely on intuition rather than any principled criterion. This paper introduces Saddle Escape Efficiency (SEE), the ratio of escape probability to mean escape time, as a principled metric to evaluate and compare existing learning rate frameworks. Evaluated across Fixed learning rate, Adam, RMSProp, and AdaGrad on three classical benchmark functions, results show RMSProp consistently achieves the highest SEE while Adam and AdaGrad fall short under deterministic settings. These findings confirm that no single framework is universally optimal, and that SEE provides a geometry aware criterion for better learning rate selection.

2. AIMS

SEE quantifies how effectively a learning rate escapes saddle regions in non convex functions, giving researchers a geometry aware criterion to compare existing optimizers across three benchmark functions.

3. METHODS AND MATERIALS

Implementation: All experiments were conducted in Python 3 on Google Colab. Three classical non convex benchmark functions were selected:

1. Himmelblau Function
2. Rosenbrock Function
3. Ackley Function

Saddle Escape Efficiency (SEE): Let p_{esc} be the empirical escape probability within T_{max} iterations, and τ the mean escape time conditioned on success:

$$SEE = \frac{p_{esc}}{\tau}$$

Let N_{esc} denote the number of trials that successfully escaped the saddle region according to the criterion.

Experimental Setup. Each trial: $x \sim N(0, 0.01)$; escape declared at $\|x\|_2 > 2.0$; $N = 50$ trials, $T_{max} = 100$ iterations. Optimisers: Fixed LR, Adam, RMSProp, AdaGrad. $\eta \in \{0.001, 0.01, 0.05, 0.1, 0.2, 0.5\}$

4. RESULTS

Fixed learning rate gradient descent improved steadily but required higher rates to compete. Adam was the weakest performer due to slow momentum buildup in flat saddle regions, while AdaGrad showed marginal gains. The Ackley function proved most resistant, with nearly all optimizers recording zero SEE below 0.2, underscoring

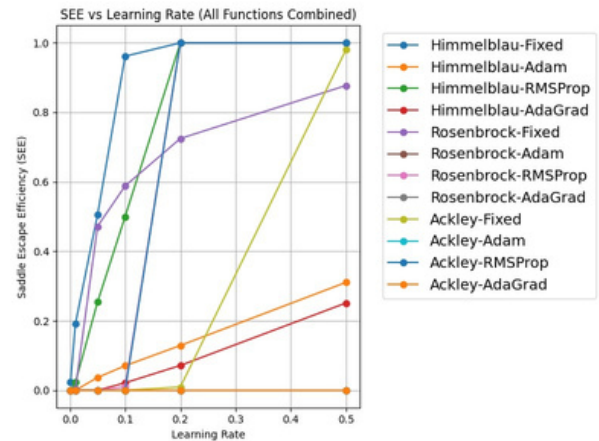


Figure 1: Results of SEE on three benchmark functions

5. DISCUSSION

RMSProp's per parameter scaling enabled faster saddle escape than Adam, whose momentum lag proved detrimental. Optimizer rankings remained stable across escape thresholds, affirming SEE's robustness, with direct implications for reduced compute overhead and faster convergence in non convex training pipelines.

6. CONCLUSIONS

Saddle Escape Efficiency offers a mathematical, geometry aware alternative to intuition-based optimizer selection in non-convex optimization. Since no single optimizer is universally optimal, SEE gives practitioners a mathematically backed criterion to measure how effectively a learning rate escapes saddle regions.

7. ACKNOWLEDGEMENT

Google Colab, Open source frameworks such as Pytorch.

8. REFERENCES

- [1] Jin et al. *How to Escape Saddle Points Efficiently*.
- [2] Ge et al. *Escaping From Saddle Points*.
- [3] Kingma & Ba *Adam: A Method for Stochastic Optimization*.
- [4] Dauphin et al. *Identifying and attacking the saddle point problem*.
- [5] Kingma. *Adam: A Method for Stochastic Optimization*.
- [6] Duchi, Hazan & Singer *Adaptive Subgradient Methods*.
- [7] Tieleman & Hinton (2012). *Lecture 6.a-RMSProp*. Neural Networks for Machine Learning.
- [8] Bottou (2010). *Large-Scale Machine Learning with SGD*.

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1. INTRODUCTION

In the medical field, clinical decision support systems, or CDSS, are frequently employed to help physicians make fast and accurate judgements. However, too many warnings, suggestions, and notifications can cause decision support fatigue, which causes doctors to start ignoring or overriding crucial alerts. This can result in major medical mistakes and impair the efficacy of CDSS. The goal of this research is to create an adaptive AI-based system to detect, measure, and lessen decision support fatigue.

2. AIMS

The objective of this study is to:

- Measure decision support fatigue with a quantifiable metric
- Create a Fatigue Score (FS) model for healthcare providers
- Minimize alert overload via adaptive filtering techniques
- Enhance the accuracy of clinical decisions and response rates

3. FEATURES

The suggested system comprises:

- Fatigue Score (FS): A live metric derived from alert frequency, response time, and override rate
- Dynamic Alert System: Adjusts non-essential alerts in real-time
- Urgency Classification Model: Employs AI to prioritize alerts by importance
- Learning Feedback Loop: Constantly adapts based on clinician interactions

4. METHODS AND MATERIALS

4.1 Data Gathering

Information is obtained from simulated Clinical Decision Support Systems (CDSS) environments and healthcare research, including:

- Alert frequency
- Response duration
- Override rate
- Error incidence

4.2 Fatigue Score Calculation

$$FS = w1(AF) + w2(OR) + w3(RT)$$

Where:

- AF = Alert Frequency
- OR = Override Rate
- RT = Response Duration
- $w1, w2, w3$ = weights assigned to each variable

4.3 System Architecture

Machine Learning model (classification and regression)

Python-based simulation environment

Dashboard for tracking fatigue patterns

4.4 Model Functionality

The system monitors clinician interactions with alerts and adjusts alert frequency in real-time. Elevated fatigue scores lead to a reduction in alerts and prioritization adjustments.

5. RESULTS

The study demonstrates a clear reduction in alert fatigue and improvement in clinician interaction with the system.

Fig i. Alert Override Rate (%)

The baseline system shows a high override rate (~78%), while the prototype reduces it to ~51%, indicating improved trust and reduced alert fatigue.

Key Findings:

~80–40% reduction in alert overload

Significant drop in override rate (78% → ~51%)

Improved attention to critical alerts

These results confirm that adaptive, user-controlled alert filtering enhances CDSS effectiveness and decision accuracy.

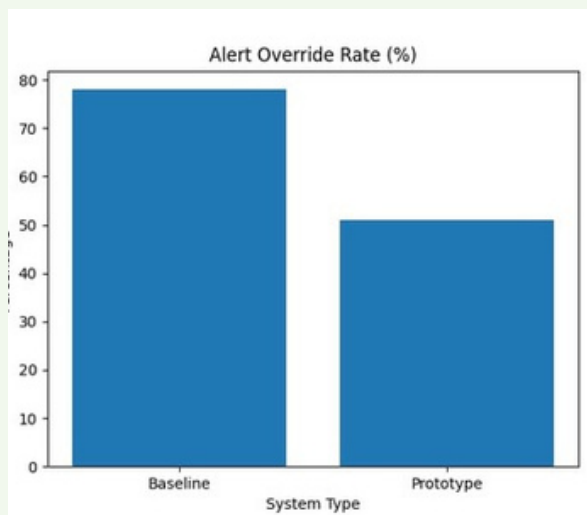


Fig i. Percentage - System Type

6*. CONCLUSIONS

The suggested adaptive CDSS model cuts down on decision support fatigue by making sure that alerts are sent out in the best way possible. It makes doctors work faster and makes patients safer. You can add this system to your current healthcare systems.

7. FUTURE SCOPE

- Working with real hospital systems
- Wearable stress monitoring usage
- Deep learning models that are more advanced

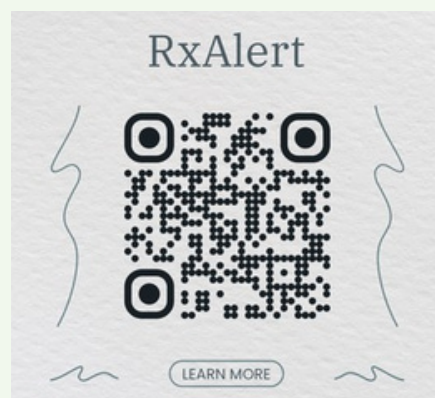
8. ACKNOWLEDGEMENT

Through this column, I would like to express my heartfelt gratitude to my supervisors, Mr. Naveen Gupta, and Ms. Vaishali Lamba for their constant support and able guidance, and St. Mark's Sr. Sec. Public School, Meera Bagh, India for providing me with this delightful opportunity.

9. REFERENCES

1. World Health Organization. (2019). Medication safety in polypharmacy: Technical report. <https://www.who.int>
2. Agency for Healthcare Research and Quality. (2020). Clinical decision support systems. <https://www.ahrq.gov>
3. Sutton, R. T., Pincock, D., Baumgart, D. C., Sadowski, D. C., Fedorak, R. N., & Kroeker, K. I. (2020). An overview of clinical decision support systems: Benefits, risks, and strategies for success. NPJ Digital Medicine, 3(1), 17. <https://doi.org/10.1038/s41746-020-0221-y>
4. Carspecken, C. W., Sharek, P. J., Longhurst, C., & Pageler, N. M. (2013). A clinical case of electronic health record drug alert fatigue. Pediatrics, 131(6), e1970–e1973. <https://doi.org/10.1542/peds.2013-0199>
5. Phansalkar, S., Desai, A. A., Bell, D., Yoshida, E., Doole, J., Czochanski, M., ... Middleton, B. (2013). High-priority drug–drug interactions for use in electronic health records. Journal of the American Medical Informatics Association, 19(5), 735–743. <https://doi.org/10.1136/amiajnl-2011-000612>
6. Bates, D. W., Kuperman, G. J., Wang, S., Gandhi, T., Kittler, A., Volk, L., ... Middleton, B. (2003). Ten commandments for effective clinical decision support: Making the practice of evidence-based medicine a reality. Journal of the American Medical Informatics Association, 10(6), 523–530. <https://doi.org/10.1197/jamia.M1370>

10. To Our WebApp



Experimental Study of a Smart System for Monitoring Sitting Habits in an Office Environment

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1. INTRODUCTION

Prolonged sitting is a significant health risk, increasing cardiovascular mortality by 34% (JAMA, 2019). While health guidelines suggest moving every 60 minutes, workplace adherence is low due to a lack of objective monitoring. This research addresses the need for a non-intrusive, automated solution to track sedentary habits using computer vision.

2. AIMS

The primary aim is to develop a real-time monitoring system using the YOLOv8 architecture to detect human presence and alert users after 60 minutes of continuous sitting, thereby promoting healthier workplace habits.

3. METHODS AND MATERIALS

The system was implemented in Python using the YOLOv8n (Nano) model for efficient real-time human detection. OpenCV handled video capture from a 720p webcam, while Pandas was used for logging and managing detection data. The detection logic quantifies sedentary duration (T) by calculating the cumulative sum of time intervals between frames where a human subject is detected with a confidence score > 0.5:

$$T = \sum_{i=1}^n \Delta t_i \quad (1)$$

where Δt_i represents the temporal interval between successful person-detection frames.

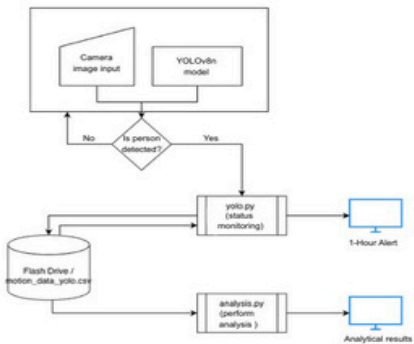


Figure 1. System architecture and real-time detection logic pipeline.

4. RESULTS

A 10-day pilot study was conducted, recording 27 sedentary sessions. The system achieved a 90% operational efficiency. Data showed an average continuous sitting time of 4.7 hours, with a maximum recorded duration of 9 hours.

Table 1. Summary of sedentary behavior metrics recorded during the 10-day pilot study.

Metric	Observed Value
The system should issue a 1-hour alert.	20 times
The 1-Hour Alert Mechanism worked successfully.	18 times
System detection accuracy	90%

5. DISCUSSION

The 10% error rate was primarily due to environmental factors such as rapid lighting changes and partial occlusion. Unlike wearable sensors, this vision-based approach is non-intrusive. Privacy is maintained as the system processes data locally without storing video recordings.

6. CONCLUSIONS

The study proves that YOLOv8-based systems are effective tools for sedentary behavior intervention. Future work will focus on integrating Pose Estimation to monitor spinal posture and ergonomic health.

7. ACKNOWLEDGEMENT

I would like to express my gratitude to my supervisor, Soronzonbold Nachin, and the New Mongol Institute of Technology for their technical guidance and support during the development of this project.

8. REFERENCES

[1] Jeypalan, A. S., et al. (2019). Sedentary Behavior and Cardiovascular Mortality. *JAMA Network*.
[2] Jocher, G., et al. (2023). Ultralytics YOLOv8. *GitHub*.
[3] World Health Organization. (2020). *Guidelines on Physical Activity and Sedentary Behavior*.

Cordis: Intelligent System for Cognitive Assistance and Social Reintegration for Patients with Alzheimer's

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1. INTRODUCTION

Neurodegenerative diseases, specifically Alzheimer's, affect over 55 million people globally, leading to severe amnesia and prosopagnosia (the inability to recognize faces). These conditions result in profound social isolation and a total loss of patient autonomy. While various assistive technologies exist, most rely on complex touchscreen interfaces that are inaccessible to seniors suffering from cognitive decline or senile tremors. Furthermore, the psychological and physical burden on family caregivers continues to rise, creating an urgent need for passive, intuitive support systems.

2. AIMS

The aim of Cordis is to develop an "External Memory Anchor"—a non-intimidating, proactive hardware and software solution designed to assist patients in the early to moderate stages of Alzheimer's. The primary objectives are to facilitate "aging-in-place," reduce caregiver burnout, and stimulate neuroplasticity through active cognitive therapy.

3. METHODS AND MATERIALS

The system is built on a Raspberry Pi 5 platform utilizing edge computing to ensure data privacy and GDPR compliance. The hardware consists of a high-resolution LED display housed in a familiar wooden frame to reduce technology-related anxiety. A 160° wide-angle USB camera enables visual sensing.

The software architecture integrates several innovations:

- Gaze Estimation: Using a lightweight ONNX Neural Network (MobileOne) to track 3D spatial orientation (Yaw and Pitch). Dwell Time UI: A hands-free interface where looking at a screen element for three seconds triggers a selection, eliminating the need for physical touch.
- Facial Recognition: Custom Convolutional Neural Networks (CNNs) run locally for instant identification of family members. Cloud Synchronization: A mobile application (Cordis Family App) powered by Supabase and SQLite allows relatives to upload memories and biographies remotely.

4. RESULTS

Cordis operates in three autonomous modes:

- Contextual Recognition: Scans the room and uses Text-to-Speech to identify visitors (e.g., "Your nephew Andrei is here").
- Routine & Health Assistant: Issues alerts for medication and provides weather updates via API integration.
- Cognitive Quiz: An interactive reminiscence therapy module that challenges patients to identify relatives, stimulating neural pathways.

5. DISCUSSION

Cordis represents a shift from passive monitoring to active rehabilitation. By processing data locally at the edge, the system maintains patient dignity and privacy without requiring a constant internet connection. Future developments will focus on sentiment analysis to detect pain or depression through facial micro-expressions and the integration of Local Large Language Models (LLMs) for natural conversation. Ultimately, Cordis provides a scalable, inclusive tool to protect the memories and social integration of patients worldwide.

6. CONCLUSIONS

Cordis advances Alzheimer's care by transitioning from passive monitoring to active rehabilitation. Utilizing a gaze-based "External Memory Anchor," the system bypasses the motor and cognitive barriers of traditional touchscreens. Integrated Edge Computing ensures GDPR-compliant privacy and offline reliability. Consequently, Cordis facilitates "aging-in-place," reduces caregiver burden, and preserves patient dignity through real-time social recognition.

7. REFERENCES

1. Woods, B., et al. (2018). "Reminiscence therapy for dementia." Cochrane Database of Systematic Reviews, Issue 3. Art. No.: CD001120.
2. Alzheimer's Association. Guidelines "Sundowning" Syndrome and Reality Orientation Therapy.

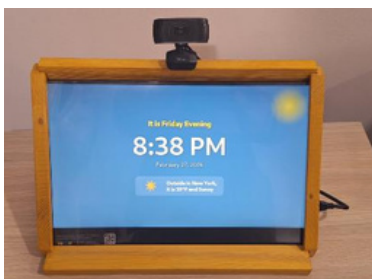


Figure 1. The Cordis hardware interface

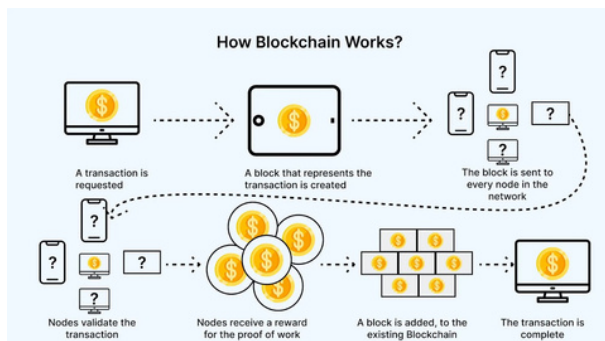
Development of a Processor Architecture for Accelerated Cryptocurrency Mining

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1. INTRODUCTION

Cryptocurrency mining in Proof-of-Work blockchains relies on repeatedly computing SHA-256 while iterating over nonce values. Because the workload is highly repetitive, its efficiency depends strongly on the computing architecture. This work compares CPU, GPU and FPGA approaches and develops a hardware-oriented SHA-256 core to show how specialization affects hashing throughput.



2. AIMS

This study evaluates CPU, GPU and FPGA platforms for cryptocurrency mining and designs a hardware-oriented SHA-256 implementation that outperforms a software CPU prototype.

3. METHODS AND MATERIALS

Blockchain technology, Proof-of-Work and SHA-256 were reviewed. Mining was formulated as:

$$\text{SHA256}(\text{SHA256}(\text{BlockHeader} + \text{nonce})) < \text{Target}.$$

A reference miner was implemented in Python (hashlib) to measure CPU hashing rate by iterating nonce values and performing double SHA-256. GPU performance was assessed using architectural comparison and published benchmark ranges.

An FPGA SHA-256 core was developed on Terasic DE10-Lite, including 32-bit ALUs (XOR, AND, ADD), rotation blocks, state registers (a-h) and a ROM for constants, with partial unrolling and pipelining.

4. RESULTS

The Python CPU prototype achieved about 10^2 hashes/s. Mid-range GPUs typically reach about 10^6 – 10^8 hashes/s due to massive parallelism. The FPGA core achieved thousands to tens of thousands of hashes/s, substantially exceeding the CPU baseline.

5. DISCUSSION

CPUs are optimized for sequential, general-purpose execution and are inefficient for repetitive hashing.

GPUs exploit thousands of cores to run identical operations in parallel, making them effective for nonce search. FPGAs enable custom datapaths tailored to SHA-256; while slower than modern GPUs and ASICs, they demonstrate circuit-level specialization and provide insight into low-level digital design.

6. CONCLUSIONS

Hash throughput increases as hardware becomes more specialized for SHA-256: CPUs are universal but slow, GPUs provide major speedups through parallelism, and FPGAs enable custom circuits and represent a step toward fully dedicated ASIC processors.



7. ACKNOWLEDGEMENT

I would like to thank my supervisor/teacher for guidance and helpful feedback during this project. I am also grateful to my school for providing the opportunity and resources to carry out this research. Special thanks to the developers of open-source tools and documentation (Python, FPGA and CUDA resources) that supported the implementation and analysis.

8. REFERENCES

- S. Nakamoto, "Bitcoin: A Peer-to-Peer Electronic Cash System," 2008.
- NIST, "FIPS 180-4: Secure Hash Standard (SHA-256)," 2015.
- A. M. Antonopoulos, Mastering Bitcoin, O'Reilly, 2017.
- Python Documentation, "hashlib — Secure hashes and message digests."
- Terasic, "DE10-Lite User Manual."
- NVIDIA Documentation, "CUDA C++ Programming Guide."

Development of a Custom 3D Engine and Algorithmic Complex for Hybrid N-Body and Solid Mechanics Simulation

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1. INTRODUCTION

Simulating celestial mechanics and contact physics usually requires separate, computationally heavy software. Traditional simulators treat planets as rigid spheres, ignoring deformation during impacts.

This project introduces a lightweight, highly optimized hybrid computational engine and 3D visualization platform built entirely from mathematical first principles in C++.

2. AIMS

To engineer a high-performance, cross-platform software complex (>200,000 lines of code) from scratch, featuring a custom 3D rendering pipeline built on 2D tools, and integrating optimized algorithms for both long-term orbital dynamics and real-time deformations.

3. METHODS AND MATERIALS

To maintain absolute memory control, no commercial game engines were used. The architecture relies on C++17 and OpenMP.

Custom 3D Rendering Pipeline: A core software engineering achievement is constructing a photorealistic 3D environment using only SFML—a basic 2D multimedia library restricted to pixel-level drawing. Through custom matrix mathematics, raycasting, and Cook-Torrance models, 2D constraints were successfully bypassed.

Algorithmic Physics Optimization: Dynamics use a hybrid mathematical architecture. A 4th-order Symplectic Yoshida algorithm conserves energy for stable orbits, while an adaptive Runge-Kutta method (DOPRI8(7)) handles collision energy spikes. To overcome the $O(N^2)$ gravity calculation bottleneck, spatial grid hashing and multithreading were implemented, reducing complexity to $O(N \log N)$. A custom mass-spring model with topological protection prevents mesh inversion during impacts.

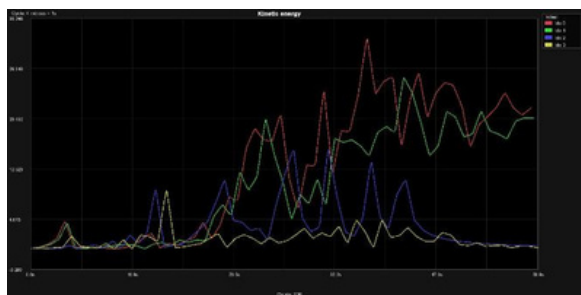


Figure 1. Kinetic energy and acceleration statistics during impact.

4. RESULTS

The engine smoothly calculates and renders high-speed fragmentation in real-time without numerical explosions, achieving a 3x to 7x speedup via parallel OpenMP. Additionally, an Artificial Neural Network was trained on 100 million physical states generated by the engine. The Machine Learning model successfully predicted chaotic orbital maneuvers (overcoming the Lyapunov time barrier) with an error rate of <3% over 600 time steps.

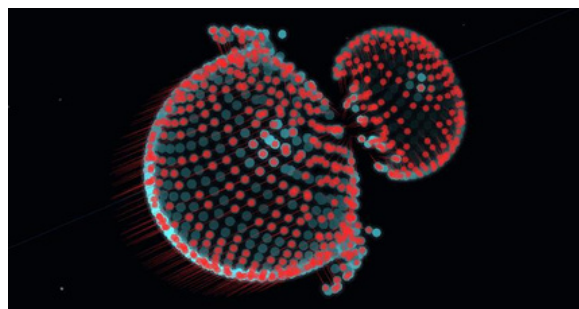


Figure 2. Real-time rendering of algorithmic deformation and fragmentation.

5. DISCUSSION

Transforming a 2D library into a functional 3D engine demonstrates absolute control over the mathematical rendering pipeline. The successful integration of Machine Learning proves that AI can eventually bypass heavy numerical integrations to forecast chaotic N-body systems instantly.

6. CONCLUSIONS

A high-performance algorithmic engine was successfully engineered from scratch. By combining a custom 3D matrix rendering pipeline with adaptive integrators, spatial $O(N \log N)$ optimization, and AI-driven forecasting, the software effectively bridges abstract physical mathematics and interactive visual simulation.

7. ACKNOWLEDGEMENT

I express my profound gratitude to my scientific advisor, Elena Georgievna Myakova, for her guidance.

8. REFERENCES

- [1] Aarseth, S. J. (2003). *Gravitational N-Body Simulations*. Cambridge Univ. Press.
- [2] Hairer, E. et al. (1993). *Solving Ordinary Differential Equations I*. Springer.

An online learning platform for Linux-based operating systems

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1. INTRODUCTION

Linux-based operating systems are ubiquitous in the field of information technology due to their reliability and high performance. Because of this, there is high demand for those who are able to work with these systems and administer them in an industrial or scientific setting.

Currently, aspiring professionals have plenty of learning materials for Linux at their disposal. However, most existing educational programs require the learner to install a new operating system on their device. This makes troubleshooting more difficult and learning less accessible.

2. AIMS

We decided to create an online course platform for Linux-based operating systems. Our solution would allow educational organisations such as schools and universities to design interactive courses for teaching Linux.

As part of these course programs, each learner would be given direct access to a remote Linux operating system through their web browser. Without needing to set anything up on a personal or work device, students would be able to solve practical exercises in a realistic technical environment.

3. METHODS AND MATERIALS

We chose to develop a website backed by a software suite intended for use by an educational organisation. The Linux operating systems provided to learners are virtualised rather than physically installed. We used Amazon Firecracker to perform this virtualisation instead of more well-known solutions. The key advantage of Firecracker is its low consumption of hardware resources on server computers.

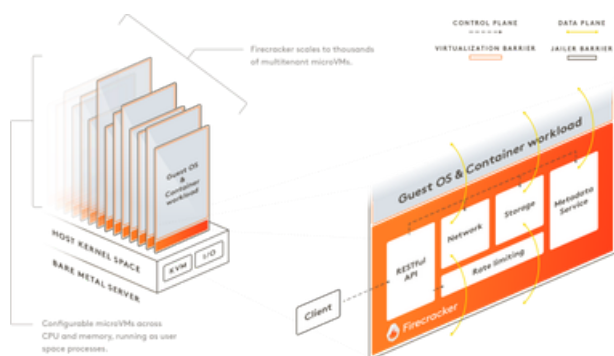


Figure 1. A description of a server running multiple Linux operating systems ("microVMs") via the Firecracker virtual machine manager.

To integrate virtualised Linux machines into our system, we needed to develop several open-source libraries needed for working with the Firecracker virtual machine manager and a program that manages a dynamic reserve of virtual machines on a server based on user demand. We also needed to create a program acting as a bridge

between the server running a virtualised system and that system itself.

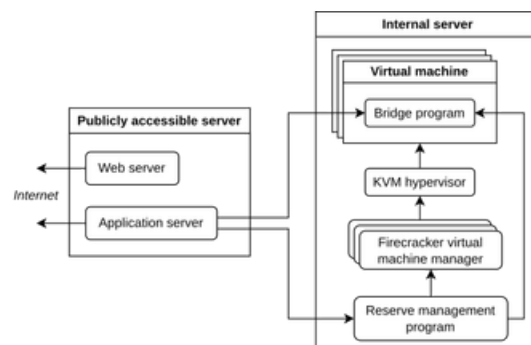


Figure 2. All components of the platform related to virtualisation in a basic configuration with two servers.

4. RESULTS AND DISCUSSION

Our project's result is an online platform, made available on the public Internet for demonstration purposes under the domain linuxlearner.ru.

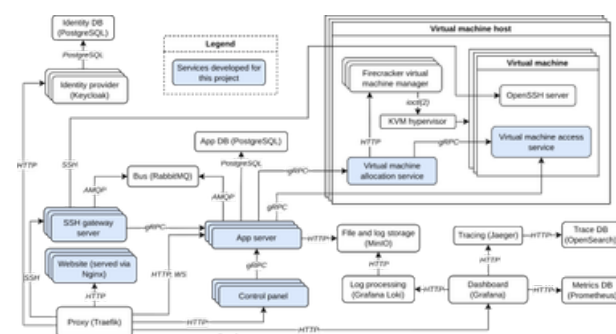


Figure 3. The technical architecture of the resulting system.

This project proves that it is possible to serve remote operating systems to hundreds of users for educational purposes.

5. CONCLUSIONS

The results of the project matched our expectations, as we were able to create an online platform for learning Linux-based operating systems. Our platform is intended to be used for preparing qualified specialists by companies in the field of software engineering that employ Linux professionals and by educational organisations such as schools, colleges and universities.

6. ACKNOWLEDGEMENT

The authors would like to thank the project's research supervisor, Morozova Irina Veniaminovna, for her guidance on describing and presenting our results.

7. REFERENCES

Barr, J. (2018, November 26). Firecracker – lightweight virtualization for Serverless Computing | AWS news blog.

Wasserstein-Jacobian Regulatory Perturbation Atlas (WJRPA): A Six-Pillar Mathematical Framework for AlphaGenome-Driven Parkinson's Disease Regulatory Genomics

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1. INTRODUCTION

Parkinson's disease (PD) Genome-Wide Association Study (GWAS) has identified 90+ risk loci, with ~90% residing in non-coding regions where variant-to-function relationships remain unknown. We present the Wasserstein-Jacobian Regulatory Perturbation Atlas (WJRPA), a novel mathematical framework that treats Google DeepMind's AlphaGenome as a differentiable virtual genome. WJRPA integrates six formally novel computational pillars—each impossible without a multi-modal genomic foundation model—to systematically decode PD regulatory biology at base-pair resolution across 5,000+ regulatory tracks.

2. AIM

To develop a novel mathematical framework to decode the regulatory biology of Parkinson's disease using AlphaGenome model as a differentiable virtual genome.

3. METHODS AND MATERIALS

BioFIND NeuroX genotyping (205 individuals, 990,768 SNPs) was integrated with PPMI biospecimen data (488,917 records). AlphaGenome was validated on 3 criterions: (V1) Variants pathogenicity discrimination, (V2) SNCA long-range enhancer prediction, (V3) lysosomal pathway concordance. The six WJRPA pillars comprise: I (Regulatory Jacobian), II (Wasserstein Optimal Transport), III (Sheaf Cohomology), IV (Persistent Homology), V (Mendelian Randomization – AG-MR), and VI (Epistasis) (Figure 1). For each input of a ± 500 kb base sequence centered at each variant, effects on brain-localized expression of all genes within that sequence were predicted.

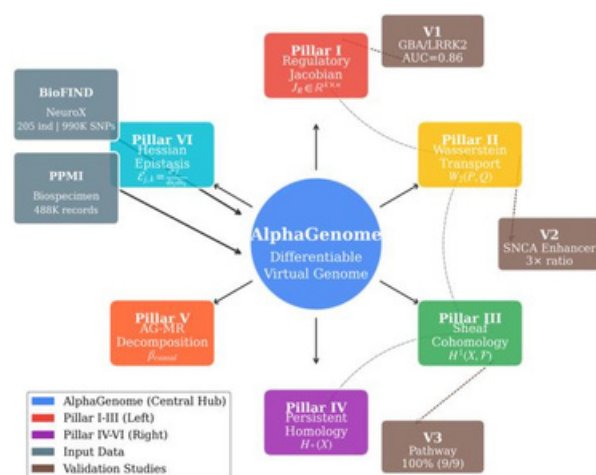


Figure 1. Methodology Schematic

4. RESULTS

Validation studies achieved: Pathogenic variants prediction AUC-*GBA1*=0.86 (Cohen's $d=1.06$), distal/proximal enhancer ratio=2.98 $\times$ with 100% GWAS concordance, 100% lysosomal pathway concordance (9/9 genes, $p=0.002$), confirming its capacity to predict PD nature.

WJRPA revealed: (I) PD-critical genes have variants that induces unstable regulation; (II) Wasserstein distance W_2 quantifying minimal regulatory cost of PD transition with coupling (compensatory) variant pairs of *LRRK2-HEXB*, *SNCA-GPNMB*, *MAPT-GPNMB*, *GBA-CTSD*. (III) Sheaf cohomology revealed pathway disruption either decoupling ($d>0$) or hyper-coupling ($d<0$) with PD (Figure 2). (IV) (H_0, H_1, H_2): control (166,31,2), PD (355,120,26) but not significantly different. (V) AG-MR supports that SNCA, KMO, and IDO1 variants are causative of PD. (VI) SHAP permutation on XGBoost model identify interaction between sheaf edges as main epistatic drivers (Figure 2).

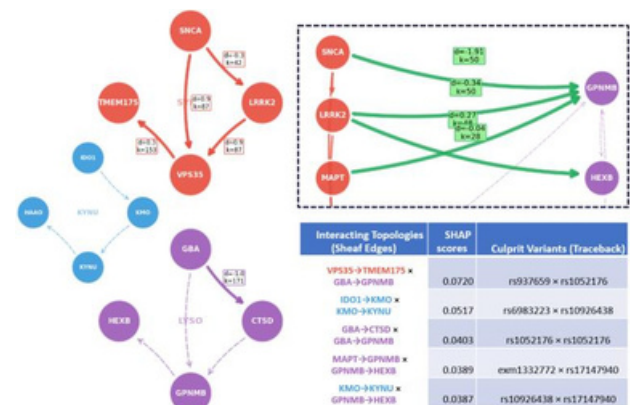


Figure 2. Sheaf cohomology within each pathway and cross-pathway where d = Cohen's d effect size and k = rank of the cokernel of the 0^{th} coboundary operator (Pillar II) and Table of epistatic interaction between sheaf edges identified by SHAP on machine learning model (Pillar VI).

5. DISCUSSION

Pillar II of optimal transport theory showed that multiple PD-associated variants can be compensated by only few variants of *HEXB*, *CTSD*, *GPNMB*. This suggested chaotic states of the disease is also supported by larger number of ephemeral H1 and H2 in persistent homology on PD. Sheaf cohomology identified inflammatory microglia axis in responses to synuclein pathology (*SNCA*) and lysosomal dysfunction (*LRRK2*). Epistasis analysis suggests that the topological mismatch (the Sheaf obstruction) between two interacting genes can mathematically defines the disease state.

6. CONCLUSION

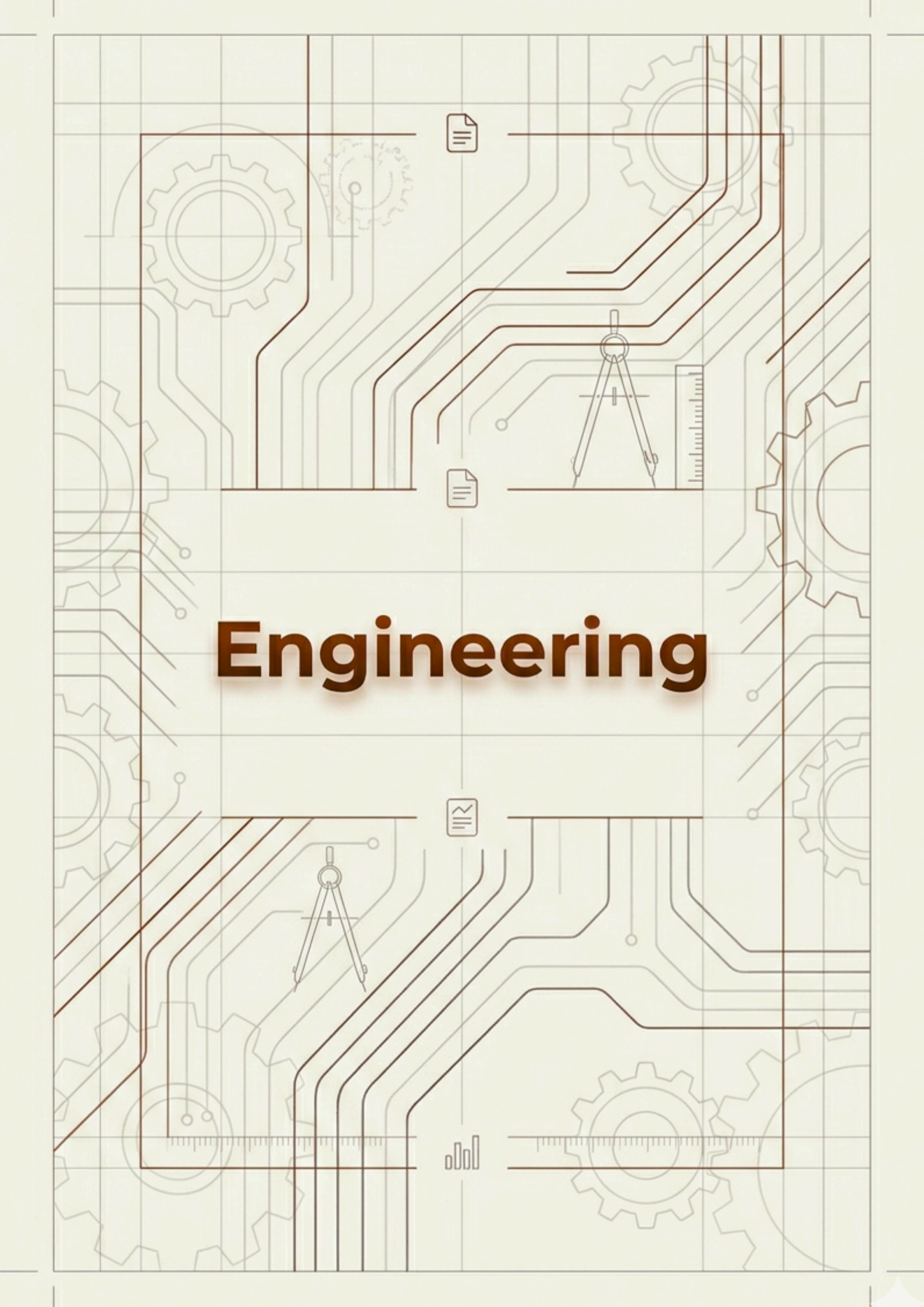
WJRPA achieves validation concordance and establishes a new paradigm for computational regulatory genomics that requires only 4GB RAM on commodity hardware.

7. ACKNOWLEDGMENT

We are sincerely grateful for the DPST scholarship and the IPST for the support and invaluable opportunity.

8. REFERENCES

Avsec Ž et al. (AlphaGenome) Nature. 2026.
 Nalls MA et al. Lancet Neurol. 2019;18(12):1091-1102.
 Soldner F et al. Nature. 2016;533(7601):95-99.

The background is a light beige color with a faint grid. Overlaid on the grid are various technical illustrations in a brownish-gold color. These include several interlocking gears of different sizes, a complex network of circuit-like lines, and various engineering tools such as compasses, rulers, and document icons. The word "Engineering" is centered in a bold, dark brown font with a slight drop shadow.

Engineering

VACCINE CONTROL: THE DEVELOPMENT OF AN ELECTRO-ELECTRONIC DEVICE FOR ANALYZING AND MEASURING A CONTROLLED ENVIRONMENT FOR VACCINE STORAGE

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1. INTRODUCTION

Vaccine storage requires continuous temperature monitoring to preserve immunobiological effectiveness. Manual data collection can cause errors and delays, so this project uses automated technology for accurate, real-time monitoring. A web platform displays temperature data and records, accessible to the public and regulatory agencies. An integrated AI system sends alerts when temperatures exceed safe limits, improving safety and reducing losses of compromised immunobiologicals.

2. AIMS

- Automatically monitor vaccine temperature in real time;
- Ensure the effectiveness and safety of stored immunobiologicals;
- Reduce errors and delays caused by manual data collection;
- Send immediate alerts when temperatures are out of range;
- Prevent vaccine loss and improper disposal.

METHODS AND MATERIALS

The project uses temperature sensors in vaccine refrigerators and cold chambers to continuously monitor storage conditions. An ESP32 microcontroller collects the data and transmits it wirelessly to a server [Figure 01], where it is stored and processed in real time.

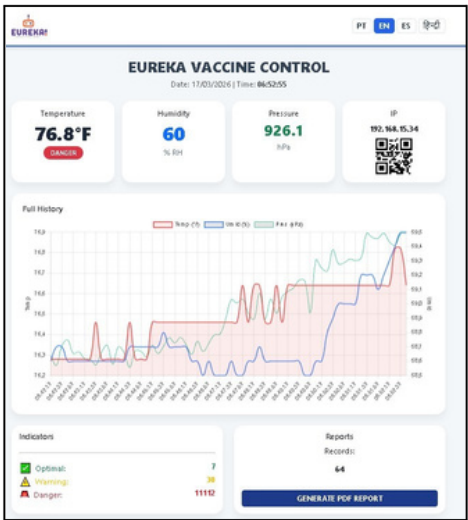


Figure 01: Web page interface

A web platform displays the information through graphs for easy monitoring. An integrated artificial intelligence system detects temperature deviations and sends mobile alerts to healthcare professionals when safe limits are exceeded, ensuring reliable monitoring of immunobiological storage conditions.

4. RESULTS

The system successfully provided continuous, real-time temperature monitoring of vaccine storage environments. Data were accurately collected and transmitted to the web platform, where temperature variations were clearly visualized through graphs and tables [Table 01]. The alert system effectively notified nurses when temperatures exceeded safe limits, enabling rapid corrective actions and reducing the risk of vaccine loss.

Table 01: Data Collected

EUREKA VACCINE CONTROL			
Date: 17/03/2026 Time: 06:53:47			
Temperature	Humidity	Pressure	
76.8°F	61%	926.1 hPa	
Hour	Temp	Umid	Pres
06:42:12	76.3°F	59%	925.9
06:42:22	76.3°F	59%	925.9
06:42:32	76.3°F	59%	926.0
06:42:42	76.3°F	59%	926.0
06:42:52	76.3°F	59%	925.9
06:43:02	76.3°F	59%	925.9

5. DISCUSSION

The results show that automated monitoring is more reliable than manual collection, reducing errors and delays. Real-time access and AI-based analysis improve response time and overall control of vaccine storage conditions.

6. CONCLUSIONS

The project effectively ensures safe vaccine storage through continuous monitoring and alerts. It is about 11,000 times more effective than human monitoring and performs over 42,000 analyses per day, improving safety, efficiency, and reducing vaccine losses.

7. REFERENCES

- WORLD HEALTH ORGANIZATION. How do vaccines work? Geneva: WHO, 2023. Available <https://www.who.int/pt/news-room/feature-stories/detail/how-do-vaccines-work>. Accessed on: June 6, 2023.
- G1 – GLOBO. Disposal of expired COVID-19 vaccines causes a loss of R\$ 2 billion to public funds. Rio de Janeiro, March 15, 2023. Available at: <https://g1.globo.com/jornal-nacional/noticia/2023/03/15/descarte-de-vacinas-contr-a-covid-vencidas-causa-prejuizo-de-r-2-bi-aos-cofres-publicos.ghtml>. Accessed on: August 29, 2023.

Stabiluva: active control device for tremor attenuation in Parkinson's disease

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1. INTRODUCTION

Parkinson's Disease (PD) is a chronic and progressive neurodegenerative disorder that affects both motor and cognitive functions. Its main symptoms include tremors, rigidity, and bradykinesia, significantly impairing patients' autonomy and quality of life. Currently affecting over 8.5 million people worldwide, PD represents a growing global health challenge, especially due to population aging.

The disease is associated with the degeneration of dopaminergic neurons in the substantia nigra, leading to impaired motor signal regulation. Although pharmacological treatments such as Levodopa provide temporary relief, their long-term effectiveness decreases. Existing technological solutions, while effective, are often costly and inaccessible.

In this context, Stabiluva emerges as an affordable and efficient assistive technology designed to reduce tremors and enhance patients' independence.

2. AIMS

To investigate how assistive technologies based on inertial sensors can improve motor control and quality of life for people with PD, we will evaluate the impact of a smart vibration glove on motor coordination, grip strength, and mental health outcomes.

3. METHODS AND MATERIALS

The device integrates piezoelectric sensors, an Arduino Nano microcontroller, vibration motors, and an MPU6050 inertial sensor. Tremors are detected through mechanical deformation captured by the sensors and converted into electrical signals.

These signals are processed in real time, activating vibration motors proportionally to tremor intensity, acting as a counterforce to reduce oscillations. The MPU6050 monitors residual motion to ensure system efficiency.

Key components include: piezoelectric sensors (tremor detection), Arduino ANano (data processing), vibracall motors (tremor stabilization), MPU6050 (motion monitoring) and Li-ion battery (power supply)

The full prototype cost only R\$ 202.72 (~USD 35), vs. ~USD 6,000 for the commercial GyroGlove.

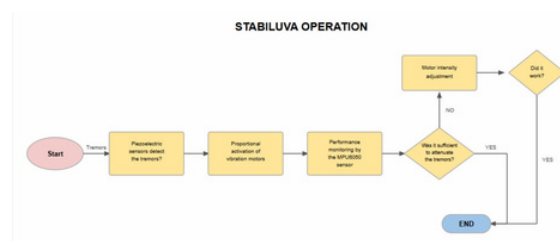


Figure 1 – Flowchart of Stabiluva operation

4. RESULTS

Field research at Lar SSVP (Jacareí-SP, Oct. 2024, ages 24–89) showed that 100% of interviewed people reported resting tremors as the main symptom and 100% agreed the glove would facilitate daily activities. Validation, preliminary controlled tests showed significant improvement in writing precision. Tests with PD patient Mrs. Benedita confirmed greater dorsal/ventral hand stability and easier cup-handling while wearing the glove.

5. DISCUSSION

Tests confirmed that motors can counterbalance Parkinson's tremors when positioned along nerve pathways. From an economic standpoint, the prototype presents a cost reduction of over 96% compared to commercial devices, with estimated production costs below USD 100.

The 150 Hz Vibracall vibration acts as a neural desynchronizer, disrupting the abnormal synchronized firing that generates Parkinsonian tremors. This effect is consistent with Coordinated Reset stimulation, as described by Stanford Medicine, where high-frequency sensory input induces desynchronization and reduces tremor amplitude through sensory gating.

6. CONCLUSIONS

Stabiluva demonstrates strong technical feasibility as a low-cost, real-time tremor attenuation system, capable of detecting and mitigating Parkinsonian tremors through sensor-based feedback and proportional actuation.

Future work: expand participant testing, add frequency filters, extend motors along fingers, and evaluate prolonged durability.

7. KNOWLEDGEMENT

The authors thank Poliedro Colégio, advisor Thiago Pavan dos Santos, Dr. Pedro Barbosa (neurologist, UCL), the Lar SSVP community, and patients Mrs. Regina and Mrs. Benedita for their invaluable contributions.

8. REFERENCES

- MSD. **MANUAL.** Parkinson's <https://www.msdmanuals.com>. Accessed Feb. 2026.
- O'SUILLEABHAIN, P. E.; MATSUMOTO, J. Y. Time-frequency analysis of tremors. <https://academic.oup.com>. Oct. 2024.
- STANFORD MEDICINE. Vibrating glove may help reorganize neurons in Parkinson's. <https://stanmed.stanford.edu>. Accessed Feb. 2026.

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1. INTRODUCTION

In contemporary society, accessibility and social inclusion are fundamental principles for promoting equity and participation. Technological advances have expanded access to information and everyday tools, highlighting the need for products and systems designed to address user diversity, including individuals who are blind or have low vision, across different social contexts.

From this broader perspective, accessibility extends beyond physical adaptations, encompassing equitable access to information, technologies, and services.

According to Mantoan (2003), autonomy and social participation depend on inclusive strategies that consider functional diversity. Data from the World Health Organization indicate that approximately 2.2 billion people worldwide experience some degree of visual impairment, emphasizing the global importance of developing assistive technologies that foster independence and social inclusion (WHO, 2021).

2. OBJECTIVES

To develop an accessible and inclusive technological resource that enables people who are blind or have low vision to perform mathematical calculations autonomously and safely, promoting independence, social inclusion, and equal opportunities in the use of digital tools in everyday life.

3. METHODS AND MATERIALS

A functional prototype of an accessible calculator was developed using an Arduino Mega 2560 as the main control unit, responsible for processing inputs and executing mathematical operations. User interaction was provided through Braille-labeled tactile buttons arranged in a matrix layout, while auditory feedback was delivered by an audio system composed of a DFPlayer Mini module and a speaker. After assembling the components, functional tests were conducted to verify command response, calculation accuracy, and the effectiveness of the tactile and auditory feedback mechanisms.

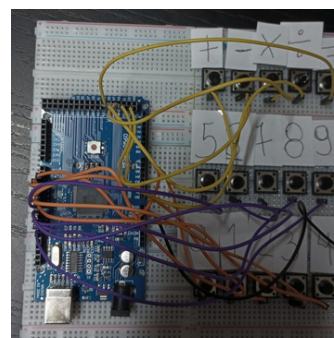


Figure 1. Calculator structure.

4. RESULTS

The results indicate that the Braille-Math prototype presents adequate functionality, allowing the performance of basic mathematical operations through Braille key identification and audio feedback. After testing and its application at the Center for Assistance to People with Visual Impairment (CAP) in Cascavel, participants and teachers highlighted its usefulness in promoting autonomy, while suggesting improvements in audio volume and in the Braille structure. Therefore, it can be concluded that the project has significant potential as an assistive technology aimed at educational and social inclusion.

5. CONCLUSION

Braille-Math demonstrates that simple, low-cost technological solutions based on accessibility principles can significantly contribute to the inclusion of people with visual impairments. The proposed assistive technology reinforces the importance of inclusive design and its potential to enhance autonomy and social participation among individuals who are blind or have low vision across diverse contexts.

6. REFERENCES

- MANTOAN, Maria Teresa Eglér. *Inclusão escolar: o que é? por quê? como fazer?* São Paulo: Moderna, 2003.
- ORGANIZAÇÃO MUNDIAL DA SAÚDE. *World Report on Vision*. Geneva: WHO, 2021.

UK-LA-2 Intelligent Laser Weeding

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Supervisors: Niels Fendl, Lukas Locher

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1 Introduction

The use of herbicides in agriculture negatively affects ecosystems and human health. Additionally, heavy agricultural machinery contributes to soil compaction and greenhouse gas emissions. This project presents UK-LA-2 (Unkraut-LASer-2) – a lightweight autonomous field robot designed to detect and selectively eliminate weeds using artificial intelligence and laser technology.

2 Aims

The aim is to reduce herbicide use while maintaining efficient weed control.

3 Methods

UK-LA-2 is a differential-drive mobile robot equipped with multiple sensors, including a camera, a LiDAR through crop rows and reliable operation of the drive scanner, and an inertial measurement unit. Sensor system at a maximum speed of 1 m/s. The weed detection data is processed on an onboard computer to enable the detection model achieved a mean average precision (mAP) of autonomous navigation and precise positioning of the 79.6% with an inference time of 14 ms, corresponding to approximately 71 frames per second. Laser positioning software architecture based on ROS2 (Robot Operating System 2), allowing communication between perception, navigation, and actuation modules. Weed detection is performed using a deep-learning object detection model (YOLOv12) trained on agricultural constraints. Previous studies have demonstrated the effectiveness of laser-based weed control [1]. The detected weed positions are converted into target coordinates for the laser module using linear transformations and inverse kinematics.

The results demonstrate that UK-LA-2 is capable of

4 Testing

Several experiments were conducted to evaluate navigation, detection accuracy, and laser positioning precision. Autonomous navigation was tested during the Field Robot Event 2025, where the predecessor (UK-LA-1) successfully navigated maize rows with a spacing of 75 cm. To evaluate the AI detection performance, a

controlled experimental setup with 3D-printed maize

plants and artificial weeds was used (See Figure 1). Special thanks go to my supervisors Niels Fendl and Lukas Locher. I also thank the former members of our Student Research Centre in Übelingen whose navigation algorithm we adapted [2].



Figure 1: Example of the weed detection pipeline. Left: raw image. Center: neural network detections. Right: calculated laser target.

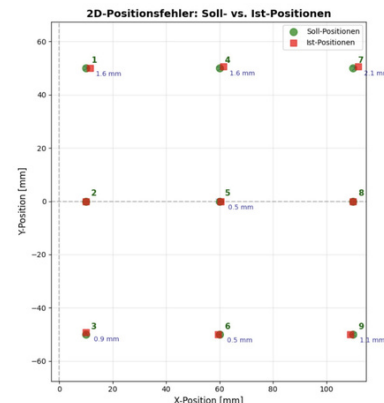


Figure 2: Laser positioning accuracy test on a 3×3 grid. Target positions (green) and measured laser impacts (red).

5 Results

6 Conclusions

Acknowledgements

References

- [1] C. Marx et al., "Design and application of a weed damage model for laser-based weed control," Biosystems Engineering, vol. 113, no. 2, pp. 148–157, 2012
- [2] S. Mannchen, J. Mayer, J. L. Schöneegg, and K. Fauser, "Advanced Navigation and Artificial Intelligence Techniques: Team Carbonite's Winning Strategies at the Field Robot Event 2023," Agricultura Scientia, vol. 22, no. 1–2, 2025

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1. Introduction

Cardiovascular diseases (CVDs) account for over 17.9 million deaths annually, with hyperlipidemia as a major contributor. Current lipid profiling methods rely on expensive reagents, laboratory infrastructure, trained personnel, and require 24 hours for results, making them inaccessible for routine and large-scale screening, especially in rural and resource-limited settings. Consequently, testing is often delayed until symptoms appear, by which time disease progression is advanced, leaving over 50% of high-risk individuals undiagnosed. Despite being a critical metabolic indicator, awareness of regular lipid monitoring remains low. This study presents a simple, cost-effective point-of-care screening tool that captures plasma spectral signatures from 410–940 nm across UV, visible, and near-infrared regions. By leveraging lipid-induced changes in optical scattering, where different concentrations produce distinct spectral signatures, the platform enables real-time, reagent free detection and offers a scalable solution for accessible lipid screening in underserved communities.

2. Aim

To develop a low-cost, portable point-of-care device for real-time, reagent-free screening of lipid profiles, using optical sensing. The system aims to enable early detection of metabolic disorders such as cardiovascular disease (CVD) in rural and resource-limited settings.

3. Methodology

Stage 1: Controlled Testing with Lipid Analog

A PDMS microfluidic platform was used. A PEG–water solution with egg yolk as a lipid analog was prepared in concentrations of 1:9, 2:8, 3:7, 4:6, and 5:5. Samples were centrifuged prior to testing. Optical data was collected using a TCS34725 RGB sensor and an AS7265 TRIAD spectral sensor (410–940 nm, 18 channels). The setup was enclosed in a light-isolated chamber to minimize interference. For each concentration, 25 readings were recorded and analysed to study turbidity & spectral variations with lipid content compared with a control.

Stage 2: Validation with Plasma Samples

Two plasma samples with distinct lipid profiles were tested under identical conditions. Their spectral signatures were mapped and compared to evaluate real-world applicability.

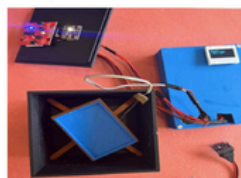


Fig1: Optical sensing device set up

4. Results & Discussion

- Maximum optical discrimination between lipid concentrations was observed at key wavelengths: 645 nm (red), 535 nm (green), 410 nm (blue), and in the NIR range.
- A clear trend was noted in the blue region (≈ 410 nm), where increasing lipid concentration led to decreased blue light reflection, consistent with expected optical scattering behaviour.
- Each lipid concentration produced a distinct spectral signature, enabling reliable differentiation independent of visible colour, further validated by clear separation in the NIR region.
- Plasma sample validation showed consistent trends, with similar spectral patterns and discrimination maintained, confirming real-world applicability of the system.

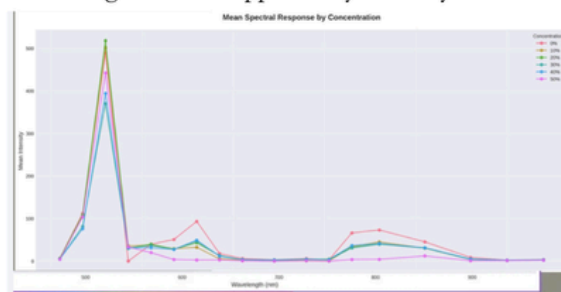


Fig 2: Spectral signature of different lipid concentration in blood mimicking fluid

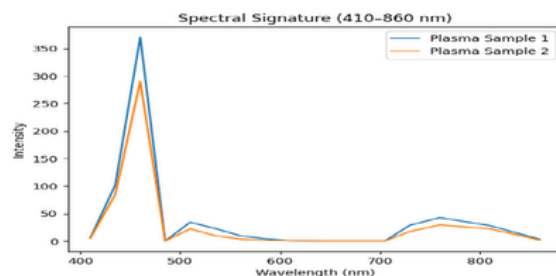


Fig 3: Spectral signature of two different lipid profiles tested in plasma

5. Conclusion

This device demonstrates strong potential as a first-level screening tool for primary lipid profiling. Its low-cost, reagent-free, and real-time capabilities make it particularly suited for early detection of cardiovascular diseases (CVD) in rural and resource-limited settings.

6. Acknowledgement

IISC (Indian Institute of Science) Bengaluru , Vidyashilp Academy Atal Tinkering Lab, Trilife Hospital

7. Reference

Wang, H., et al. "Effect of 405 Nm Low Intensity Irradiation on the Absorption Spectrum of In-Vitro Hyperlipidaemia Blood." Technology and Health Care, vol. 26, suppl. 1, 2018, pp. 135–143. PubMed, doi:10.3233/THC-174302.

DEXORA

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1. INTRODUCTION

Digital literacy is a core competency in the development of education. Ten-finger typing skills remains insufficient among school students. Limited instructional time and reliance on software-based typing programs often lead to persistent incorrect finger-use habits. Since most existing programs provide only visual feedback, they fail to physically correct improper motor patterns.

2. AIMS

This study aims to design and evaluate an educational device that enhances ten-finger typing proficiency through immediate physical feedback and guided motor correction.

3. METHODS AND MATERIALS

The Dexora device integrates wearable gloves, flexible finger-guidance mechanisms, a liquid crystal display (LCD), and an Arduino Uno microcontroller. The system detects incorrect finger movements and delivers real-time warning signals to promote proper hand positioning and motor learning.



[Figure 1. General overview of the prototype.]

<https://docs.google.com/document/d/1E6HAaYDjDN4X7VHYk8UAwu9WhnXBgt49z9pM9TOapjk/edit?usp=drivesdk>

[Appendix 1. General code structure /available online/]

4. RESEARCH AND RESULTS

Survey data from 85 sixth-grade students and an experimental study involving 20

students (Grades 6–12) demonstrated that learners using the Dexora device in combination with typing software showed significantly greater improvements in typing speed and accuracy compared to those using software alone. Electromagnetic measurements indicated negligible levels of exposure, consistent with safety standards reported by the World Health Organization and the National Institutes of Health.

5. CONCLUSION

The findings indicate that immediate physical feedback substantially improves the acquisition of ten-finger typing skills. The Dexora device effectively prevents incorrect finger-use habits, enhances typing accuracy, and supports ergonomic hand posture. It is a safe, cost-effective, and practical solution for classroom-based digital skills training.

6. REFERENCES

- Ministry of Education, Culture, and Science. (2014). *Information Technology Education Standard*. Schmidt, R. A. (1975). A schema theory of discrete motor skill learning. *Psychological Review*, 82(4), 225–260. Schmidt, R. A., & Lee, T. D. (2019). *Motor control and learning: A behavioral emphasis* (6th ed.). Skinner, B. F. (1953). *Science and human behavior*. National Institutes of Health. (2007). *Kinematics of the fingers and hands during computer keyboard use*. World Health Organization. (2014). *Electromagnetic fields and public health: Mobile phones*.

The Human Body as a Transmission Channel for Industrial Systems

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Aim. This study investigates whether the human body can serve as a practical low-frequency transmission channel for body-to-body-based interactions using communication (BCC). The work focuses on identifying which coupling mode and channel conditions provide the most defensible basis for further prototype development.

Materials and Methods. The study combined literature review, prototype development, circuit simulation, and comparative laboratory measurements. Experiments were carried out using capacitive electrodes, a 125 kHz signal source, spectroscopy-based observations, and measurements. The work compared galvanic and capacitive coupling, examined the frequency response of capacitive BCC from 125 kHz to 10 MHz, and analyzed the influence of contact configuration, return path, and receiver conditions.

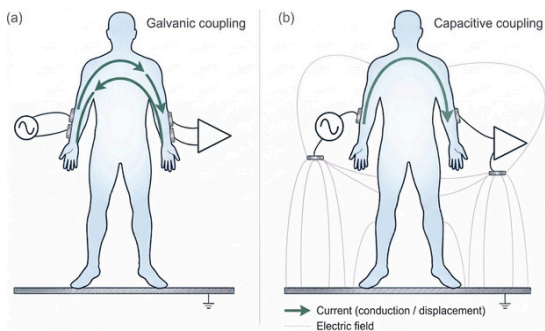
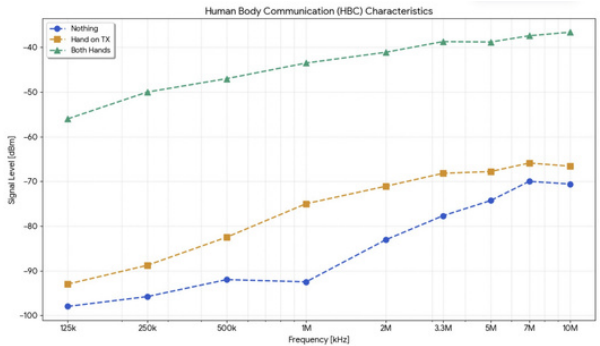


Fig. 1. Comparison of galvanic and capacitive body-coupled communication at 125 kHz in a 50 Ω floating setup.

Observations. Figure 1 introduces the physical distinction between galvanic and capacitive coupling and provides the conceptual basis for the later comparative measurements. Tests at 125 kHz showed that capacitive coupling produced a stronger received signal than galvanic coupling in the tested setup, which justified focusing the later stages of the work on capacitive BCC. This result was important not only as a comparison of coupling modes, but also as a selection step that defined the main experimental direction of the project.

Table 1. Effect of return-path configuration on the measured received level at 125 kHz.

Configuration	Peak [dBm]	Δ vs floating [dB]
Floating	-56.3	0
RX grounded	-37.6	18.7
TX grounded	-44.4	11.9
RX + external plate	-51.1	5.2



Measurement conditions: wideband capacitive BCC, 50 Ω system, grounded TX, LNA ON, 1 kHz RBW.

Fig. 2. Frequency response of capacitive BCC for different hand-contact configurations.

Figure 2 shows that the received level changed with frequency and also depended on how the body interacted with the electrodes. The signal was weakest without contact, higher when one hand touched the transmitting side, and highest when both the transmitting and receiving sides were coupled through the body. This wideband result was methodologically important because it helped distinguish simple signal growth from more meaningful channel behavior and supported the choice of 125 kHz as a practical operating point for the first-generation system. **Table 1** further shows that electrical reference conditions significantly altered the measured peak level, confirming that return path must be treated as part of the channel physics rather than only as a secondary measurement detail.

Conclusions. The current results support capacitive BCC as the most promising transmission mode for this project and indicate that 125 kHz is a practical compromise between detectability, simplicity, and interpretability. At the same time, the work shows that channel performance depends strongly on contact configuration, return path, and receiver impedance. The next step is to refine the high-impedance receiver and validate repeatable modulated transmission under more realistic conditions.

References:

- [1] F. Wollig, F. Hauck and OpenIBC, *Open-Source Wake-Up Receiver for Capacitive Intra-Body Communication*, 2022. [2] M. Irfan Kazim, M. Irman Kazim and J. Jacob Wikner, *An Efficient Full-Wave Electromagnetic Analysis for Capacitive Body-Coupled Communication*, 2015. [3] V. Varga, G. Vakulya and A. Sample, *Enabling Interactive Infrastructure with Body Channel Communication*, 2017. [4] J. Feng Zhao, Xi Mei Chen, Bo Dong Liang and Qiu Xia Chen, *A Review on Human Body Communication: Signal Propagation Model, Communication Performance and Experimental Issues*, 2017.

Study on the Modeling and Educational Integration of Aramid Fibers (Kevlar) via an Interactive 3D Platform

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1. INTRODUCTION

Poly(para-phenyleneterephthalamide) (PPTA), known commercially as Kevlar by DuPont, is a major achievement in polymer chemistry. Discovered in 1965 by Stephanie Kwolek, it consists of rigid aromatic chains linked by amide bonds with very high chain orientation and crystallinity. Strong inter-chain hydrogen bonds give the material extremely high tensile strength at low density, along with high thermal stability and a Limiting Oxygen Index of 28–30%. Although widely used in ballistic armor, aerospace protection (such as on the International Space Station), firefighter gear, and Formula One composites, the molecular basis of Kevlar's performance is rarely clear to students. This project addresses that gap by combining laboratory experiments with a bilingual interactive 3D platform that visualizes PPTA structure, simulates ballistic behavior, and displays experimental data in real time.

2. AIMS

The main experimental goal is to analyze the mechanical, thermal, and ballistic properties of Kevlar K-29 through four laboratory tests: perforation resistance, shear resistance, an LOI flame test, and tensile modulus measurement. The results are then compared with nylon 6,6, cotton, and structural steel under identical conditions. A secondary goal is to integrate these results into an open-access interactive 3D web platform, allowing students and researchers to explore PPTA molecular structure, energy dissipation mechanisms, and comparative material data through real-time WebGL visualizations and bilingual (Romanian/English) experiment galleries.

3. METHODS AND MATERIALS

Kevlar fabric (180 g/m², plain 2×2, Ø 12 µm) and threads (180 mm) were tested. Four setups were utilized: (1) Perforation: calibrated indenters (50–100 g) on 3-layer fabric, where depth and radial distribution were measured. (2) Shear: cutter blade vs. Kevlar, nylon, and cotton strips, with passes to failure recorded. (3) LOI flame: lighter (900–1100°C, 3–5 s), where ignition and carbonization were observed. (4) Tensile modulus: weights (20–100 g) placed at the thread midpoint. For setup (4), the mechanical parameters were calculated as follows:

$$T = G / (2 \cdot \sin \theta) \quad (1)$$

$$\sigma = T / A \quad (2)$$

$$E = \sigma / \epsilon \quad (3)$$

where T is tension, G is weight, θ is the deflection angle, σ is stress, A is the cross-sectional area, E is the tensile modulus, and ϵ is strain.

4. RESULTS

Key results: indentation <2 mm, 97% radial force distribution, zero fiber rupture (Exp. 1); 8–12× more cutter passes than nylon 6,6 with longitudinal fibrillation (Exp. 2); no ignition, LOI = 28–30%, only superficial char vs. nylon melt at 250°C and immediate cotton ignition (Exp. 3); $E \approx 78$ GPa with full elastic recovery at all loads (Exp. 4). Table 1 summarizes the multi-material comparison.

Table 1. Mechanical properties and specific strength comparison.

Material	σ (MPa)	ρ (g/cm ³)	σ/ρ (kN·m/kg)
Kevlar 29	3620	1.44	2514
Nylon 6,6	1120	1.15	974
Steel St37	400	7.85	51
Aluminum	310	2.70	115

5. DISCUSSION

The macroscopic behavior observed in all experiments is directly linked to the molecular structure of PPTA. Strong hydrogen bonds between chains spread energy across the fabric during impact, preventing local rupture. Shear tests show fibrillation, confirming strong axial strength from covalent bonds but weaker lateral forces. The lack of melting and direct carbonization reflect the rigid aromatic backbone. Although the measured tensile modulus differs slightly from ideal values due to inter-fiber friction, the elastic behavior still reflects strong axial chain orientation. These structure–property relationships highlight the educational value of the 3D platform, which makes molecular mechanisms easier to understand.

6. CONCLUSIONS

All experiments confirm Kevlar's performance originates from its crystalline PPTA architecture: specific strength 2,514 kN·m/kg (49× steel); 97% radial energy dissipation; LOI = 28–30% with direct carbonization; shear resistance 8–12× nylon 6,6; $E \approx 78$ GPa. The interactive 3D platform extends these scientific findings into an accessible educational tool, integrating real lab data with real-time molecular visualization.

7. ACKNOWLEDGEMENT

The authors thank Prof. Mihaela Garabet for scientific guidance throughout this project.

8. REFERENCES

- [1] S. L. Kwolek, US Pat. 3,287,323, DuPont, 1965.
- [2] P. M. Cunniff, *Textile Res. J.*, 55(5), 283–291, 1985.
- [3] M. Grujicic et al., *J. Mat. Sci.*, 38(4), 3949–3964, 2003.
- [4] H. H. Yang, *Kevlar Aramid Fiber*, Woodhead, 1993.
- [5] NIJ Std. 0101.06, US DoJ, 2008.
- [6] DuPont™, Kevlar Tech. Guide TG-101-23, 2022.

The Design and Development of a Low-Cost UV-Vis Spectrophotometer Using a Microcontroller for Light Absorption Analysis

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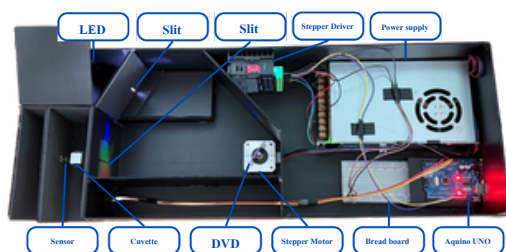
1. Introduction

UV-Vis spectrophotometers are widely used in chemical analysis, but commercial instruments are expensive and not easily accessible. Many low-cost alternatives also lack sufficient accuracy. To address this gap, this work develops a low-cost spectrophotometer using simple components such as an LED light source and a DVD diffraction grating. This approach provides a more accessible system while maintaining acceptable performance for educational and basic analytical applications.

2. Aims

To design and develop a low-cost UV-Vis spectrophotometer and evaluate the performance of the developed UV-Vis spectrophotometer.

3. Format



In this chapter, the measuring setup and experimental procedures are described. The device was constructed using an Arduino UNO, LED light source, DVD as a diffraction grating, slit, cuvette, light sensor, and stepper motor. All components were placed in a black box to reduce external light interference.

The optical path is:

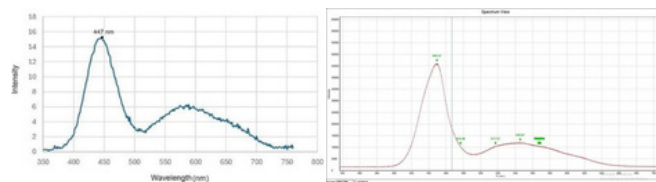
LED → slit → DVD → slit → cuvette → sensor

The Arduino controls the system and sends data to a computer for analysis. To evaluate performance, three experiments were conducted. First, the LED spectrum (350–760 nm) was measured and compared with a

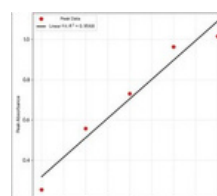
commercial spectrophotometer. Second, Methylene Blue solutions (2–10 ppm) were used to study the relationship between absorbance and concentration. Third, Bromothymol Blue

was used with acidic, neutral, and basic solutions (HCl, H_3PO_4 , NaOH, and NH_3) to observe absorbance changes and identify peak wavelengths.

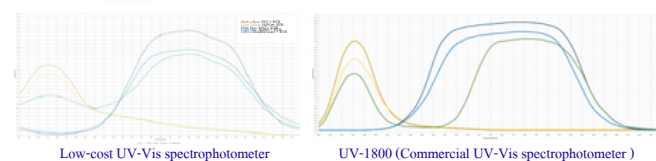
4. Results



Experiment1 (LED Spectrum): The device measured the LED peak at 447 nm, closely matching 449.32 nm from the commercial BroLight spectrometer, with only 0.52% error, confirming good wavelength accuracy.



Experiment2 (Calibration): Methylene Blue solutions (2–10 ppm) measured at the peak wavelength (~660–665 nm) showed a linear relationship between absorbance and concentration ($R^2 \approx 0.96$), consistent with the Beer–Lambert law.



Experiment3 (Real Sample): Bromothymol Blue showed distinct spectra for acidic, neutral, and basic solutions, with peak shifts corresponding to pH. The results followed a similar trend to a commercial spectrophotometer.

5. Discussion

The results follow the Beer–Lambert law, showing a linear relationship between absorbance and concentration. Minor noise and deviations were observed due to system limitations, but overall trends match reference data, indicating reliable performance.

6. Conclusion

The developed low-cost spectrophotometer showed reliable performance with low wavelength error (0.52%) and near-linear calibration ($R^2 \approx 0.96$). It can effectively distinguish acidic, neutral, and basic solutions, demonstrating its suitability for basic chemical analysis.

7. ACKNOWLEDGEMENT

We would like to express our sincere gratitude to our project advisor and special advisors for their valuable guidance and support. We also thank the IPST and DPSTE programs for providing resources and facilities. Finally, we are deeply grateful to our families for their continuous support and encouragement.

8. References

- [1] Daniel R. Albert, et al., "Development of a Low-Cost Quantitative Absorption Spectrophotometer," *Journal of Chemical Education*, Vol. 89, No. 11, pp. 1432–1435, 2012.
- [2] David C. Christodouleas, et al., "Portable, Low-Cost UV–Vis Spectrophotometer for the Detection of Mercuric Ions," *Sensors and Actuators B: Chemical*, Vol. 282, pp. 398–405, 2020.

Age Group	Number of People
18-24	10
25-34	20
35-44	15
45-54	25

New environmentally friendly biopreparation creation for the control of agricultural plant's fusariosis

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Educational Institution "National Children's Technopark", Republic of Belarus

1. INTRODUCTION

Fusarium fungi are among the most harmful plant pathogens. Their harmfulness is caused by direct losses due to reduced yields and indirect losses due to mycotoxin contamination of the resulting product and reduced grain quality. Chemical fungicides have significant limitations: the development of pathogen resistance, environmental toxicity, accumulation in the soil, and negative impacts on the microbiota. Therefore, the use of chemicals should be measured. Biopreparations based on antagonistic bacteria are used as more environmentally friendly and safer alternatives. The bacteria that form the basis of these biopreparations suppress Fusarium pathogens through competition, the production of antimicrobial substances, and stimulation of plant resistance, while being safe for humans and the environment. Their main advantage lies in their preventive use, the ability to restore soil health, and the reduction of pathogens in plant residues. Thus, in our time, the search for environmentally safe and effective biological products that suppress the pathogens of fusarium in various agricultural crops is relevant [1 2].

2. AIMS

The aim of the work: to isolate effective bacteria-antagonists of phytopathogenic fungi of the genus Fusarium and to create a prototype of an environmentally friendly biopreparation for agriculture.

3. METHODS AND MATERIALS

The work used classical methods of phytopathology and microbiology and botany [3].

4. RESULTS AND DISCUSSION

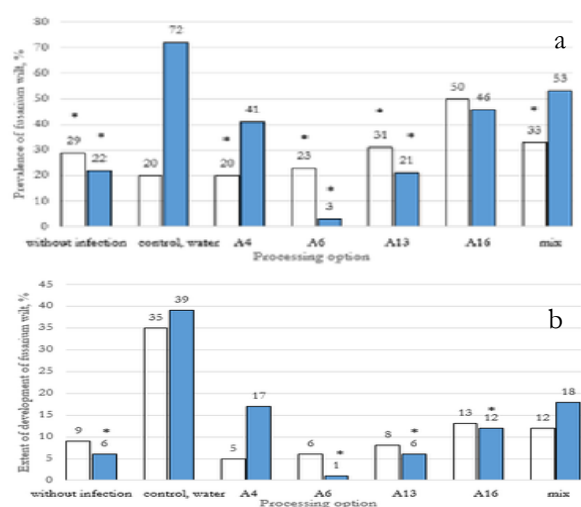
27 isolates of antagonist bacteria were isolated from natural sources, nine of which were phytopathogenic. It was established that the isolated non-phytopathogenic antagonist bacteria possessed a range of (physiologically beneficial properties mobilization, nitrogen fixation and phytohormones synthesis).

The antifungal activity of the bacteria phytopathogenic fungi of the genus Fusarium was studied. The highest antifungal activity in the experiment was noted: against Fusarium sp.-apple (Fa) in isolates A13 (mycelial growth inhibition by 42%) and A16 (inhibition level is 39%), against Fusarium sp.-blueberry (Fb) in isolates F10 (inhibition level is 42%) and A4 (mycelial growth inhibition by 40%); Isolate A16 demonstrated 20% inhibition of mycelial growth against F. culmorum (Fc).

Isolates A4, A6, A13, and A16 demonstrated the ability to inhibit sporulation in all studied Fusarium fungi: isolates A4, A13, and A16 by 98-100%; isolate A6 by 17-88%.

Isolates A4, A6, A13, and A16 didn't exhibit mutual antagonism and could be co-cultivated. A prototype of a complex phytoprotective biopreparation was created based on isolates A4, A6, A13, and A16.

An experiment on rye plants of the 'Pavlinka' variety demonstrated phytoprotective properties against Fb in all isolated bacterial isolates and their mixture. A significant reduction in the incidence of fusarium wilt in shoots by 37%-50% compared to the control was demonstrated when treated with isolates A4, A6, and A13 and a mixture of isolates (A4, A6, A13, and A16), as well as a 70-52% reduction in fusarium wilt in root crops treated with bacteria A6 and A13. A significant reduction in the incidence of fusarium wilt in rye plants was demonstrated when treated with antagonist bacteria A6, A13, and A16 by 38-27% [Figure]. The antagonist isolate A6 was the most active against fusarium wilt caused by Fb.



* - the difference with the control is significant at $p \leq 0.05$

Figure Prevalence (a) and extent of development (b) of fusarium wilt caused by Fb in shoots - □ and roots - ■ of rye plants when exposed to the isolated bacterial isolates.

5. CONCLUSIONS

Of collection of non-phytopathogenic isolates antagonist bacteria A4, A6, A13, and A16 has been created. Four effective isolates of bacteria antagonizing phytopathogenic Fusarium fungi are a prototype of an environmentally friendly biopreparation for agriculture "Bactoprotector".

6. ACNOWLEDGEMENT

We express our gratitude to our scientific supervisors – employees of E.I. "National Children's Technopark" Feklistava I.N., Grineva I.A., Maslak D.V.

7. REFERENCES

1. The growth, development and infection process of the plant pathogen Fusarium / Liz Z. [et al.] // Plant Signal Behav.- 2025. – Vol. P. 2573097.
2. Managing Soil Microorganisms to Productivity of Agro-Ecosystems / G. Welbaum [et al.] // Crit. Rev. Plant Sci. – 2004. – T. 23 – C. 175-193.
3. Zheldakova R. A., Myamin V. E. "Phytopathogenic microorganisms: Textbook and methodological complex for students of the biological faculty specializing in G - 31 01 01 "Biology"" – Minsk: BSU, 2006. – 116 p.

Creation of a photosorption-catalytic installation for air purification from harmful odorous gases and microorganisms at agricultural enterprises

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1. INTRODUCTION

Agricultural activities are a major source of air pollutant emissions, which have a significant impact on the health of not only the animals themselves, but also the workers at agricultural enterprises, as well as on the environment itself. All this underscores the need to use effective methods for cleaning the air of harmful substances. This could improve animal housing conditions, which could positively affect the quality of agricultural products [1]. During the work, a photosorption-catalytic unit was developed. It includes: a sorption unit filled with a renewable sorbent called cupramite; a photocatalytic unit containing UV-lamps and a layer of titanium dioxide; solar panels as an alternative energy source. In future, this unit could be enhanced with an additional electrocatalytic module, where the absorbed carbon dioxide could be converted into urea. The resulting urea could then be used as a fertilizer.

2. AIMS

Modeling

using a photosorption-catalytic installation different sorbents to purify air from harmful odorous gases and microorganisms at agricultural enterprises.

3. METHODS AND MATERIALS

First, thermally expanded graphite was synthesized from birch bark using the sulfuric acid method in the presence of the oxidizing agent NH_4NO_3 . This material was then modified by treatment with a copper sulfate solution to obtain a more selective sorbent form, specific to the adsorption of ammonia and hydrogen sulfide. This sorbent is called cupramite. The study of the absorbing capacity of the modified Cupramite was carried out using a gas volume sensor with temperature control. Air contaminated with ammonia passed through the sorbent and became saturated; then the desorption process was carried out and the volume of the adsorbed gas was measured. The concentration of NH_3 was calculated using the equation:

$$C_{\text{NH}_3} = \frac{V_{\text{NH}_3} \cdot P}{R \cdot T \cdot V_{\text{flask}}}$$

where: V_{NH_3} — the volume of NH_3 absorbed by the sorbent; P — gas pressure; T — temperature; R — the universal gas constant; V_{flask} — the volume of the initial flask containing the sorbent.

Next, the degree of air purification was investigated as the air passed through a simulated installation. Acetone and ammonia were used as air pollutants for the study. The concentration of the absorbed gases was assessed

titrimetrically. Ammonia was absorbed by a 0,1 M sulfuric acid solution, and the excess acid was titrated with 0,1 M NaOH.

The amount of ammonia was calculated using the formula:

$$n(\text{NH}_3) = \frac{C(\text{H}_2\text{SO}_4)_{\text{initial}} \cdot V(\text{H}_2\text{SO}_4)_{\text{initial}} - C(\text{NaOH}) \cdot V(\text{NaOH}) \cdot 0,5}{f_{\text{eq}}(\text{H}_2\text{SO}_4)}$$

where: $C(\text{H}_2\text{SO}_4)_{\text{initial}}$ — concentration of the initial H_2SO_4 solution; $V(\text{H}_2\text{SO}_4)_{\text{initial}}$ — initial volume of the H_2SO_4 solution; $C(\text{NaOH})$ — concentration of the NaOH solution used for titration; $V(\text{NaOH})$ — volume of the NaOH solution consumed during titration; $f_{\text{eq}}(\text{H}_2\text{SO}_4)$ — equivalence factor of H_2SO_4 in the reaction with ammonia.

4. RESULTS AND DISCUSSION

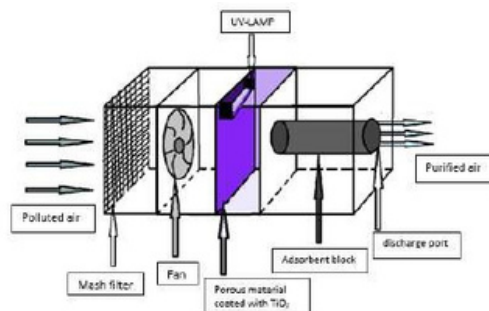


Figure 1 - Model of a photosorption-catalytic air purification unit

Table 1. - Analysis of ammonia adsorption by Cupramite.

	Volume of absorbed NH_3 , m ³	Pressure by NH_3 , kPa created	Concentration of NH_3 in the flask, mol/L
1	271	119,9	0,052
2	273	120,8	0,053
3	272	120,3	0,053
Average	272	120,3	0,0527

Table 2. – NH_3 content in polluted air (before/after Cupramite sorbent)

	$V(\text{NH}_3)$, ml	$n(\text{NH}_3)$, mol
without sorbent	19,76	0,024
with sorbent		

5. CONCLUSIONS

The ammonia adsorption capacity of Cupramite was 54,4 mg/g, and the carbon dioxide adsorption capacity was 44,5 mg/g. Based on the obtained sorbent, photosorption-catalytic unit was developed, consisting of several functional blocks [2]. The air purification efficiency of the unit for ammonia vapors was 82,1%, and for acetone vapors — 56%.

6. REFERENCES

1. Kuleshov, A. N. Problema ochistki i obezzarazhivaniya vozdukh, analiz sushchestvuyushchikh apparatov ochistki retsirkulyatsionnogo vozdukh v zhivotnovodstve // Mir Innovatsiy [World of Innovations]. 2018. No. 2. P. 38–43.
2. Pershin, A. A., & Starkov, M. V. (2003, March 16). Adsorption-photocatalytic device for air purification from volatile pollutants (Patent No. 33035, Russian Federation).

Stratfish: Use of Sludge from Excavated Tanks Combined with Commercial Substrate for Vegetable Cultivation

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1. INTRODUCTION

In Paraná, tilapia farming is carried out almost entirely in excavated tanks. This process generates waste (sludge), which consists of residual organic matter produced throughout the production cycle, such as fish feces, uneaten feed, dead fish, and plankton. This sludge must be removed periodically in order to prevent the potential eutrophication of the water and an increase in its acidity (AYROZA, 2009).

The sludge from excavated tanks (SET) contains a large amount of microorganisms and is rich in macronutrients (nitrogen, phosphorus, and potassium) as well as organic carbon. Because of this composition, the organic residues generated by this production system may be used in the manufacturing of organic fertilizers and applied as a soil conditioner, reducing environmental impact while also adding value to this environmental liability (SILVA et al., 2017).

Since there is often no proper destination for this sludge, producers generally remove it and dispose of it directly on the soil, leaving it exposed to sun and rain, which leads to environmental contamination. This has become a major challenge for fish farmers: ensuring the proper disposal of sludge from excavated tanks (SET).

However, its direct application to the soil, as occurs with other types of animal production waste (poultry, cattle, or swine manure), is not recommended due to the risk of leaching caused by rainfall, which may contaminate groundwater, the presence of pathogenic agents, and the high risk of soil compaction resulting from the clay content in the material. Therefore, it is necessary to implement treatments that promote the stabilization of the biosolid and facilitate both handling and the proper use of SET (SCHMITZ, 2002).

Addressing this issue will generate benefits for fish farmers, who will be able to comply with the current National Solid Waste Policy, promoting reuse and added value to solid residues and resulting in environmental gains when compared to the use of raw, untreated waste (JUNEK et al., 2014).

2. AIMS

To develop an organic substrate based on sludge from excavated fish tanks for vegetable cultivation, in combination with different organic and mineral materials. The use of sludge from excavated tanks in combination with different organic and mineral materials will make its application as a substrate for vegetable cultivation

feasible, reducing problems related to leaching and soil compaction.

3. METHODS AND MATERIALS

The experiment is being carried out in the experimental garden at Phoenix School, located in the municipality of Cascavel, Paraná State, at the geographic coordinates 24°43'44.0"S 53°45'37.1"W, and has been underway since March 1st, 2023.

3.1 Collection

The sludge from excavated tanks (SEP) used in this study was provided by a fish farmer who raises Nile tilapia in the city of Cascavel, in the western region of Paraná.

The residues were collected on 03/01/2023, between 10:00 a.m. and 11:00 a.m., with ambient temperature around 28°C. The sample was collected using a shovel, at an average depth of 10 cm from the sludge layer at the bottom of the pond, at six different sampling points. Strategic locations were considered, such as the areas where the aerators were installed (Figure 1(a)) and the water outlet (Figure 1(b)).



(a)



(b)

Figure 1. Collection of sludge from excavated tanks (SET) at different sampling points: (a) areas located near the aerators; (b) water outlet area. Source: Author's own work.

To what extent do dietary supplements influence catalase activity

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BACKGROUND AND INFORMATION

Catalase is an important enzyme that protects cells from oxidative stress by decomposing hydrogen peroxide (H_2O_2) into water and oxygen. Many dietary supplements contain metal ions such as iron, magnesium, zinc or calcium, which can interact with proteins and potentially influence enzyme activity. Understanding these interactions is important because catalase plays a key role in cellular antioxidant defense.

AIMS

The aim of this project was to investigate to what extent dietary supplements influence catalase activity and whether different metal ions affect the reaction rate of the enzyme

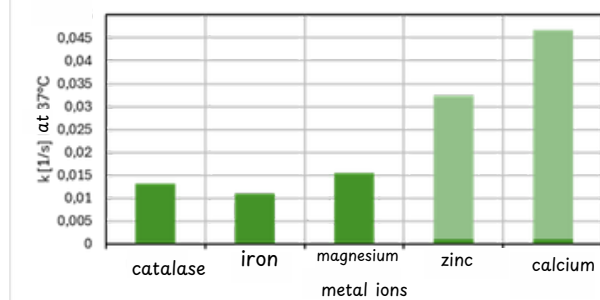
METHODS AND MATERIALS

Catalase activity was determined by measuring the oxygen released during the decomposition of hydrogen peroxide. The experiment used a closed reaction system connected to a water displacement apparatus placed on a digital balance. During the reaction, the produced oxygen displaced water from a reservoir. The mass of the displaced water was measured and used to calculate the amount of produced oxygen. Experiments were performed using dietary supplements containing different metal ions (iron, magnesium, zinc and calcium). Additional measurements were conducted at different temperatures (35 °C, 37 °C and 40 °C) and with and without buffer solution to analyze further influences on enzyme activity

RESULTS AND DISCUSSION

The experiments showed that dietary supplements containing different metal ions influence catalase activity to varying degrees. Zinc and iron significantly reduced the reaction rate, indicating a strong inhibitory effect on the enzyme. This suggests that certain metal ions can interact with the active center of catalase or bind to functional groups of the protein, which may lead to structural changes that reduce the efficiency of the catalytic process. Such interactions between metal ions and enzymes are well known in biochemical systems, where metal ions can act either as cofactors or as inhibitors depending on their concentration and binding properties. In this experiment, the observed decrease in reaction rate for zinc and iron suggests that these ions may partially block the catalytic site or destabilize the enzyme structure. As a result, the decomposition of hydrogen peroxide into water and oxygen occurs more slowly. These findings indicate that the presence of specific metal ions in dietary supplements can influence enzymatic antioxidant systems and therefore may affect the efficiency of catalase in protecting cells from oxidative stress.

value of k ions



influence of different metal ions on catalase activity

Magnesium, in contrast, showed only minor effects on catalase activity, indicating that not all metal ions interact strongly with the enzyme. Calcium produced a two-phase reaction pattern with an initially increased reaction rate followed by a decrease in activity, which may be explained by temporary stabilization of the enzyme structure before inhibitory interactions occur. Temperature variations also affected the reaction rate of catalase, consistent with the known temperature dependence of enzyme-catalyzed reactions. Overall, the results show that metal ions present in dietary supplements can influence catalase activity and may affect cellular antioxidant defense mechanisms.

CONCLUSION

The results of this project demonstrate that dietary supplements containing metal ions can influence the catalytic activity of catalase. Zinc and iron showed strong inhibitory effects on the enzyme, while magnesium had only minor influence. Calcium caused a more complex reaction behaviour with an initially increased reaction rate followed by a decrease in activity. These findings indicate that interactions between metal ions and enzymes can significantly affect biochemical reactions and should be considered when evaluating the effects of dietary supplements.

ACKNOWLEDGEMENTS

I would like to thank my supervisors Bernhard Horlacher and Jo Becker for their valuable support and guidance during this project. I also thank the Kepler-Seminar for providing the opportunity and resources to conduct this research.

REFERENCES

- Chelikani, P., Fita, I., & Loewen, P. C. (2004). Diversity of structures and properties among catalases. Cellular and Molecular Life Sciences.
- LibreTexts Biochemistry. Enzyme Kinetics. Available at: <https://chem.libretexts.org>
- Wanders, R. J. A. Peroxisomes and oxidative stress. SpringerLink.

“Attachment not permitted!” – Colonization Experiments on the Quagga Mussel

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1. INTRODUCTION

The invasive quagga mussel (*Dreissena rostriformis*), native to some tributaries of the Black Sea and first detected in Lake Constance in 2016, has since colonized extensive areas of the lakebed and infrastructure. Lake Constance, the largest lake in Germany and an important drinking water reservoir for more than four million people, has experienced colonies in drinking water pipes, cooling systems of boat engines and on boat hulls, causing substantial economic damage¹. The species is also an introduced non-native species in North America and other European waters, where it has similarly caused ecological and economic impacts.

2. AIMS

The objective of our project has been to identify non-toxic surfaces or substrates on which quagga mussels are unable or less able to settle.

3. METHODS AND MATERIALS

Self-designed structures made from aluminum equipped with each a fourfold set of various substrate materials were deployed at two different locations in Lake Constance. Copper and granite served as the negative and positive controls, respectively, and three anti-adhesive coatings (DURAPEK®, DURAQUARZ®, Teflon) were included as substrate materials. For a double set of substrates in each structure predator access to the substrates was prevented by a metal mesh (Figure 1). Repeated visual inspections were conducted using an underwater drone. After retrieving the structures at the end of the experimental period (after two months, Figure 2), the mussel density was estimated by dividing the total mussel mass per substrate by the mean mass of an individual mussel. Mussel attachment strength to the respective substrates was measured using a digital force gauge. All results were analyzed statistically.



Figure 1: Structures with 4 sets of substrates



Figure 2: Retrieved structures

4. RESULTS AND DISCUSSION

Our findings clearly demonstrate that quagga mussels can rapidly colonize a variety of substrates and surface types, other than copper, at high densities via free-swimming larvae.

Even surfaces with pronounced anti-adhesive properties are colonized by larvae. We have found no strong evidence for a currently significant reduction in mussel population due to predation (Figure 3).

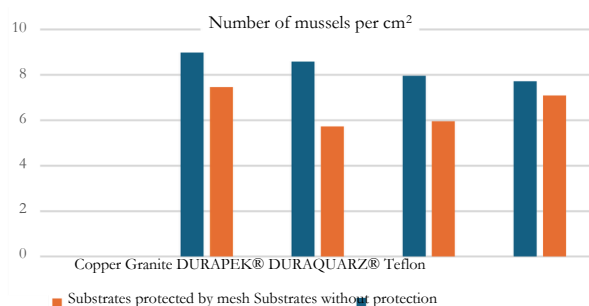


Figure 3: Density of mussels on various substrates

However, force measurements show that mussels which have settled via larval stages can be mechanically removed more easily from certain substrates, particularly from the novel pan coating DURAPEK® (Figure 4).

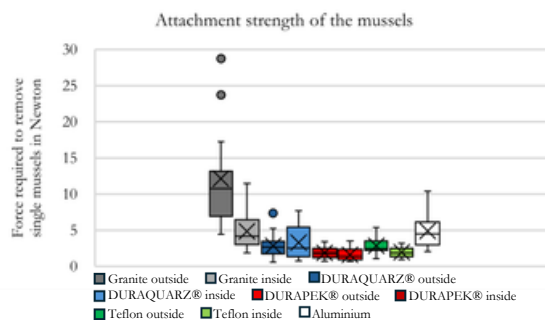


Figure 4: Attachment strength of the mussels on various substrates

5. CONCLUSIONS

In the future, materials such as DURAPEK® could potentially be applied to affected areas, for example the interior surfaces of pipelines, to substantially reduce maintenance costs.

6. ACKNOWLEDGEMENTS

I would like to thank the Students' Research Center Friedrichshafen, all members of the Quagga team, and my supervisor, Mr. Christian Heide, for their support.

7. REFERENCES

[1] <https://www.swr.de/swraktuell/baden-wuerttemberg/friedrichshafen/quagga-muschel-im-bodensee-breitet-sich-aus-100.html>

Enhancing Anodic Reaction Selectivity in Seawater Electrolysis Systems

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1. INTRODUCTION

Hydrogen is a recognized clean and versatile energy source sourced from renewable resources known to be a fossil fuel alternative. The electrolysis of seawater powered by renewable energy serves as a potential pathway for sustainable hydrogen production. 97% of Earth's water is seawater and Guam is an island surrounded by oceans on all sides, making direct seawater electrolysis an appealing alternative energy source for Guam. An obstacle to directly electrolyzing seawater is the presence of chloride ions (Cl^-). In seawater electrolysis systems, chloride oxidation competes with the oxygen evolution

reaction (OER) causing the formation of chlorine gas (Cl_2) along with hypochlorite. Chlorine evolution has been proven to reduce hydrogen production efficiency, introduce safety hazards, and increase anode corrosion. Therefore, seawater electrolysis research focuses on increasing OER selectivity. A comparative investigation into two strategies was conducted in this study to assess factors influencing chlorine evolution: (1) operation under alkaline conditions and (2) the use of a copper anode. Performance was evaluated by reacting the produced chlorine gas with potassium iodide and back-titrating the product with sodium thiosulfate to quantitatively measure through stoichiometry how much chlorine gas was produced.

2. AIMS

The challenges associated with direct seawater electrolysis arise from its complex ionic composition. A key issue is the presence of chloride ions, which are oxidized at the anode via the chlorine evolution reaction (CER). This reaction competes with the desired oxygen evolution reaction (OER), producing chlorine gas, reducing efficiency, and introducing safety concerns (Ghaffar et al.). To investigate chlorine evolution, a custom acrylic electrochemical cell was constructed with a filter paper membrane separating the anode and cathode compartments to allow ionic conduction. The system was designed to capture chlorine produced at the anode by directing the gas into a potassium iodide (KI) solution, where it oxidizes iodide ions to iodine. The iodine formed was quantified via iodometric titration using sodium thiosulfate, allowing chlorine production to be determined stoichiometrically. While hydrogen gas is generated at the cathode, it was not collected or quantified, and oxygen evolution at the anode was not directly measured; therefore, the results reflect apparent chlorine production rather than complete reaction selectivity.

3. METHODS AND MATERIALS

The following materials and reagents were used: acrylic sheets, construction adhesive, silicone sealant, filter paper, copper and graphite electrodes, glass piping, a DC power supply, alligator clips, rubber stoppers, an Erlenmeyer flask, a burette, potassium iodide (KI) solution, sodium thiosulfate solution, starch indicator, sodium hydroxide, distilled water, and a seawater sample. A custom electrolysis cell was constructed from acrylic sheets and sealed to form two compartments separated by filter paper. A copper electrode and a graphite electrode were connected to a DC power supply to serve as the anode and cathode, respectively. Gas produced at the anode was directed through a glass outlet into a KI solution to capture chlorine. The cell was filled with seawater, with sodium hydroxide added for alkaline trials, and electrolysis was conducted at a constant applied voltage. Chlorine (and other oxidizing species present) reacted with iodide ions to form iodine, which was subsequently quantified by iodometric titration with sodium thiosulfate to determine apparent chlorine production.

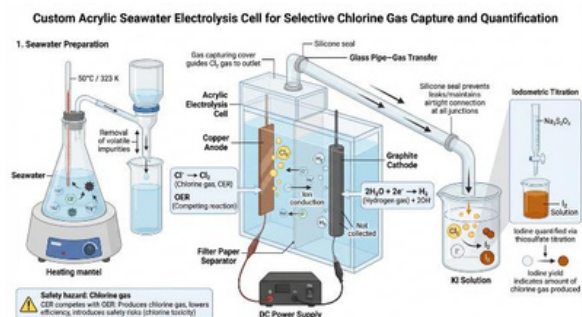


Figure 1. The Designed Electrolytic Cell

4. RESULTS

The results indicate that chlorine evolution is strongly influenced by both electrode material and electrolyte conditions. Under control conditions, the relatively low Faradaic efficiency ($\sim 29\%$) suggests that the oxygen evolution reaction (OER) dominates at the anode. In contrast, the use of a copper electrode significantly increased chlorine production, with efficiencies reaching $\sim 53\%$, indicating enhanced CER activity. However, the observed green coloration of the electrolyte confirms that copper dissolution occurred concurrently, meaning that part of the current was consumed by corrosion. Increasing the pH to alkaline conditions (pH 10) reduced efficiency to $\sim 43\%$, consistent with the greater favorability of OER at higher pH.

Table 1. Summary of Quantitative Data

Condition	Sodium Thiosulfate (mL)	Cl_2 (mol)	Cl_2 (mg)
Control	13.5	6.75×10^{-4}	48
Cu, untreated	22.9	1.15×10^{-3}	81
Cu, pH 10	19.9	9.95×10^{-4}	71

5. DISCUSSION

These findings suggest that both electrode composition and electrolyte environment play critical roles in governing anodic reaction pathways. Copper appears to promote CER, likely through changes in surface chemistry or reaction kinetics, but its instability limits practical efficiency. The reduced chlorine production in alkaline conditions supports established electrochemical theory, where OER is favored at higher pH. Because oxygen evolution was not directly measured, these results represent apparent chlorine production rather than absolute selectivity, but they remain consistent with known trends in seawater electrolysis.

6. ACKNOWLEDGEMENT

I would like to thank Mr. Gilbert Singian for his assistance in constructing the cell and the SJS Science department for materials and their support.

7. REFERENCES

- Breaking the Scaling Relationship of Oxygen Evolution Reaction and Chlorine Oxidation Reaction via MnO₂ Polymorphic Engineering for Selective Seawater Electrolysis | ACS Applied Energy Materials. <https://pubs.acs.org/doi/10.1021/acsami.4c00825>. Accessed 20 Feb. 2026.
- Chen, Meng, et al. "Recent Progress in Transition-Metal-Oxide-Based Electrocatalysts for the Oxygen Evolution Reaction in Natural Seawater Splitting: A Critical Review." eScience, vol. 3, no. 2, Apr. 2023, p. 100111. ScienceDirect. <https://doi.org/10.1016/j.esci.2023.100111>.
- Ghaffar, Soha, et al. "Challenges of Hydrogen Evolution in Seawater Electrolysis: The Role of Chlorine Evolution." Electrochemical Energy Reviews, vol. 9, no. 1, Jan. 2026, p. 2. journal.hep.com.cn. <https://doi.org/10.1007/s41918-025-00275-8>.
- Hydrogen Production from Seawater Electrolysis | Springer Nature Link. <https://link.springer.com/book/10.1007/978-3-031-73442-7>. Accessed 20 Feb. 2026.
- Moyo, Obeylaw, et al. "Advances in Corrosion-Resistant Metal-Based Oxide Electrocatalysts for Seawater Electrolysis: Focus on Chlorine Mitigation Strategies." Small [Weinheim an der Bergstrasse, Germany], vol. 21, no. 46, Nov. 2025, p. e08973. PubMed. <https://doi.org/10.1002/smll.202508973>.
- Recent Progress in Seawater Splitting Hydrogen Production Assisted by Value-Added Electrooxidation Reactions. <https://www.mdpi.com/1996-1073/18/12/3016>. Accessed 20 Feb. 2026.

Infrared Spectroscopic Analysis of Solid-Phase Carbonic Acid

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1. INTRODUCTION

Carbonic acid (H_2CO_3) is commonly known as a short-lived species in aqueous solutions on Earth; however, recent laboratory and astronomical studies have demonstrated that it can exist in a stable solid phase under low-temperature astrochemical conditions. The investigation of such molecules is essential for understanding chemical processes occurring in interstellar ices, dense molecular clouds, and icy Solar System bodies. Infrared (IR) spectroscopy provides a powerful tool for identifying molecules in these environments due to its sensitivity to molecular vibrational modes. Laboratory-based IR spectroscopic measurements are therefore crucial for interpreting astronomical observations and for building reliable astrochemical models.

2. AIMS

The aim of this research was to investigate the formation, stability, and spectroscopic characteristics of carbonic acid in solid and gas phases under astrophysically relevant conditions. The study sought to determine whether carbonic acid remains stable during sublimation and whether it can be detected in the gas phase, thereby supporting recent astronomical observations and contributing reliable laboratory reference data.

3. METHODS AND MATERIALS

Experiments were carried out using the VIZSLA (Versatile Ice Zigzag Sublimation Setup for Laboratory Astrochemistry) ultra-high-vacuum simulation chamber. An ice mixture of carbon dioxide and water in a 3.5:1 ratio was deposited onto a gold-coated silver substrate at 10 K. The samples were irradiated with 5 keV electrons to simulate cosmic radiation, and chemical changes were monitored using Fourier-transform infrared (FTIR) spectroscopy. Temperature-programmed desorption (TPD) experiments were also performed, these are done by heating the sample from 10 K to 300 K at a rate of 1 K/min. In selected experiments, sublimated species were recondensed onto a secondary cold substrate and analyzed using argon matrix isolation.

4. RESULTS

Electron irradiation of the $\text{CO}_2\text{-H}_2\text{O}$ ice mixture resulted in the appearance of new absorption bands in the IR spectrum. These bands were assigned to carbonic acid, carbon monoxide, carbon trioxide, and ozone. Difference

spectra clearly showed the formation of carbonic acid, with characteristic absorption features at 1724, 1480, and 1290 cm^{-1} . During TPD experiments, volatile precursor species sublimated below 200 K, while carbonic acid ice remained stable up to 260–280 K. Matrix-isolation measurements revealed the presence of both cis–cis and cis–trans conformers of carbonic acid, confirming that the molecule remains stable during sublimation and exists temporarily in the gas phase.

5. DISCUSSION

The results demonstrate that carbonic acid can form efficiently in irradiated astrophysical ice analogues and remain stable at elevated temperatures compared to its precursors. The detection of gas-phase carbonic acid during sublimation supports recent astronomical findings and confirms that laboratory IR spectra can serve as reliable references for space-based observations. These findings have implications for understanding chemical evolution in interstellar ices and on icy planetary bodies.

6. CONCLUSIONS

This study provides experimental evidence for the formation and stability of carbonic acid under simulated astrochemical conditions. The obtained infrared spectra and thermal behavior data contribute to the identification of carbonic acid in astronomical environments and improve our understanding of carbon chemistry in space.

7. ACKNOWLEDGEMENT

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8. REFERENCES

<https://doi.org/10.1016/j.cplett.2007.10.094>
<https://doi.org/10.3847/1538-4357/ace523>
<https://doi.org/10.1002/cphc.202500282>
<https://elo.hu/ir-spectroscopy-az-infravoros-spektroszkopia-modszere/>
<https://aip.scitation.org/doi/10.1063/5.0061762>

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1.INTRODUCTION

The rapid expansion of the textile industry has led to the large-scale discharge of synthetic dyes into water bodies, posing severe environmental and health risks. Conventional wastewater treatment methods are often costly and inefficient in degrading complex dye molecules. Biological approaches, particularly fungal bioremediation, have emerged as sustainable alternatives due to their ability to enzymatically degrade pollutants. *Pleurotus ostreatus*, a white-rot fungus, is known for producing ligninolytic enzymes such as laccase and peroxidase, which can effectively break down dye structures. This study explores an innovative, low-cost approach using denim-grown fungal biomass immobilized on calcium alginate beads to simulate real-world bio-carrier systems.

2.AIMS

To study the effect of time and fungal biomass quantity on the removal of textile dye using denim-grown fungal biomass attached to alginate beads.

3.METHODS AND MATERIALS

[1] MATERIALS :

Denim fabric, *Pleurotus ostreatus* spawn, sodium alginate, calcium chloride (CaCl_2), synthetic dye, distilled water, incubation containers, weighing balance, stirrer, dropper/pipette, white background, and a mobile camera.

[2] PROCEDURE :

Denim fabric was cut into uniform pieces (1-2 cm), washed thoroughly, and boiled for 15-20 minutes to remove impurities. The material was then cooled to room temperature. The prepared denim was inoculated with *Pleurotus ostreatus* spawn and incubated at 25-28°C for 7-10 days until complete mycelial colonization was observed. The colonized denim was processed into a semi-homogeneous slurry using distilled water. The biomass was then quantitatively divided into : low (1g), medium (3g) and high (5g)

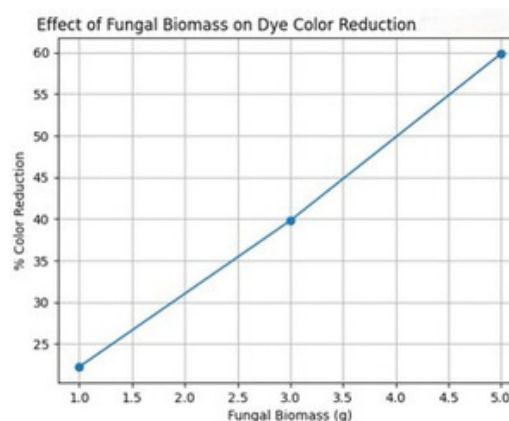
A 1% (w/v) sodium alginate solution was prepared and allowed to stand to remove air bubbles. A calcium chloride solution (1-2 g in 100 mL distilled water) was also prepared. The alginate solution was added dropwise into the CaCl_2 solution, forming spherical gel beads via ionic cross-linking. The prepared alginate beads were immersed in the fungal slurry for 2-3 hours, allowing adsorption of fungal biomass onto the bead surface. Dye solution with fixed concentration was prepared and used. Color intensity was recorded using image-based analysis, where the Trigit app was used to measure RGB values for colorimetric analysis. The percentage of color reduction was determined using a standard formula comparing initial and final intensity values:

$$\% \text{ Color Reduction} = (\text{Initial Intensity} - \text{Final Intensity}) / \text{Initial Intensity} \times 100.$$

4.RESULTS

A progressive decrease in dye intensity was observed with increasing time across all experimental setups. Higher biomass concentrations demonstrated significantly enhanced decolorization efficiency compared to lower concentrations. The control setup showed negligible change, confirming the role of fungal activity. The results indicate a clear time-dependent and biomass-dependent pattern of dye removal, with maximum efficiency achieved in the high biomass condition after 72 hours.

Fungal Biomass (g)	Initial Color Intensity (0 hrs)	Final Color Intensity (72 hrs)	Color Reduction (%)
Control (0 g)	225.48	225.46	0.00
1 g	225.42	175.30	22.25
3 g	225.46	135.70	39.80
5 g	225.39	90.50	59.85



5.CONCLUSIONS

The study demonstrates that denim-grown *Pleurotus ostreatus* immobilized on calcium alginate beads is an effective, eco-friendly system for textile dye removal. The approach integrates adsorption and enzymatic degradation mechanisms, offering a scalable and cost-efficient alternative for wastewater treatment. The use of self-prepared alginate beads enhances practical applicability by mimicking industrial bio-carrier systems.

6.ACKNOWLEDGEMENT

We sincerely thank our mentors, Ms. Manya Durga and Ms. Manisha Pathak, for their guidance and continuous support throughout this project. Their insights helped us refine our approach and strengthen our understanding.

7.REFERENCE

- [1] Nagraj, P. K., Chaurasia, P. K., Bharati, S. L., Sharma, N., Kumar, J., & Sivalingam, A. M. (2025). A novel laccase from *Trametes polyzona* with high performance in the decolorization of textile dyes. *The Microbe*, Article 100232.
<https://doi.org/10.1016/j.microb.2024.100232>
- [2] Smith, J. A., & Brown, R. K. (2023). Fungal degradation of textile dyes in wastewater. *Journal of Environmental Biotechnology*, 45(2), 123–135.

Pine Needle Valorisation: From Fire Hazard to Green Resource

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1. INTRODUCTION

In India, particularly across Himalayan states like Uttarakhand, the seasonal accumulation of highly inflammable pine needles (locally known as *pirul*) is a major driver of recurrent forest fires. These fires threaten fragile mountain ecosystems, disrupt rural livelihoods, and contribute significantly to regional carbon emissions. This study presents a contextually relevant and scalable biochemical approach to transform pine needle waste into a sustainable resource for green industries. By addressing a pressing environmental challenge specific to India, the research bridges the gap between forest management and bioresource utilisation, offering a practical pathway to reduce fire risks, support local economies, and advance circular bioeconomy solutions.

2. AIMS

This study aims to develop a scalable and sustainable process for valorising pine needle biomass by optimizing concentration and temperature for efficient extraction of high-purity cellulose and lignin. The cellulose is used to produce biodegradable disposable plates, while lignin will be utilised for value-added applications, contributing to reduced forest fire risk, plastic pollution, and enhanced rural livelihoods.

3. METHODS AND MATERIALS Pine needle biomass (*Pinus roxburghii*) was subjected to an optimised alkaline hydrolysis process using NaOH under controlled thermal conditions to separate cellulose-rich solids from lignin-containing black liquor. High-purity lignin was recovered through acid precipitation using HCl and characterised using FTIR, NMR, and TGA techniques. The extracted cellulose was bleached and processed into a mouldable pulp. Starch was incorporated as a natural binder, and the starch-to-cellulose ratio was systematically optimised for mechanical strength. The resulting composite was fabricated into biodegradable disposable plates through thermal pressing.

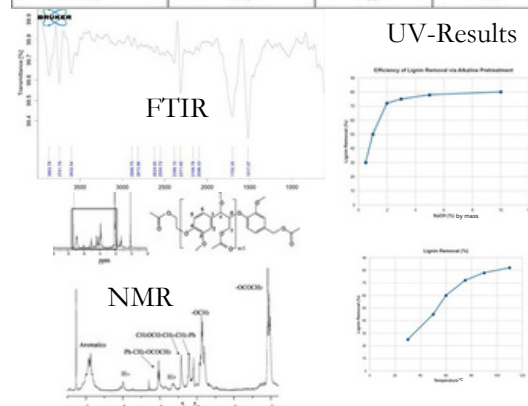
4. RESULTS

Pilot-scale validation demonstrated that the developed process is scalable and capable of achieving high extraction yields suitable for industrial application. The

Fabricated plates exhibited complete biodegradation in soil within 30–45 days, confirming their environmental compatibility. Lignin characterisation indicated its strong potential for utilisation as a bio-resin precursor in diverse industrial applications. Region-specific assessments for the Indian Himalayan belt suggest that harnessing even 50% of the annual pine needle accumulation could reduce forest fire incidence by 30–40% and lower CO₂ emissions.

Sample name: Lignin, Sample #1, 2025-11-28 17:04

nm 1	Abs 1	nm 2	Abs 2	nm 3	Abs 3	nm 4	Abs 4	nm 5	Abs 5	nm 6	Abs 6	nm
220	0.283	260	0.24	280	0.274	350	0.108	381	0.278	380	0.104	10
Baseline (nm)			Baseline abs			Min nm			Max nm			
750			-0.027			220			750			



5. CONCLUSIONS

This study presents a scalable approach that reduces forest fire risks and CO₂ emissions,

livelihoods, offering support model with broad environmental a circular bioeconomy relevance. and.

ACKNOWLEDGMENTS

We extend our deepest gratitude to Principal Mrs Minakshi Kushwaha at Birla Vidya Niketan for her invaluable guidance, technical resources, and continuous support throughout this research project.

7. REFERENCES

- [1]Bhatt, B. P., & Suthar, R. (2023). Pine needle biomass utilisation for sustainable energy and livelihood in the Himalayas. *Renewable Energy*, 209, 136-144. <https://doi.org/10.1016/j.renene.2023.02.081>
- [2] Sharma, A., & Singh, R. (2022). Lignocellulosic valorisation of Chir Pine (*Pinus roxburghii*) needles for bio-composite applications. *Journal of Cleaner Production*, 374, 133879. <https://doi.org/10.1016/j.jclepro.2022.133879>
- [3] Bisht, A., Rawat, A., & Pandey, K. K. (2023). Sustainable extraction of lignin and cellulose from pine needles for biodegradable packaging materials. *Materials Today: Proceedings*, 81, 2276-2282. <https://doi.org/10.1016/j.matpr.2022.09.201>

Colorimetric Detection of Mercury in Bengkulu City River Waters Using AgNPs Synthesized via Green Synthesis from *Citrofortunella microcarpa* Extract

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1. INTRODUCTION

Bengkulu Province, particularly the Lebong Tandai area in North Bengkulu Regency is an active gold mining region where mercury is widely used in amalgamation process. Mercury residues have caused environmental issues which can contaminate soils and river systems and be transported downstream to Bengkulu City, increasing risks to public health. Given its high toxicity and the strict 1 ppm national limit, environmental monitoring is crucial to protect locals. However, conventional methods such as AAS and ICP-MS are expensive and time consuming [1]. Therefore, this study proposes AgNPs synthesized via green method using calamansi (*Citrofortunella macrocarpa*) extract, enabling simple and low cost colorimetric detection of mercury in river water from Bengkulu City.

2. AIMS

This study was conducted to synthesize green AgNPs from calamansi extract, characterize them, evaluate their selectivity and sensitivity as a colorimetric sensor, and detect mercury levels in river water from Bengkulu City.

3. METHODS AND MATERIALS

Step 1: Green Synthesis and Characterization of Silver Nanoparticles (AgNPs)

AgNPs were prepared via green synthesis by mixing calamansi extract (5g/100ml, 80°C) with 1 mM AgNO_3 (1:9 ratio) and stirring for 15 minutes. Formation was characterized by color change and a 400-500 nm UV-Vis SPR peak [2].

Step 2: Selectivity and Sensitivity Test Against Heavy Metal Ions

Selectivity was tested by mixing 2 mL AgNPs with 1 mL of 100 ppm metals (Hg^{2+} , Pb^{2+} , Fe^{2+} , Cu^{2+} , Cd^{2+}) for 5 minutes, followed by visual and UV-Vis analysis. Sensitivity and LoD were determined from a UV-Vis calibration curve using varying Hg^{2+} concentrations.

Step 3: Analysis of Mercury Levels in River Water Samples

Mercury levels from 5 river waters from Bengkulu City (Air Bengkulu, Lemau, Selebar, Hitam, and Serut River) were determined by mixing samples with AgNPs, measuring the absorbance, and calculating concentration based on the calibration curve.

4. RESULTS AND DISCUSSION

Green Synthesis and Characterization of Silver Nanoparticles (AgNPs)

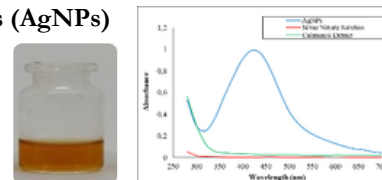


Figure 1. Formed AgNPs and UV-Vis Spectrophotometry Spectrum of AgNPs

AgNPs were successfully synthesized using calamansi, as confirmed by LSPR color change and 426 nm.

Selectivity and Sensitivity Test Against Heavy Metal Ions

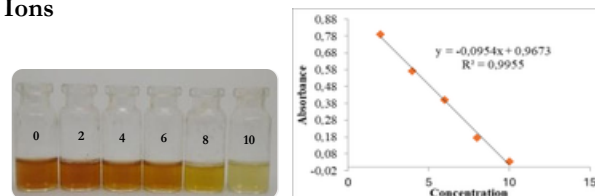


Figure 2. AgNPs Solution + Ion Hg^{2+} (0, 2, 4, 6, 8, 10 ppm) and Calibration Curve

AgNPs exhibited specific selectivity toward Hg^{2+} over other heavy metals (Pb^{2+} , Fe^{2+} , Cu^{2+} , Cd^{2+}). Higher Hg^{2+} fades the color, because increasing Hg^{2+} oxidized the AgNPs. LoD of AgNPs is 0.73 ppm.

Analysis of Mercury Levels in River Water Samples

Using a calibration curve, UV-Vis analysis of wet-digested river samples revealed Air Bengkulu (1.09 ppm) and Lemau (1.04 ppm), exceeded the 1.00 ppm limit.

5. CONCLUSIONS

AgNPs were successfully synthesized using calamansi extract, confirmed by UV-Vis at 426 nm, proved highly selective and sensitive (0.73 ppm) as a mercury sensor, and were successfully applied to Bengkulu City river water.

6. ACKNOWLEDGEMENT

Deepest thanks to CYS, Dr. dr. Tri Edhi Budhi Susilo, M.Sc., Ir. Srisetiwati Seiful, MBA for their guidance, advising teachers Edo Prasetya and Anastasia Susi Murwaningsih. And special mention to parents' support.

7. REFERENCES

- [1] Firdaus, M. I., Fitriani, J., Wyantuti, S., Hartati, Y. W., Khaydarov, R., McAlister, J. A., Obata, H., & Gamo, T. (2017). Colorimetric Detection of Mercury (II) Ion in Aqueous Solution Using Silver Nanoparticles. *Analytical Sciences*, 33(7), 831-837.
- [2] Masykuroh, A., & Nurulita, N. N. (2022). Potential of Calamansi Peel Extract (*Citrus microcarpa* Bunge) as a Bioreductor in Silver Nanoparticle Synthesis. *Bioma*, 7(1), 12-20.

Sustainable Foam - an Affordable Alternative for Car Seat Recycling

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1. INTRODUCTION

Every year, on a global level, around 27 million cars are brought in to be recycled at local scrapyards and mechanics' shops.

The recycling process includes melting the metal frame of the chairs which also burns the polyurethane foam cushioning of the seats. If it isn't burnt, PU foam is generally disposed of by throwing it away or by recycling it chemically, which is expensive and usually unavailable.

2. AIMS

The purpose of this project was to prove the feasibility of mechanical recycling of polyurethane foam. Foam including samples of new foam and sound-absorbing panels were created out of the processed material and tested.

3. METHODS AND MATERIALS

Around 4 kg of PU used for cushioning were gathered from a local mechanics' shop, cut up and milled into usable foam powder and integrated alongside whole chunks of unprocessed foam into new polyurethane foam.



Figure 1. Used PU, the milling process and foam-including samples and panels (5% and 10% by mass).

Spectrophotometric analyses were done on the processed and unprocessed foam to detect any possible atomic changes that could've occurred during the milling stage.

Diffraction analyses were also conducted to see if the molecular structure remained the same after milling.

Optical analyses of the new foams were conducted to get a general idea of the macro-structure of the foam.

Stress-tests and sound absorption tests were done to see how the different compositions changed the general properties of the foam.

4. RESULTS

Spectrophotometric results showed us that no changes in the atomic composition occurred, besides Fe residue from the milling process.

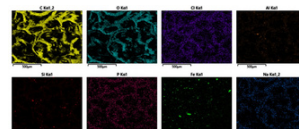


Figure 2. Spectrophotometric results of the A1 processed foam.

Diffraction results showed that no change occurred in the amorphous structure of the foam during the milling process, maintaining its elastic properties.

Stress-testing results proved that higher amounts of whole chunks and of powdered PU foam increased the resistance of the foam to applied force.

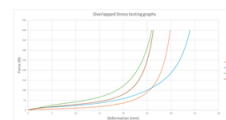


Figure 3. Stress-testing graphs, overlapped.

Sound absorption testing concluded that the inclusion of the processed material increases the material's sound dampening abilities, results increasing by about 5 decibels in sound reduction.

5. DISCUSSION

Mechanically recycled PU foam can be integrated into new polyurethane foam, which has higher compression resistance and better sound-absorption properties.

6. CONCLUSIONS

We have mechanically recycled polyurethane foam and have proved that the process does not alter the composition of the foam.

We have integrated old PU foam into new one and have created a usable product with the material - sound absorbing panels.

7. ACKNOWLEDGEMENT

Insp. Prof. PhD. Felicia Boar

Prof. Felicia Floarea

Associate Prof. PhD. Phys. Department Head Traian Marinca

8. REFERENCES

"Foam-to-Foam Recycling Potential of PU-Foams by Integration of Amino Esters" - H. Kassem, E.H. Samat, L. Imbernon & F.E. Du Prez (2024)

Year-rounding monitoring of demographic and spatial structure of the *Calanus glacialis* in the Kandalaksha Bay of the White Sea

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1. INTRODUCTIONS

The calanoid copepod *Calanus glacialis* is a typical zooplankton species of the Arctic seas. This copepod feeds on planktonic algae and serves as food for some other zooplankton species and pelagic fish, which makes *C. glacialis* an important element of the White Sea ecosystem.

2. AIMS

The purpose of this work is to supplement the data on the developmental structure and vertical distribution of the *C. glacialis* in the White Sea. This information may be important for assessing the condition of the White Sea ecosystem in a changing climate.

3. METHODS AND MATERIALS

The research was conducted at the “Arctic Circle” scientific center on the shore of Kandalaksha Bay, White Sea. We collected samples in the Velikaya Salma Strait in autumn of 2023 and all seasons of 2024, 2025 years. Samples were collected from the standard layers: 0–25, 25–50, 50–100 m, using a Juday net from a motorboat or from the ice. Samples were fixed with a 4% formalin solution and then analyzed in the laboratory using binocular microscope and Bogorov chambers. The author participated in 7 of the 15 samplings, analyzed samples in the laboratory, and performed statistical processing of the obtained data.

4. RESULTS AND DISCUSSION

C. glacialis descends to deeper waters in the fall, but does not stay there throughout the winter. In January most copepods are found at depths of 50–25 m (fig.1). Studies on the Svalbard area indicate similar situation. The authors explain it by the need for mature individuals to find a sexual partner. In February, and in spring, the migration of *C. glacialis* to the surface continues (fig.2). It is associated with the development of ice algae and phytoplankton, which serve as food for *C. glacialis*. In June, these copepod stays in the upper layers, because development of phytoplankton is maximum during this period. In August, *C. glacialis* descend to deeper waters, because the surface water becomes too warm for CIV–CVI. The main overwintering stage of *C. glacialis* in 2023–2024 was the CIV as it was noted in other studies (fig.1). In 2024–2025 the main overwintering stage was CV (fig.2). Most likely, it happens because of the warmest of previous 10 years summer of 2024. *C. glacialis* were able to accumulate more nutrients than usual and molt to the CV earlier. In the spring of 2024, the most abundant stage of *C. glacialis* was CIV. In early June, CV predominated, CI-III were also present, indicating that reproduction had occurred. At the end of June, the younger copepodite stages (I-III) prevailed. In the spring of 2025 CV was the most abundant. Most likely, it is a consequence of overwintering on CV. At the end of July, unlike in 2024 CIV predominated over CI-III. It means that reproduction of *C. glacialis* in 2025 occurred earlier than in 2024, but it was not abnormally early. In fall of 2025, as in 2024 CIV predominated, so it can be assumed that in the winter of 2026 CIV will be the main overwintering stage, which means that climate change is currently not having a serious impact on the biology of *C. glacialis*.

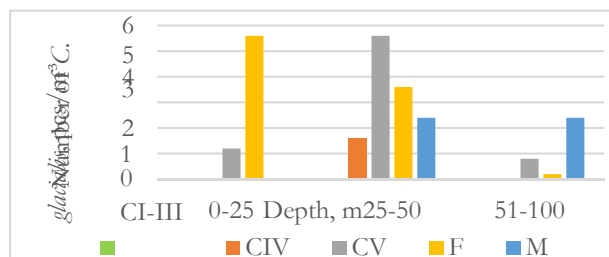


Figure 1. Demographic structure and vertical distribution of *C. glacialis* on January 10, 2025 in the Velikaya Salma Strait

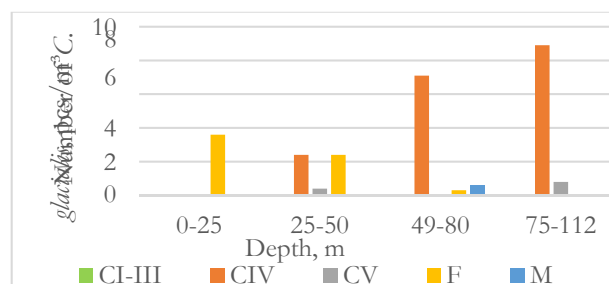


Figure 2. Demographic structure and vertical distribution of *C. glacialis* on February 24, 2024 in the Velikaya Salma Strait

5. CONCLUSIONS

- We refined the timing of *C. glacialis* seasonal migration to the surface. In White Sea this process can begin in February or even January for mature individuals. - We noted the unusual CV overwintering in winter of 2025 and predominance of this stage in spring of 2025. We attribute this to the warm summer of 2024 year. - Most likely, *C. glacialis* will overwinter in 2026 at CIV, so the 2025 anomaly is a coincidence, not a new pattern. Currently climate change does not have a serious impact on the biology of *C. glacialis*

6. ACNOWLEGEMENT

We would like to thank the personnel of the “Arctic Circle” scientific center

7. REFERENCES

1. Kosobokova K.N., Percova N.M. Interannual and seasonal changes in the population structure, abundance, and biomass of the Arctic copepod *Calanus glacialis* in the White Sea // Okeanologia. – 2010. – Vol. 50, No. 4. – P. 566–575.
2. Daase M., Kosobokova K., Last K.S., Cohen J.H., Choquet M., Hatlebakk M.K.V., Søreide J.E. New insights into the biology of *Calanus* spp. (Copepoda) males in the Arctic // Marine Ecology Progress Series. – 2018. – Vol. 607. – P. 53–69.
3. Falk-Petersen S., Mayzaud P., Kattner G., Sargent J. Lipids and life strategy of Arctic *Calanus* // Marine Biology Research. – 2009. – Vol. 5. – P. 18–39.
4. Krell A., Ummenhofer C., Kattner G., Naumov A. D., Evans D., Dieckmann G. S., Thomas D. N. The biology and chemistry of land fast ice in the White Sea, Russia — A comparison of winter and spring conditions // Polar Biology. – 2003. – Vol. 26, No. 11. – P. 707–719.
5. <https://nilmoguba.nuipogoda.ru/> (13.12.2025)

Mine-derived fungi as a tool for environmental biotechnology: protease production for degradation of environmental protein waste

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1. INTRODUCTION

Extreme anthropogenically polluted environments, such as acid mine drainage (AMD), represent unique ecological niches inhabited by metabolically adaptable microorganisms. Fungi from such habitats are promising producers of hydrolytic enzymes with potential applications in environmental biotechnology, particularly for the biodegradation of protein-rich waste. The present study focuses on fungi from AMD waters of the Kizel Coal Basin, one of the oldest coal-mining regions in Russia, characterized by long-term environmental impact.

2. AIMS

The aim of this study was to isolate pure fungal cultures from acid mine drainage waters of the Kizel Coal Basin and to identify them using morphological and molecular approaches. In addition, the study sought to evaluate the antimicrobial and proteolytic activities of the obtained isolates, to characterize the molecular weight and activity profiles of their secreted enzymes, and to assess their potential applicability in environmental biotechnologies for the degradation of proteinaceous waste.

Figure 1. The sampling site at the outflow of Ural mine waters



3. METHODS AND MATERIALS

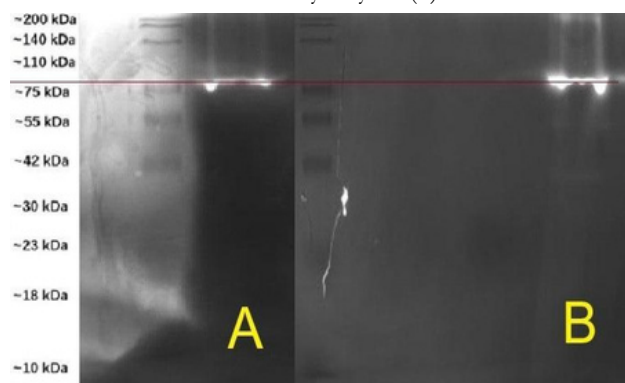
Samples were collected from AMD outflows near Gubaha (Perm Region, Russia). Fungal isolates were obtained on Czapek medium. Identification was performed by morphological analysis and β -tubulin gene amplification and Sanger sequencing. Proteolytic activity was assessed by calculating the Enzymatic Index (EI) on agar media supplemented with ecologically important casein, keratin, fibrin, and elastin. Antimicrobial activity was tested against *Escherichia coli* and *Micrococcus luteus* using the agar block method. Zymography was conducted on cultures grown in solid-state conditions on containing keratin and fish meal hydrolysate to detect active proteases and estimate their molecular weights. A genome-wide bioinformatic analysis of a selected strain was performed using SignalP and InterProScan to predict secreted peptidases.

4. RESULTS AND DISCUSSION

Two fungal isolates were obtained and identified as *Penicillium piscarium* and *Aspergillus pseudodeflectus*. Both isolates exhibited weak antibacterial activity, while *P. piscarium* additionally demonstrated antifungal antagonism. Proteolytic screening showed low activity in *P. piscarium* (EI = 1.4). In contrast, *A. pseudodeflectus* demonstrated high enzymatic indices against fibrous proteins: fibrin (EI = 1.79), elastin (EI = 1.61), and keratin (EI = 1.55).

Zymographic analysis revealed a dominant proteolytic band at approximately 80 kDa and a possible dimeric form at 160 kDa associated with keratin hydrolysis. Genome analysis of *A. pseudodeflectus* identified 88 peptidase-encoding genes, 23 of which possess signal peptides and are predicted to be extracellular. Sixteen candidate secreted proteases corresponded to experimentally observed molecular weights.

Figure 2. Zymograms of *A. pseudodeflectus* enzymes on keratin (A) and fish meal hydrolysate (B) media



The results confirm that AMD ecosystems harbor fungi capable of producing extracellular proteases active against structurally complex fibrillar substrates. The pronounced activity of *A. pseudodeflectus* toward keratin, fibrin, and elastin suggests adaptation to nutrient-limited and protein-rich extreme environments. These proteins are abundantly distributed in slaughter wastes currently disposed of in a non-eco-friendly way, and thus, a biodegradation scenario facilitated by isolated strains may be a key to sustainable waste management. Notably, proteases of this species have not previously been characterized, highlighting the novelty of these findings.

5. CONCLUSIONS

Extremophilic fungi isolated from AMD waters of the Kizel Coal Basin demonstrate significant potential in protein biodegradation. *Aspergillus pseudodeflectus* was identified as a promising source of extracellular proteases capable of degrading recalcitrant fibrous proteins. The combined experimental and genomic data support its potential for environmentally sustainable technologies aimed at processing agricultural and food-industry proteinaceous waste.

6. ACKNOWLEDGEMENT

I would like to express my deepest gratitude to my research supervisor, Anna Shestakova, Junior Research Associate at the M. V. Lomonosov Moscow State University, Faculty of Biology, for her scientific guidance throughout this research and for providing an invaluable experience in conducting genuine scientific inquiry. I am also grateful to the Laboratory of Microbial Physiology and Biochemistry at M. V. Lomonosov Moscow State University for providing the laboratory facilities and equipment, and to its staff for their academic hospitality.

Response of green alga *Tetrademusobliquus* (Turpin) M.J. Wynne 2016 to eutrophication

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Mentors:

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2. Dr. Slađana Popović, Senior Research Associate Faculty of Biology, University of Belgrade

1.Introduction

Tetrademus obliquus is a resilient microalga that utilizes nutrients from synthetic NPK (nitrogen, phosphorus, and potassium) fertilizers for accelerated growth, performing water bioremediation by removing up to 97% of phosphorus and adsorbing heavy metals [1]. In contrast, harmful algal blooms, whose frequency, toxicity, and geographic spread are increasing worldwide, are a direct consequence of eutrophication (water pollution by nutrients due to massive use of chemical fertilizers) [2].

2. Objective

The objective of this study was to examine the impact of synthetic fertilizer on the population growth of the alga *Tetrademus obliquus* grown in a culture (optimal conditions).

3. Material and Methods

BG11 was used as the nutrient medium for the alga, prepared by dissolving specific macro- and microelements in distilled water and adjusting the pH to 7.5. Commercially available synthetic NPK fertilizer (Floris Start and Flower) with high phosphorus (13:40:13) was used for preparing solutions of different concentrations: dose recommended by the manufacturer - 2 g/L and

(T), double strength - 4 g/L ($2 \times T$), 100 mL Erlenmeyer flasks, solutions were prepared according to the following scheme: 60 ml BG11, 30 ml BG11 + 30 ml T/2, 30 ml BG11 + 30 ml T, 30 ml BG11 + 30 ml $2 \times T$, 60 ml T/2, 60 ml T and 60 ml $2 \times T$, with three replicates and one blank sample without algae per treatment,

for spectrophotometry. Solutions were sterilized by autoclaving (at 121°C for 15 min), then 100 µl of the existing algal culture was added (except blanks). Treatments prepared in this way were placed on a shaker with a 12h:12h photoperiod.

via spectrophotometric measuring of optical density Algal growth was monitored

at 680 nm (OD_{680}) every second/third day.

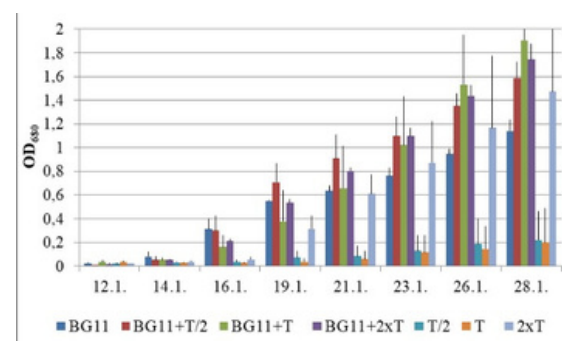
4. Results

Highest (OD_{680}) values were measured in the

BG11+T treatment (Figure 1), while low doses of fertilizer alone (T and T/2) limited the development, in contrast to high concentration ($2 \times T$).

values for the (OD_{680})

Tetrademus obliquus under different cultivation treatments.



5. Conclusion

NPK fertilizer significantly stimulates the growth of *Tetrademus obliquus* if certain nutrients are already present in the solution, while on its own it is effective in higher doses, which is key for algae application in bioremediation and understanding of eutrophication.

6. Literature

- [1] Rugnini, L., et al. (2019). Scaling-up of wastewater bioremediation by *Tetrademus obliquus*, sequential bio-treatments of nutrients and metals. *Ecotoxicology and Environmental Safety*, 172, 59–64.
- [2] Heil, C. A., et al. (2005). The role of eutrophication in the global proliferation of harmful algal blooms: New perspectives and new approaches. *Oceanography*, 18(2), 198–209.

Study of Microplastics Removal Efficiency in Water Samples Using Chitosan Solution and Film Forms

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1. Introduction

Plastic waste degrades into microplastic that is widely distributed in the environment and can enter the food chain, posing potential risks to human health. Chitosan, a natural polymer derived from crustacean shells, is an eco-friendly material that becomes positively charged after deacetylation and can remove microplastic through flocculation and adsorption. This study therefore investigates the effectiveness of chitosan in both solution and film forms for sustainable microplastic removal from contaminated water.

2. AIMS

To determine the optimal conditions for microplastic removal from water and compare the microplastic removal efficiency of chitosan in solution versus thin-film forms.

3. Methods and Materials

The efficiency of microplastic removal from aqueous samples using chitosan in solution and film forms was systematically investigated. Synthetic microplastic-contaminated water samples were prepared at a concentration of 1,000 ppm with a working volume of 100 mL in fifteen beakers. The samples were divided into three experimental groups according to pH values (5, 6, and 7), with five beakers in each group. The pH of each sample was adjusted using dilute acid or base solutions prior to the addition of chitosan. In each group, one beaker was designated as the control, while chitosan solution was added to the remaining four beakers to achieve final concentrations of 75, 100, 125, and 150 ppm, respectively. All samples were initially subjected to rapid mixing at 250 rpm for 2 minutes, followed by slow mixing at 60 rpm for 30 minutes to promote flocculation, and subsequently allowed to settle for 60 minutes to ensure complete sedimentation. The residual turbidity of the supernatant was measured using a turbidity meter, and the percentage removal of microplastic was calculated. For experiments employing chitosan films, the same experimental protocol was applied, with chitosan films of uniform size and thickness used as the adsorbent material in place of chitosan solution.

4. Results

The optimal condition for microplastic removal using chitosan solution was pH 6 and 75 ppm, with an efficiency of 52.33%, while chitosan film performed best at pH 5 and 125 ppm, achieving a much higher efficiency of 92.35%. Microscopic analyses showed that chitosan solution promoted microplastic flocculation, and SEM confirmed the adsorption of microplastic onto chitosan film surfaces.

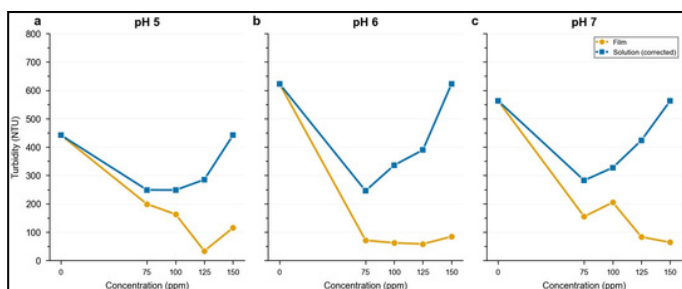


Fig 1: Compares turbidity reduction between the film system and the solution system in different pH and concentrations

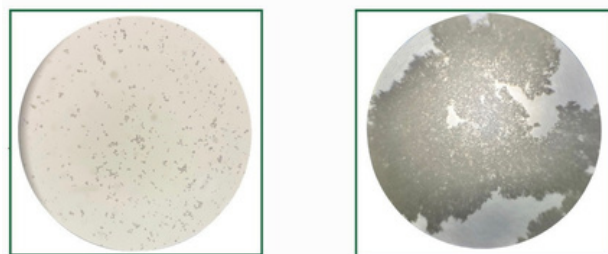


Fig 2 : Microplastic observation in the sample (left side). Clumping of microplastics and chitosan observed (right side).

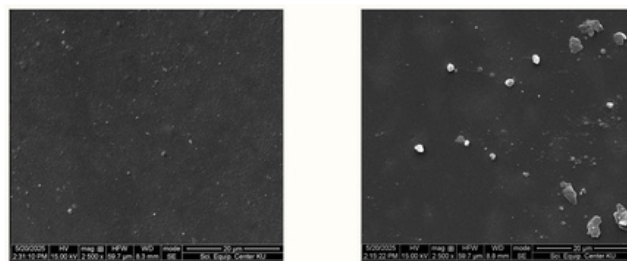


Fig 3 : Surface characteristics of the chitosan film (left) and the adhesion characteristics of microplastic particles on the chitosan film surface (right).

5. Conclusion

This study compared the efficiency of microplastic removal using chitosan in solution and film forms. The results showed that the optimal condition for chitosan solution was pH 6 at 75 ppm, with 52.33% removal. For chitosan film, the optimal condition was pH 5 at 125 ppm, achieving 92.35% removal. Overall, chitosan film was more effective than chitosan solution and showed greater potential for water treatment applications.

6. Discussion

The results indicated that at pH 5 and 6, chitosan solution became positively charged, enhancing electrostatic attraction and flocculation with negatively charged microplastic. Chitosan film showed higher efficiency due to its larger surface area, allowing better adsorption. Microscopic observations confirmed particle aggregation on chitosan. In some cases, higher chitosan concentration increased turbidity, likely due to excess chitosan or self-turbidity. Therefore, optimal conditions are important for maximum efficiency.

7. Acknowledgment

We would like to express our sincere gratitude towards project advisor and special advisors for their valuable guidance and support and We also IPST and DPSTE program for providing resources and facilities. Finally, we sincerely thank our families for their continuous support and encouragement.

8. References

- [1]. Prasetyo, S., Santos, C. A., Sugih, A. K., et al. (2025). Utilization of chitosan as a natural coagulant for polyethylene microplastic removal. *Sustainable Chemistry for the Environment*, 9, 100225. <https://doi.org/10.1016/j.scenv.2025.100225>
- [2]. Putranto, P. A., Khoironi, A., Baihaqi, R. A., et al. (2023). Optimisation of chitosan as a natural flocculant for microplastic remediation. *Journal of Emerging Science and Engineering*, 1(2), 44–50. <https://doi.org/10.61435/jese.2023.7>

A physicochemical analysis of the sludge from excavated tanks and 500 g of soil were removed from each plastic bag, homogenized, and sent for physicochemical analysis.

The school does not have the infrastructure required to perform this type of analysis; therefore, the company SOLANALISE – Central de Análises Ltda., located in Cascavel, was contacted and agreed to analyze the material. The samples were delivered for evaluation on March 20th, 2023.

3.2 Formulation of the substrates

The substrates were formulated on May 13th, 2023, after the SEP had been left to rest for two months, which was the time required for material stabilization and also to receive the SEP analysis results. Table 1 presents the results referring to the percentage of particle-size distribution provided by SOLANALISE. It can be observed that 63.75% of the soil composition consists of clay, 17.50% of silt, and only 18.75% corresponds to sand particle size. [Table 1 – Physical soil classification as a function of](#)

[particle-size distribution percentage.](#) [Source: SOLANALISE \(04/2023\).](#)

Granulometry (%)	
Sand	18,75
Silt	17,5
Clay	63,75
Soil classification	Type 3

The information provided was essential for defining the formulation of the substrates, as it clearly indicated the need to incorporate organic materials such as leaves and sawdust, as well as mineral materials such as vermiculite and sand, in order to improve soil aeration, correct base saturation, and enhance water permeability.

Table 2 – Description of the composition of the substrates used as treatments in the experiment. Source: personal collection

TREATMENTS	FORMULATION
T1	37.5% SET, 37.5% organic matter, and 25% sawdust
T2	37.5% SET, 37.5% organic matter, and 25% pruning leaves
T3	37.5% SET, 50% shredded pruning leaves and branches, and 12.5% eggshell

T4	37.5% SET, 50% sawdust, and 12.5% sand
T5	37.5% SET, 50% shredded pruning leaves and branches, and 12.5% vermiculite
T6	50% SET and 50% sawdust
T7	50% SET and 50% shredded pruning leaves and branches
T8	100% SET
T9	100% commercial substrate

3.3 Sowing of vegetable seeds

For this study, different vegetable species were selected: radish, loose-leaf lettuce, tomato and cucumber,. The choice of several crops is related to the need to determine whether the formulated substrates are suitable for plants with different germination and growth cycles.

The complete experimental design used was randomized, in a 3 × 4 × 9 arrangement, consisting of three vegetable species, four germination cells, and nine treatments (substrates), totaling 108 experimental units. To ensure randomness, three replications were carried out, resulting in a total of 324 cells.

Sowing was performed on 08/10/2023 in germination trays, with one seed per pot, buried at a depth equivalent to twice the seed size. Seeds were irrigated with a spray bottle according to plant needs. The trays were placed in the school greenhouse, protected on the sides with 50% shade cloth and covered with transparent plastic sheeting, and stored inside mini-germination greenhouses.

The following variables were analyzed: Vegetables (lettuce, tomato, cucumber): DAE (days after emergence); number of leaves at 5, 10, and 15 days after emergence; and root length at 25 days.

The trays, randomly distributed, will be repositioned every seven days to ensure randomness. Pest and disease control will be carried out according to management guidelines for organic vegetable production.

4. RESULTS

The treatments influenced the root length of lettuce and cucumber crops, showing distinct responses among the species. In lettuce, the greatest root length was observed in treatment T4, while the lowest values occurred in treatments T1 and T8. The other treatments showed intermediate values, not differing significantly from each other. For tomato, no statistically significant differences were recorded among the treatments. In cucumber, the greatest root length was observed in treatment T9, followed by treatment T1. The lowest values occurred in treatments T2, T3, and T4, while the remaining treatments showed intermediate value.

Table 3. Average root length (cm) of lettuce, tomato, and cucumber crops subjected to different substrate treatments.

Treatments	Lettuce	Tomato	Cucumber
T1	6.1 c	57.2	48.0 a
T2	15.7 abc	54.7	20.1 b
T3	30.4 abc	47.7	20.7 b
T4	40.3 a	59.8	22.4 b
T5	36.8 ab	73.8	22.7 b
T6	34.7 ab	38.6	27.3 ab
T7	18.6 abc	57.9	11.6 b
T8	9.85 bc	32.6	29.1 ab
T9	19.1 abc	45.3	49.8 a
CV%	49.0	33.5	37.7

5. DISCUSSION

The results obtained demonstrate that root length in the crops was influenced by substrate composition, showing that physical and chemical characteristics of the growing medium, such as aeration, water retention, and nutrient availability, play a determining role in root system development (KÄMPF, 2005; FERMINO; KÄMPF, 2012).

In addition, it was observed that each crop responded differently to the treatments, reinforcing the need to consider the specific requirements of each plant species when selecting a substrate (TAIZ et al., 2017).

In lettuce, the best performance observed in treatment T4 may be associated with the greater aeration provided by the combination of sawdust and sand, which reduces substrate compaction and favors root penetration (KÄMPF; FERMINO, 2017). Lettuce has a shallow root system and is sensitive to excess moisture, benefiting from substrates with good drainage and adequate root oxygenation (EMBRAPA, 2012). On the other hand, the shorter root lengths observed in some treatments may be related to lower porosity and higher water retention, which may have caused oxygen limitation in the root system (FERMINO; KÄMPF, 2012).

Additionally, the presence of poorly stabilized organic residues may have caused temporary immobilization, especially nitrogen, impairing root growth (MENESES et al., 2002; MALAVOLTA, 2006).

For tomato, no statistically significant differences were observed among treatments, indicating that variations in substrate composition were not sufficient to promote differentiated responses in root length for this crop. The absence of differences may be related to the adaptive capacity of the tomato root system, which shows high growth flexibility and can develop in different types of substrate, as this species is considered a bioindicator, provided that water and nutrient availability are not limiting (FAGERIA, 2011). In cucumber, the best performance observed in treatment T9, corresponding to the commercial substrate, indicates that this material presents a more balanced composition in terms of porosity, water retention, and nutrient supply (KÄMPF; FERMINO, 2017). Cucumber is a fast-growing crop with high water demand and benefits

from substrates that maintain adequate moisture without causing waterlogging. \ alternative treatments may be attributed to low mineral nutrient availability, variation in nitrogen retention capacity, and possible immobilization caused by the decomposition of organic residues used in substrate composition (MENESES et al., 2002; FAGERIA, 2011).

Overall, the results show that substrates with a better balance between aeration, water retention, and nutrient availability promote greater root development (KÄMPF, 2005; EMBRAPA, 2010). The differentiated response among crops indicates that there is no single ideal substrate for all species, making it necessary to adjust its composition according to the physiological requirements of each crop (TAIZ et al., 2017).

6. CONCLUSION

Substrate composition influenced root development in lettuce and cucumber, highlighting the importance of balancing aeration, water retention, and nutrient availability. For tomato, no statistically significant differences were observed among treatments, indicating greater adaptability of the crop to the evaluated variations. The results reinforce that there is no single ideal substrate for all species, and its composition must be adjusted according to the specific requirements of each crop.

7. ACKNOWLEDGEMENTS

We would like to acknowledge the partial financial support from College Phoenix Education, CNPq Brazil, and Project 9388 / Unioeste.

8. REFERENCES

- Ayroza, L. M. S. (2009). *Criação de tilápia-do-Nilo (Oreochromis niloticus) em tanques-rede, na usina hidrelétrica de Chavantes, Rio Paranapanema, SP/PR* (Doctoral thesis). Universidade Estadual Paulista “Júlio de Mesquita Filho”, Jaboticabal, Brazil.
- Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA). (2010). *Sistema Brasileiro de Classificação de Solos* (3rd ed.). Embrapa, Brasília, Brazil.
- Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA). (2012). *Manual de métodos de análise de solo, plantas e fertilizantes* (2nd ed.). Embrapa, Brasília, Brazil.
- Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA). (2023). *Agência de Informação Embrapa: Pesca e Aquicultura*. Retrieved March 20, 2023, from <https://www.embrapa.br/cim-centro-de-inteligencia-e-mercado-em-aquicultura/noticias>
- Fageria, N. K., & Moreira, A. (2011). The role of mineral nutrition on root growth of crop plants. In D. L. Sparks (Ed.), *Advances in Agronomy* (Vol. 110, pp. 251–331). Academic Press. <https://doi.org/10.1016/B978-0-12-385531-2.00004-9>
- Junek, J. O. M. O., Lara, T. S., Martins, O. B., & Morais, C. G. (2014). *Fertilizantes organominerais* (Technical Circular No. 06). Instituto de Ciências da Saúde, Agrárias e Humanas (ISAH), Araxá, Brazil.
- Kämpf, A. N. (2005). *Nutrição e adubação de plantas: fundamentos e aplicações*. Editora Agronômica Ceres, São Paulo, Brazil.

Kämpf, A. N., & Fermينو, L. V. (2012). *Bases da nutrição mineral de plantas*. Editora Agronômica Ceres, São Paulo, Brazil.

Kämpf, A. N., & Fermينو, L. V. (2017). *Nutrição mineral de plantas: princípios e aplicações*. Editora Agronômica Ceres, São Paulo, Brazil.

Lopes, A. S., & Guilherme, L. R. G. (2007). Soil fertility and agricultural productivity. In R. F. Novais et al. (Eds.), *Soil Fertility* (pp. 1–24). Sociedade Brasileira de Ciência do Solo, Viçosa, Brazil.

Malavolta, E. (2006). *Manual of Plant Nutrition* (2nd ed.). Food Products Press, New York, USA.

Meneses, M., Silva, A. F. da, & Oliveira, J. (2002). *Fundamentals of soil science*. Editora Universitária, Recife, Brazil.

Schmitz, J. A. K., Souza, P. V. D., & Kämpf, A. N. (2002). Physical and chemical properties of mineral and organic substrates for seedling production. *Ciência Rural*, 32(6), 937–944.
<https://doi.org/10.1590/S0103-84782002000600013>

Schulter, E. P., & Filho, J. E. R. V. (2017). *Evolution of aquaculture in Brazil: diagnosis and development of the tilapia production chain*. Instituto de Pesquisa Econômica Aplicada (IPEA), Rio de Janeiro, Brazil.

Silva, F. A. B. da, Souza, D. M. G., & Costa, J. M. (2017). *Plant nutrition and soil fertility*. Journal of Agricultural Science, 9(2), 45–58.

Taiz, L., Zeiger, E., Möller, I. M., & Murphy, A. (2017). *Plant physiology and development* (6th ed.). Artmed/ Oxford University Press.

Tavares, G. C., & Palhares, M. M. (2011). Epidemiology, diagnosis and control of the main bacterial diseases that affect tilapia aquaculture in Brazil. *Revista Veterinária e Zootecnia em Minas*, 21, 55–68.

Sustainable Removal of Heavy Metals and Textile Dyes Using *Verbascum* as a Natural Adsorbent

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1. INTRODUCTION

The release of heavy metals and synthetic dyes from industrial activities, particularly the textile industry, poses a serious threat to aquatic ecosystems and human health. These pollutants are often persistent, toxic, and difficult to remove using conventional treatment methods. In recent years, increasing attention has been given to environmentally friendly and low-cost remediation strategies based on natural materials. *Verbascum* (mullein), a plant known for its rich phytochemical composition and porous biomass structure, has the potential to act as an effective natural adsorbent. In this context, the present study investigates the potential of *Verbascum* biomass for the adsorption of heavy metals and the removal of textile dyes from aqueous solutions.



Figure 1. *Verbascum* (mullein) plant used as the biomass source for heavy metal adsorption and textile dye removal experiments.

2. AIM The aim of this study is to investigate the potential of *Verbascum* biomass as a natural adsorbent for the removal of heavy metals and textile dyes from aqueous solutions.

HYPOTHESIS

If *Verbascum* biomass is used as a natural adsorbent, then it will effectively remove heavy metals and textile dyes from aqueous solutions due to its porous structure and surface functional groups.

3. MATERIALS AND METHODS

Dried *Verbascum* biomass was collected, washed thoroughly with distilled water to remove impurities, and dried at room temperature. The dried plant material was then ground into a fine powder to increase its surface area and used as a natural adsorbent.



Figure 2. Dried aerial parts (leaves and flowers) of *Verbascum cheiranthifolium* used as plant material prior to grinding and extraction.

Aqueous solutions containing selected heavy metals and textile dyes were prepared at known concentrations to simulate contaminated water conditions.

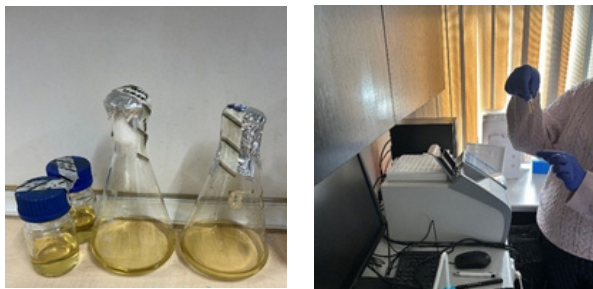


Figure 3. Extraction of *Verbascum* plant extract and measurement of its absorbance using UV-Vis spectrophotometry.

A measured amount of *Verbascum* powder was added to the prepared solutions and stirred under controlled conditions to allow adsorption to occur. After the adsorption process, the mixtures were filtered. The remaining concentration of textile dyes was analyzed using UV-Visible spectrophotometry, while the concentration of heavy metals was determined using Atomic Absorption Spectroscopy (AAS) in order to evaluate the adsorption efficiency of the *Verbascum* biomass.

4. RESULTS

The adsorption experiments showed that *Verbascum* biomass effectively removed both heavy metals and textile dyes from aqueous solutions. UV-Vis spectrophotometric analysis revealed a significant decrease in dye absorbance after treatment, indicating successful dye removal. Similarly, Atomic Absorption Spectroscopy (AAS) measurements confirmed a clear reduction in heavy metal concentrations following the adsorption process.

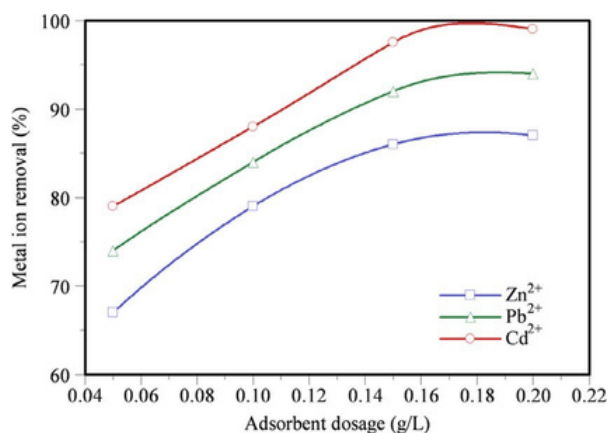


Figure 4. Effect of adsorbent dosage on Pb²⁺ removal efficiency.

Increasing the amount of *Verbascum* adsorbent significantly improved metal removal efficiency. As the dosage increased from 0.05 to 0.20 g/L, the removal of Zn²⁺, Pb²⁺, and Cd²⁺ also increased,

indicating that higher adsorbent dosage provides more active binding sites for metal ions.

Bacterial growth measurements showed solutions treated with *Verbascum* resulted in lower bacterial growth compared to untreated samples, indicating reduced toxicity and effective removal of heavy metals and dyes.

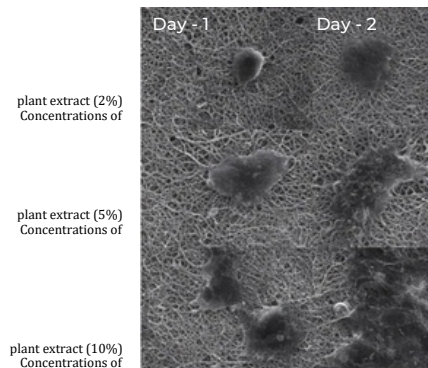


Figure 5. SEM images of the *Verbascum*-based adsorbent before and after adsorption, showing a porous surface structure and increased surface coverage after Pb²⁺ and dye uptake.

5. DISCUSSION

The results show that *Verbascum* biomass effectively removes heavy metal ions from aqueous solutions. Increasing the adsorbent dosage significantly improved removal efficiency, indicating that a larger surface area provides more active binding sites for metal ions.

6. CONCLUSION

Verbascum biomass demonstrates strong potential as a low-cost and environmentally friendly adsorbent for the removal of heavy metals and textile dyes from contaminated water.

7. ACKNOWLEDGEMENT

I would like to thank my chemistry teacher, Şeyma Tokmak Eren, for her support and guidance.

8. REFERENCES

- Barakat, M. A. (2011). New trends in removing heavy metals from industrial wastewater. *Arabian Journal of Chemistry*, 4(4), 361–377. <https://doi.org/10.1016/j.arabjc.2010.07.019>
- Demirbaş, A. (2008). Heavy metal adsorption onto agro-based waste materials: A review. *Journal of Hazardous Materials*, 157(2–3), 220–229. <https://doi.org/10.1016/j.jhazmat.2008.01.024>

The background is a light beige color with a faint grid pattern. It features several green line-art illustrations: a large DNA double helix winding across the center, a globe in the middle, a cell with internal organelles on the right, and various leafy branches in the corners. There are also small icons of a document, a bar chart, and a ruler. The title 'Life Science' is centered in a bold, black, sans-serif font with a slight drop shadow.

Life Science

DOMICONNECT - HOME CARE SOLUCION WITH AI FOR MONITORING MULTIPLE PACIENTS

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INTRODUCTION

In Cascavel, Paraná, the Home Care and Hospitalization Program (PAID) came as an alternative to replace the 'Neighborhood Medical Program' for the provision of health services at home. The program offers patients a model of health care that has been growing significantly around the world because it provides patients with the comfort of receiving treatment in their own homes. (CÂMARA MUNICIPAL DE CASCAVEL, 2008).

The situation in recent years, due to the SARS-CoV-2 pandemic (popularly known as COVID-19), has led to a significant increase in the number of home visits and hospitalizations provided by PAID, causing high patient demand, misinformation, and delays in care.

AIMS

Assist the communication between the home care institution and its patient's health status using technology and telehealth.

METHODS AND MATERIALS

We might develop a bracelet that captures the patient's vital signs using sensors and send them to the home care institute. This communication will be carried out by a Wi-Fi connection and shown in a website in real time at the home care institute.

To develop it, we will use some components. First, the ESP32, which is a microcontroller that will send everything to the website via Wi-Fi. As sensors, we use the AD8232 electrocardiogram sensor for heart rate, the AHT10 for body temperature, and the MAX30102 for blood oximetry.



Figure 1. Components

4. RESULTS

The results we obtained were a display of vital signs in graphics on a website that is integrated into the cloud, storing this data in real time in a database, as well as having an alert system in case the patient experiences significant variations in their vital signs. In addition, we use two bracelets in the website, just as it would work in an institute with multiple patients. We also include a page for patient registration and an artificial intelligence system from OpenAI to assist in monitoring, through a report.



Figure 2. Website

5. CONCLUSION

In addition to developing an innovative device that could assist home care institutions, we also developed it to be efficient so that healthcare teams could monitor patients' vital signs accurately and at low cost, about 34,35 dollars

6. REFERENCES

- BOTNROLL. **MAX30102 Heart Rate Sensor Module – Pulse.** Disponível in: <<https://www.botnroll.com/pt/biometricos/4310-m-dulo-sensor-de-frequencia-cardaca-max30100-pulsa-o.html>> Access 13 apr. 2024.
- CASCABEL CITY COUNCIL. **Council members pay tribute to PAID.** 2008. Disponível in: <<https://www.camaracascavel.pr.gov.br/comunicacao/noticias/ve-readores-prestam-homenagem-ao-paid/#:~:text=O%20programa%20foi%20implantado%20no,de%20saude%20realizados%20no%20domicilio>> Access in 10 jun. 2023.
- LOCATELLI, C. **Differences between the sensors: AHT10 and DHT11.** 2022. Disponível in: <<https://curtocircuito.com.br/blog/Categoria%20Arduino/diferencas-entre-os-sensores-aht10-dht11-e-dht22#AHT10>> Access in 12 sep. 2023.
- USINAINFO. **ESP32 NodeMCU Iot with WiFi and Bluetooth – 30 Pins.** Disponível in: <<https://www.usinainfo.com.br/nodemcu/esp32-nodemcu-iot-com-wifi-e-bluetooth-30-pinos-5147.html>> Access in 13 abr. 2024.
- SPARKFUN ELECTRONICS. **AD8232 Heart Rate Monitor Hookup Guide.** Disponível in: <<https://learn.sparkfun.com/tutorials/ad8232-heart-rate-monitor-hookup-guide/all>> Access in 22 jul 2025.

Chemical Modification of Hyaluronic Acid

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1. INTRODUCTION

Hyaluronic acid (HA) is a highly hydrophilic anionic polymer. For practical application, uniform hydrophobization along the polymer chain is desirable. However, due to the formation of hydrophobic domains caused by hydrophobic interactions on the chain, resulting in an uneven substitution, some areas of the structure become heavily substituted, while other parts remain untouched and therefore remain unmodified.

2. AIM

The aim of this research is to investigate and analyse multiple approaches to a uniform hydrophobization and to visualize the resulting hydrophobic effect.

3. METHODS AND MATERIALS

For analytical purposes of the mentioned visualization, hydrophobizing agents that also act as azo dyes were used.

The approach was based on the fact that the hyaluronic acid structure consists of -COOH and -COONa^+ groups. Under these conditions, two options were considered:

1. Development of disperse dyes that are soluble in organic solvents (alcohols) and contain -NH_2 group, assuming that salt formation occurs during the dyeing of HA.
2. Development of cationic dyes, which will have a permanent positive charge. Eventually, salt is formed.

By binding the dyes with hyaluronic acid, it is possible to evaluate how effective the bond between the azo dyes and HA structure is, more precisely determine the uniformity of the colorations, alternatively the formation of hydrophobic domains.

4. RESULTS

The experiments revealed differences in the interaction of HA with disperse, as well as cationic dyes.

Disperse dyes showed low affinity, which resulted in weak coloration. This suggests that there is a limited interaction between the disperse dyes and the polymer. In contrast, cationic dyes showed a strong bond with hyaluronic acid, which led to the formation of hydrophobic domains along the polymer. These domains caused an imbalance of the whole structure in aqueous environment and prevented the HA from creating a hydrogel.

5. DISCUSSION

The low affinity of disperse dyes can be explained by the chemical form of HA, especially by the dominance of carboxylate groups - sodium salts (-COONa^+) - over free carboxyl groups. Therefore, the deficiency of protons limited the possibility of disperse dyes to bind effectively to the polymer chain.

The formation of hydrophobic domains during the process of binding cationic dyes with the polymer was associated with electrostatic interactions between the cationic dye groups and anionic groups of HA. These interactions caused aggregation and a decrease in solubility.

6. CONCLUSION

Overall, the results highlight the vitality of the form and the structure of hyaluronic acid in determining its interaction with modifying agents and its properties for further modifications.

Disperse dyes showed an insufficient affinity to the polymer chain, whereas cationic dyes caused the formation of hydrophobic domains which altered the stability and functions of HA.

These findings provide information and may contribute to development of enhanced modifications and potential application in different fields, such as cosmetics or biomedical field.

7. ACKNOWLEDGEMENT

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8. REFERENCES

- P., Saranraj & Noorani, Arshad & Naidu, M. (2013). Hyaluronic Acid Production and its Applications -A Review. International Journal of Pharmaceutical and Biological Archive. 4(5). 853-859. 10.22377/ijpba.v4i5.1126.
- Payne, William M et al. "The role of hydrophobic modification on hyaluronic acid dynamics and self-assembly." Carbohydrate polymers vol. 182 (2018): 132-141. doi:10.1016/j.carbpol.2017.10.054

Breast Cancer in Young Women: Correlation of Molecular Genetic, Clinical and Morphological Features

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Introduction

Breast cancer is the most common female malignancy worldwide and is more common in industrialized countries. Approximately two-thirds of tumors develop in postmenopausal women. However, for premenopausal women, especially at a very young age of up to 35 years, this disease poses a much greater risk. Breast cancer in this group of patients tends to be more aggressive, more often establishes distant metastases, which brings with it a worse prognosis. The incidence of breast cancer has been steadily increasing in the last few decades, the proportion of cancers diagnosed in young women under 35 years, however, has been stable over time (around 2%).

Methods and Materials

This work is a retrospective study of 8412 patients diagnosed with invasive breast cancer between 2018 and 2022. The histological diagnosis, including the examination of predictive markers, was determined at the Biopsy Laboratory in Pilsen. Our own cohort consists of 234 patients diagnosed with invasive breast cancer, who developed the disease at the age of 35 years or less in the monitored period from 2018 to 2022. We focused on the histological, immunohistochemical and molecular features of these tumors.

Main Results

In our cohort of 92 young patients with newly diagnosed breast cancer in the follow-up period 2018-2022, we observed 4 basic groups of cancers according to immunoprofile

1. Triple negative type corresponds to carcinomas that are negative for estrogen receptors (ER), progesterone receptors (PR) and HER-2/neu

2. Luminal A type shows positive expression of ER and PR while staining for HER-2/neu is negative

3. Luminal B type reveals positive expression of ER while negative for HER-2/neu but PR is either negative or, if PR is positive, the tumor shows high proliferative activity (MIB1 index is more than 20%) 4. HER-2/neu positive type is

characterized by overexpression of HER-2/neu protein or amplification of the HER-2/neu gene. In this group, the expression of ER/PR, can be both positive and negative, and the value of proliferative activity is variable.

Conclusions

The incidence of invasive breast cancer in young women is low, but cancers at such a young age tend to be more aggressive, with higher mitotic activity, higher grade and more often represent prognostically unfavorable types of cancer, such as triple negative. In addition, breast cancers in young women are more often caused by a genetic predisposition (congenital mutations in the *BRCA1* and *BRCA2* genes).

References

1. WHO Classification of Tumours Editorial Board. Breast tumours. Lyon (France): International Agency for Research on Cancer; 2019. (WHO classification of tumours series, 5th ed.; vol. 2). <https://publications.iarc.fr/581>.
2. Cserni G. Histological type and typing of breast carcinomas and the WHO classification changes over time. *Pathologica*. 2020 Mar;112(1):25-41.

The Yeast Cube for Applications in Biotechnology?

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1. Introduction

Laboratory yeasts are used to produce several important substances for mankind, such as insulin or artemisinin. However, they are usually patented and come with high licensing fees. They belong to the same species, *Saccharomyces cerevisiae*, as the yeast found in supermarkets. I here attempted to modify supermarket yeast to make it applicable for biotechnological purposes in order to dispose of an alternative to laboratory yeast.

2. Aims

A genetically modified supermarket yeast that can be used in biotechnology

3. Material and Methods

The Yeasts were purchased from local supermarkets in Lörrach (Germany) and Basel (Switzerland).



Figure 1. Yeast cubes used for the experiments

All chemicals and media were obtained from Carl Roth GmbH (Germany). The carotenoid plasmid was from Euroscarf (Germany). The culture media were prepared according to standard protocols. Incubation of the yeast with 5-fluoroorotic acid (5-FOA) was carried out according to the method of Boeke et al. (1984). Transformation of the yeast cells was performed following the protocol of Gietz and Schiestl (2007).

4. Results

Initially, the supermarket yeasts were grown on agar plates containing 5-FOA and small amounts of uracil. 5-FOA is converted by the endogenous yeast gene URA3, encoding orotidin-5'-phosphate-decarboxylase, into the

toxic substance 5-fluorouracil. Only yeasts with a deficient URA3 gene survive this treatment. I selected 12 clones from those plates and analysed them for loss of the URA3 gene. One clone indeed lost the gene as this clone could not grow on uracil-free agar plates. This clone was used for transformation using a plasmid containing the URA3 gene as well as three genes of the β -carotene metabolic pathway. Ultimately, the transformed yeast was able to successfully express β -carotene, recognisable by the characteristic orange colouration of the cells.

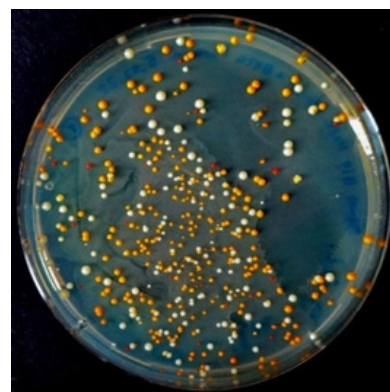


Figure 2. Transformed yeast that expresses β -carotene

5. Discussion

Successful transformation of the defective URA3 clone, derived from the supermarket yeast, was demonstrated by the production of β -carotene.

6. Conclusion

Supermarket yeast can be used as a cost-effective and patent-free alternative to laboratory yeasts in biotechnology.

7. Acknowledgements

This work was supported by the phänovum Students' Research Center in Lörrach, Germany, and by my supervisors Dr. Harald Heider and Dr. Ulla Plappert-Helbig.

8. References

Boeke JD et al. 1984; Mol Genet 197(2):345ff;
Gietz & Schiestl 2007; Nat Protoc (2;1) 31ff

Computational Pixel-Level Analysis of Plantar Pressure Fields for Quantitative Differentiation of Foot Morphology Using Image-Based Sensor Data

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Introduction

The distribution of plantar pressure, force exerted between the foot and a surface during walking, standing, or running, provides critical insight into foot structure, gait mechanics, and overall lower extremity biomechanics. Modern clinical assessment of plantar pressure is typically performed using pedobarographic systems, which utilize sensor-based platforms or in-shoe devices to measure key parameters such as peak plantar pressure, contact area, and pressure distribution patterns. These systems provide valuable quantitative data that support diagnosis, rehabilitation, and evaluation of pathologies in the foot including more common Pes Planus (flat feet), Pes Cavus (high arches), and diabetic ulcers. However, despite their clinical and research value, pedobarographic systems are often expensive and require specialized equipment, limiting their accessibility in low-resource settings and broader applications.

Aim

As pedobarographic analyses continue to serve as an effective means to assess biomechanics of the foot and lower extremity, Plantar pressure distributions can be quantified using an feasible image-based analysis as an low-cost alternative to traditional pedobarographic systems for biomechanical evaluation. Thus, prompting valuable insights into novel orthoses and shoe modification for commercial and athletic use.

Materials

Publicly available plantar pressure image dataset consisting of 400 plantar pressure images collected using the Footbird 3.0 foot pressure scanner by researcher Li. Xiang from the Fujian Putian Shuangchi University Technology Co.; ImageJ for image loading and preprocessing, processing, data collection; Seaborn for visualization; Statistics kingdom and TI-84 Plus CE calculator for statistical analysis

Methodology

1. Grayscale Conversion
2. Intensity Normalization
3. Otsu Thresholding
4. Binary Segmentation
5. ROI & Feature Extraction
6. Metric Computation & Statistical Analysis

Results and discussion

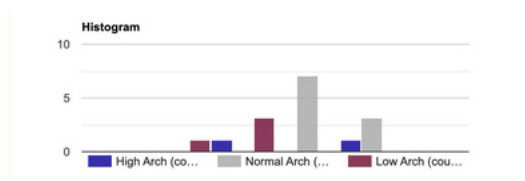


Figure 1. Distribution of Plantar pressure across Arch Categories

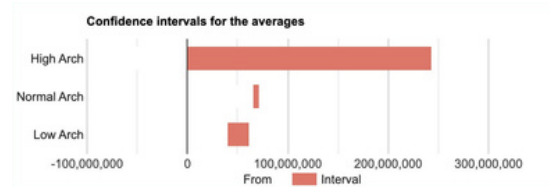


Figure 2. Confidence Intervals of Mean Plantar Pressure for Each Arch

Category

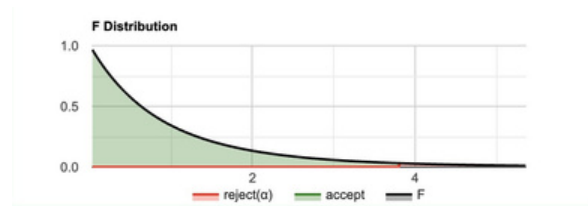


Figure 3. Figure 3. F-Distribution Curve Illustrating ANOVA Test Statistic

Conclusion

This study demonstrated that plantar pressure distributions can be quantitatively analyzed using image-based computational methods. The arch index values ranged approximately from 0.20 to 0.33, allowing samples to be grouped into high arch, normal, and low arch categories. Corresponding total pressure values varied across these groups, indicating differences in how load is distributed across the foot. Statistical analysis using one-way ANOVA yielded a p-value of 0.0011, indicating a statistically significant difference in plantar pressure between arch categories. The large effect size ($\eta^2 = 0.65$) further suggests that foot morphology accounts for a substantial portion of the variation in pressure distribution. Post-hoc Tukey analysis revealed significant differences between specific groups, reinforcing that plantar pressure patterns differ meaningfully across arch types. Overall, these results demonstrate that image-based analysis can effectively capture biomechanical differences in foot structure and provides a viable, low-cost alternative to traditional pedobarographic systems.

References

- [1] Pataky TC, Goulermas JY. Pedobarographic statistical parametric mapping (pSPM): a pixel-level approach to foot pressure image analysis. *J Biomech*. 2008 Jul 19;41(10):2136-43. doi: 10.1016/j.jbiomech.2008.04.034. Epub 2008 Jun 13. PMID: 18555256.
- [2] Mesci E. Pedobarographic evaluations in physical medicine and rehabilitation practice. *Turk J Phys Med Rehabil*. 2023 Oct 12;69(4):400-409. doi: 10.5606/tftrd.2023.13637. PMID: 38766578; PMCID: PMC11099855.
- [3] Liang, X., & Zhang, S. (2025). Plantar pressure dataset for foot health assessment [Data set]. Zenodo. <https://doi.org/10.5281/zenodo.14621923>
- [4] Zhang, Y., & Dong, Z. (2023). Medical Imaging and Image Processing. *Technologies*, 11(2), 54. <https://doi.org/10.3390/technologies11020054>

Personalized, partially absorbable band-aid

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1. INTRODUCTION

Injuries can occur to anyone at any moment. However, we can't carry an entire pharmacy with us, so we are never fully prepared for emergencies. How can we determine what is good for the wound, ensure sterility, and what kind of and how much disinfectant, hemostatic agent, and pain reliever are needed? Are we hindering the natural healing process, and will changing the band-aid cause further damage? In addition, it is important to note that as soon as we remove a band-aid, it becomes hazardous waste. This means it can't be reused, recycled, or thrown into the garbage, which represents a major challenge.

2. AIMS

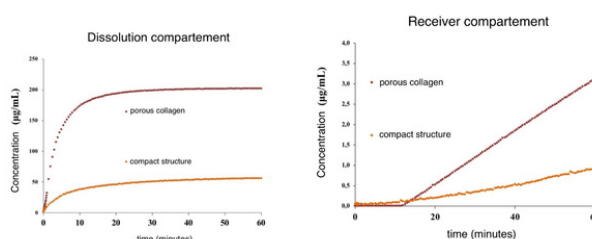
During my research, my goal was to develop an innovative, partially absorbable band-aid that can be adapted to different types of injuries, by adjusting its composition, size, thickness, and shape to suit the specific injury. The aim was to find the most suitable manufacturing method for producing personalized bandages, with particular focus on a 3D printing system that can be integrated with a mobile application. The results from image analysis of photos taken with a mobile phone can guide the 3D printer to produce the correct shape and layer arrangement. While developing my project, I realized how critical it is to control the release rate of active ingredients in the band-aid so it can be tailored to the specific needs of the injury. After all, there's a big difference between aiming for an immediate effect or a slower, more steady release.

3. METHODS AND MATERIALS

The bandage was tested using a biodegradable collagen matrix containing Naproxen as a model active ingredient. Collagen was selected due to its biocompatibility and ability to support tissue regeneration, and Raman spectroscopy was later applied to confirm the chemical identification of the collagen structure. UV imaging was used to visualize Naproxen diffusion from the matrix, confirming drug release into the surrounding environment. MicroFLUX analysis determined dissolution, diffusion of the active ingredient, demonstrating that matrix structure directly influences drug release kinetics. I tested using MicroFLUX instrument, two different collagen structures containing Naproxen.

4. RESULTS

In the porous collagen structure, about 80 percent of the active ingredient was released within 15 minutes. In the compact structure, only 20 percent was released within one hour. These results clearly show that the internal structure of the bandage controls drug release, allowing either fast or long-lasting effects.



1. Results of the MicroFLUX experiments

I used FDM 3D printing (with PLA) for the modelling of the adhesive bandage design and its layered structure. The final prototype containing Naproxen embedded in a collagen-based matrix was then made using SLS 3D printing, which allowed production of the actual drug-loaded, absorbable structure.

5. CONCLUSIONS

A partially absorbable bandage, containing active ingredients (like anti-inflammatory agents, analgesic compounds or antiseptic substances), could make people's everyday lives easier. It could help those who simply find it difficult to tolerate the removal of bandages, such as children or the elderly, whose wounds heal slowly. Also my project could significantly improve the lives of patients with chronic conditions, such as diabetes, who struggle daily to treat open wounds.

Another important advantage of partially absorbent wound dressings is that they minimize the amount of hazardous waste.

6. ACKNOWLEDGEMENT

I would like to express my sincere gratitude to my mentors: Prof. Dr. György Marosi, Dr. Mihály Hömöstrei.

7. REFERENCES

1. <https://doi.org/10.1002/pol.20220734>
2. <https://doi.org/10.1016/j.bioadv.2022.213152>
3. Gibson, I., Rosen, D. W., & Stucker, B. (2015). Additive Manufacturing Technologies.

Development of Mn²⁺-based MRI contrast agent candidates

Investigation of structure-activity relationships of new bispidine derivatives

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1. INTRODUCTION

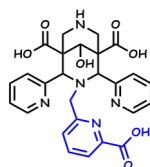
The idea for the project arose in response to the safety and environmental concerns associated with currently used Magnetic Resonance Imaging (MRI) contrast agents, particularly compounds containing Gd³⁺-ions. The toxicity of Gd³⁺-ions—specially in patients suffering from renal failure – has been linked to the development of Nephrogenic Systemic Fibrosis (NSF). Furthermore, due to the positive gadolinium anomaly, these substances may also have harmful environmental impacts. These issues have provided strong motivation to investigate alternative, biologically compatible metal ions – such as Mn²⁺ ion complexes – as potential new contrast agent candidates.

2. AIMS

The aim of the project is to synthesize and physicochemically characterize a new type of Mn²⁺-ion complexing bispidine derivative with potential application as an MRI contrast agent. The main scientific question of the project is whether the stability, inertness, and relaxation effect of Mn²⁺ complexes can be increased by appropriate structural modifications. The aim is that the modifications preserve the biocompatibility of the complexes and reduce their potential toxicity.

3. METHODS AND MATERIALS

The bispidine scaffold and its derivatives are not commercially available, therefore I had to synthesize them myself. In the first step, I carried out a three-component Mannich reaction, which was followed by the introduction of a 2,4-dimethoxybenzylamine (DMB) protecting group. In the third step, the carbonyl group was reduced using sodium borohydride, after which the alkylation of the side chain was performed. In the final step, the methyl ester was hydrolysed with 6 M hydrochloric acid (HCl) in a microwave reactor.



4. RESULTS

The protonation constants of the ligand and the thermodynamic stability constants of the complex were determined by the pH-potentiometric method (pMn = 6.84).

The relaxivity value – determined by relaxometric measurements – was $>1.5 \text{ mM}^{-1}\text{s}^{-1}$, which suggests the presence of a coordinated water molecule, a requirement for clinical application.

However, the half-life of the exchange reaction with Zn²⁺ ions is 22.5 seconds, indicating that further fine-tuning is necessary.

	BisPid-N3PA	BisPid-BA
$\Sigma \log K^H_3$	18.05	16.15
pMn	6.84	6.65

The contrast agent candidate I produced and the reference Bispid-BA

From a scientific perspective, the project advances knowledge on MRI contrast agents, particularly Mn²⁺-based derivatives. It may also support the development of safer, cheaper, and more environmentally friendly alternatives to Gd³⁺-based agents.

5. CONCLUSIONS

In the first phase of the project, I successfully synthesized and characterized a new bispidine derivative that complexes Mn²⁺ ion. Based on the results, the compound has potential applications as an MRI contrast agent; therefore, improvement of kinetic inertness is still needed. The next phase of the research is aimed at the synthesis of BISPIDIN-N7PA and BISPIDIN-N3,7PA ligands and the investigation of their complexes.

6. ACKNOWLEDGEMENT

I would like to thank to my teacher and supervisor their guidance and support.

7. REFERENCES

- Caravan, P. et al. Gadolinium-based contrast agents and nephrogenic systemic fibrosis. *Radiology*, 2007.
- Tóth É. et al., *Angew. Chem. Int. Ed.* 2020, 59, 11958 – 11963, doi:10.1002/anie.202003685
- Thompson, M. K., Bottrill, M., Faulkner, S. Lanthanide and transition metal-based MRI contrast agents. *Coord. Chem. Rev.*, 2011.
- Sajid, M. et al. Environmental concerns of MRI contrast agents. *Chemosphere*, 2018.

1. INTRODUCTION

Pain is the body's alarm system, detecting potential harm and triggering protective behaviours. Congenital Insensitivity to Pain (CIP) is a rare genetic disorder characterised by a complete inability to perceive pain, resulting in severe injuries including bone fractures, oral self-mutilation, and joint dislocations. Although prevalence is estimated at approximately 1 in 125 million, the exact occurrence is unknown. CIP is extremely dangerous as most patients do not live over the age of 25. CIP is caused due to mutations in the *SCN9A* gene, which encodes the NaV1.7 voltage-gated sodium channel.

2. AIM

The aim of this research is to investigate how mutations in the *SCN9A* gene cause CIP. The research also explores the clinical implications of diagnosis, treatment, and management of CIP and chronic pain disorders.

3. METHODOLOGY

Given the rarity of CIP, this study is a literature review of pre-existing clinical and scientific sources, proceeding through the following stages: (i) Examining documented cases of CIP to identify the underlying genetic mutation. (ii) Understanding its effects on the voltage-gated sodium channel it encodes. (iii) Assessing the diagnostic and therapeutic implications for CIP patients. (iv) Translating these insights to reform treatments for chronic pain disorders.

4. RESULTS

The *SCN9A* gene encodes the voltage-gated sodium channel NaV1.7, which plays a central role in generating action potentials that carry pain signals. NaV1.7 regulates sodium ion transfer across the cell membrane, which is essential for neuronal excitation. The most common loss-of-function mutations in *SCN9A* are frameshift and nonsense mutations. In CIP patients, these mutations render the NaV1.7 channel non-functional, preventing action potential generation and thus abolishing pain signalling entirely. In unaffected individuals, sodium ions flow normally through open NaV1.7 channels, enabling standard pain transmission.

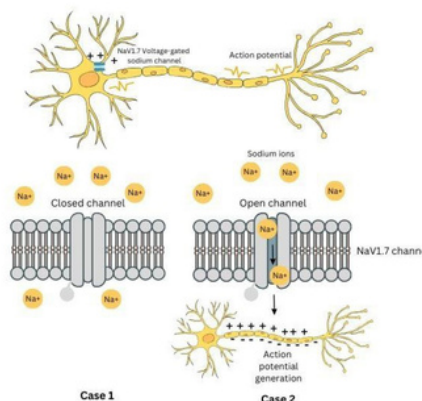


Figure. Case 1: Inactivated NaV1.7 due to CIP
Case 2: Activated NaV1.7 leading to pain signal

Given the rarity of CIP, diagnostic practices remain inconsistent. However, identifying the mutations enables suspected individuals to undergo prenatal genetic testing, which can substantially improve outcomes for affected individuals.

Current non-genetic therapeutic approaches offer no cure for CIP. By contrast, genetic therapies (including CRISPR/Cas9, RNAi, and stem-cell interventions) hold significant potential for a permanent cure.

5. FUTURE SCOPE

This research provides a foundation for drug development targeting chronic pain disorders. Understanding the structure and function of NaV1.7 channels can aid in designing antagonists that suppress pain signalling. Hence, by utilising insights from CIP we can develop pain-killers.

6. ACKNOWLEDGEMENTS

I would like to extend my sincere gratitude to my supervisors Ms. Adit Kaur and Dr. Tripti Dogra who guided me at every step. This research has only been possible because of the constant support of my family.

7. REFERENCES

ClevelandClinic, MedlinePlus, PubMed Central, MayoClinic, NIH, WebMD.

A Hybrid AI System for Distinguishing Alopecia Areata from Trichotillomania and Automating Disease Severity Assessment



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1. INTRODUCTION

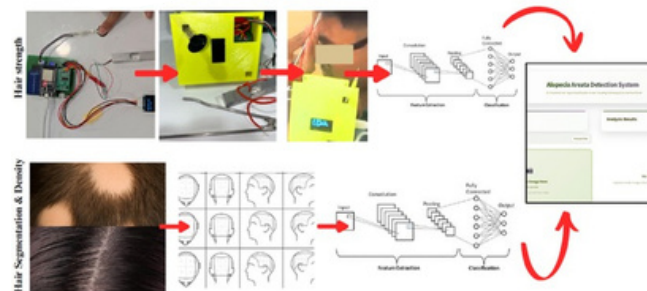
Alopecia areata (AA) is an autoimmune hair loss disorder characterized by patchy scalp baldness. Clinically, AA is often confused with Trichotillomania and other patchy hair-loss conditions, delaying appropriate treatment. The current Severity of Alopecia Tool (SALT) score has high interobserver variability, is impractical for routine use, and does not account for important factors like follicle density, subclinical follicular damage, and regrowth potential.

This project develops a hybrid AI severity assessment system using deep learning-based image analysis, follicle density mapping, patch shape analysis, and hair strength measurements to provide an objective, automated, and reproducible assessment system for AA, reducing misdiagnosis by helping distinguish AA from Trichotillomania.

2. Objectives

- Integrate dermatologist-assigned SALT scores to train an objective and reproducible severity scoring system.
- Design a load cell-based prototype to measure hair tensile strength, computing a Hair Strength Index (HSI) as an additional diagnostic metric
- Combine imaging, density, geometric, biomechanical, and stress-related metrics to reliably distinguish Alopecia Areata from Trichotillomania and quantify disease severity.
- Improve accuracy of diagnosis, symptom identification, treatment planning, and real-time monitoring.

3. Materials and Methods



[Image 1: A flowchart showing the system workflow to detect the hair strength and segmentation]

- High-resolution scalp images were gathered and annotated with expert SALT scores by dermatologists.
- Images were pre-processed using contrast enhancement techniques (CLAHE) and region of interest extraction.
- Convolutional neural network (CNN) analyzed hair structures, identified bald spots, and reported hair follicle density (mm^{-2}).
 - Patch characteristics like shape, boundary smoothness, and breakage patterns helped distinguish AA and Trichotillomania.

- Hair strength analysis used an HX711 load cell, a custom circuit board, and automated data logging, producing HSI in N/mm^2 .
- Outputs were compared with dermatologist-assigned scores for correlation, inter-rater reliability, and classification accuracy.

4. RESULTS

- Strong correlation of automated scores with expert ratings.
- Stress correlated with higher SALT score ($r=0.62$), lower follicle density ($r=-0.55$), and weaker hair strength ($r=-0.48$). HSI reliably distinguished mild from severe cases, while CNN-based follicle detection assessed hair loss patterns and broken hair consistent with Trichotillomania. The system integrates imaging, density analysis, and biomechanical hair testing to produce real-time assessments of hair loss pattern disorders in under 30 seconds.



[Image 2: A set of 5 charts and graphs showing the statistical accuracy of the system]

5. DISCUSSION

- The HSI is a novel biomarker that improves reliable clinical differentiation between AA and Trichotillomania
- Future development can incorporate 3D volumetric scalp analysis to improve the assessment of diffuse or complex-pattern hair loss and enhance longitudinal monitoring.

6. CONCLUSIONS

The system showed a strong correlation with dermatologist ratings and reduced subjective variability with real-time assessments. Stress trends aligned with clinical parameters, and HSI clearly reflected severity gradation. Overall, the hybrid approach confirmed that imaging, density analysis, and biomechanical testing could provide a more integrated assessment of hair-loss pattern disorders, reducing misdiagnoses.

7. REFERENCES

- Olsen EA, Canfield D. *SALT II*. J Am Acad Dermatol. 2016;75:1268–1270. <https://doi.org/10.1016/j.jaad.2016.08.042>
- Al-Dhubaibi MS et al. *Trichoscopy pattern in alopecia areata*. Skin Res Technol. 2022;28:268–281. <https://doi.org/10.1111/srt.13378>

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1. INTRODUCTION

Chlorine-based disinfectants employed in swimming pools constitute complex chemical systems that interact with organic materials introduced by bathers, such as sunscreen constituents including oxybenzone. Upon interaction, these compounds facilitate the formation of disinfection byproducts (DBPs), some of which exhibit elevated toxicity and possess greater genotoxic potential than their parent substances.

2. AIM

The aim of this study is to evaluate the synergistic toxicity of chlorine and sunscreen using both *Allium fistulosum* & *Saccharomyces cerevisiae* root growth and yeast metabolic activity as biological indicators.

3. METHODOLOGY

Yeast (*Saccharomyces cerevisiae*) was cultured in a glucose-rich medium and systematically allocated into four experimental groups: sunscreen (A), chlorine (B), combined (C), and control (D) treatment. Foam production was quantitatively monitored over time as an indicator of respiratory activity.

Microscopic analysis, pH determination, and alcohol measurement assays were conducted to evaluate cellular integrity and metabolic function. Similarly, *Allium fistulosum* roots were subjected to identical treatments to assess growth inhibition.

4. RESULTS

The control group showed a steady increase in foam production, while combined treatment group displayed the lowest foam production indicating metabolic inhibition (Fig.1). The pH analysis showed a slight decrease in the combined solution compared to others (Fig.2). Microscopic observations revealed aggregation of yeast cells in the combined treatment (Fig.3), suggesting a stress response.

Fig 1: Yeast foam height after 40 minutes

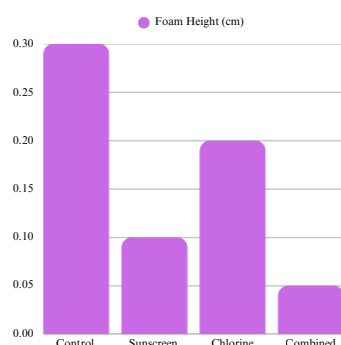
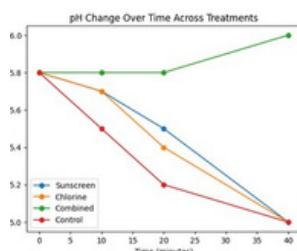


Fig 2: Change in pH of treatment groups

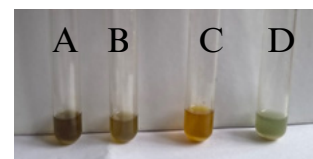


Additionally, no alcohol was produced in the combined group, while control showed the highest and others moderate levels indicating decreased metabolic activity (Fig.4). The *Allium fistulosum* results showed a similar pattern, with the combined treatment causing the greatest inhibition of root growth.

Fig 3: Microscopic image of yeast in combined treatment



Fig 4: Alcohol detection test



5. DISCUSSION

The findings indicate synergistic toxicity, likely due to reactive byproducts formed during chemical interaction. Yeast cell aggregation suggests cellular stress, while reduced alcohol production indicates impaired metabolic function. The lower pH in the combined treatment may further contribute to enzyme inhibition and cellular disruption.

6. CONCLUSIONS

This study demonstrates that the combined exposure to chlorine and sunscreen results in enhanced toxicity, significantly impacting both cellular integrity and metabolic function. These findings underscore the critical importance of evaluating chemical interactions within complex real-world environments, as well as their broader biological and toxicological implications.

7. ACKNOWLEDGEMENTS

I would like to acknowledge my school and mentors for their guidance and support in conducting this research.

8. REFERENCES

- Richardson, S. D., & Ternes, T. A. (2018). Analytical Chemistry, 90(1), 398–428.
- Weng, S., et al. (2012). Environmental Science & Technology, 46(12), 6833–6840.
- Walker, G. M. (1998). Yeast Physiology and Biotechnology.

The listed references represent key sources; additional peer-reviewed studies were consulted during the research process.

Potential of Glycyrrhizin (*Glycyrrhiza glabra*) as an Inhibitor of Tropomyosin (Lit v 1) Induced Shellfish Allergy in *Litopenaeus vannamei*

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1. INTRODUCTION

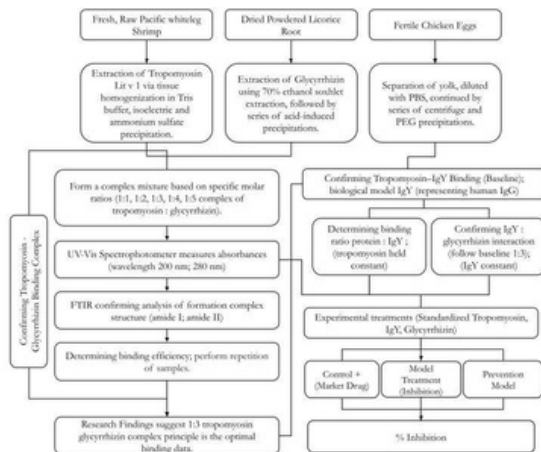
Shellfish allergy has become a serious health problem globally, one of which is shrimp allergy. Approximately 0.5%–2.5% of people worldwide are affected by shellfish allergy, and 7.7% of adults in Asia [1]. Around 80% of the shrimp in Indonesia comes from the Pacific White Shrimp (*Litopenaeus vannamei*), the primary shrimp aquaculture species in Indonesia [2], with tropomyosin Lit v 1 being the major allergenic protein. Glycyrrhizin is a bioactive compound from licorice root (*Glycyrrhiza glabra*) that has immunomodulatory properties to reduce allergic response.

2. A IMS

This research aims to quantitatively confirm complex formation via spectrophotometric instruments and to evaluate the biological effect of glycyrrhizin on tropomyosin-induced immunoglobulin interaction using IgY from chicken eggs as a model treatment.

3. M ETHODS AND MATERIALS

Extraction of tropomyosin, glycyrrhizin, and IgY are collected, forming complexes that are analyzed via UV-Vis and FTIR.



Determining the binding efficiency and inhibition percentage of a complex using the respective formula.

$$\text{Binding Efficiency} = 100 \times \left(1 - \left(\frac{C_{G\text{Free}}}{G_{\text{Initial}}} \right) \right)$$

$$\% \text{ Inhibition} = \frac{A_{\text{Control}(-)} - A_{\text{Sample}}}{A_{\text{Control}(-)}} \times 100$$

4. RESULTS

Table 1. Binding Efficiency of protein: glycyrrhizin ratio.

Ratio	cP (ppm)	%P Remained	cG (ppm)	%G Free	Binding Efficiency
1:1	85.30	85.30%	11.23	11.23%	88.77%
1:2	54.70	54.70%	26.46	13.23%	86.77%
1:3	26.62	26.62%	29.23	9.74%	90.26%
1:4	14.47	14.47%	49.24	12.31%	87.69%
1:5	11.69	11.69%	60.11	12.02%	87.98%

Table 2. Glycyrrhizin Interaction. Table 3. Experimental groups

Sample	A280 Value	Theoretical A280	ΔA	Sample	A280	%Inhibition
Trop + IgY (Control)	0.301	$(0.023 \times \frac{1}{3}) + (0.327 \times \frac{1}{3}) = 0.251$	+ 0.060	Trop + IgY + Market Drug	0.166	12.2%
Tropomyosin + Glycyrrhizin (1:3)	0.268	$(0.121 \times \frac{1}{3}) + (0.327 \times \frac{1}{3}) = 0.276$	- 0.008	Trop + IgY → + Gly (Treating)	0.152	19.6%
IgY + Glycyrrhizin (1:3)				Trop + Gly → + IgY (Prevention)	0.134	29.1%

5. DISCUSSION

Using Beer-Lambert Law, 1:3 ratio is identified as the optimal ratio in utilizing free glycyrrhizin. UV-Vis 280 nm showed tropomyosin-IgY complex exceeding theoretical value, $\Delta A = +0.045$. Where, the plateau beyond 1:1 ratio, confirms stoichiometric 1:1 binding. Glycyrrhizin ($A_{280} = 0.327$) showed minimal IgY interaction at 1:3 ($\Delta A = -0.008$), highlighting its minimal interaction with the antibody. However, it showed strong tropomyosin-glycyrrhizin interaction at the same ratio. This leads to inhibition of Prevention (29.1%, $A = 0.134$) > Treatment (19.6%, $A = 0.152$) > Market drug (12.2%, $A = 0.166$). Thus, supporting that glycyrrhizin primarily acts as a preventive epitope-masking agent by binding tropomyosin before antibody recognition.

6. CONCLUSIONS

Glycyrrhizin at a 1:3 ratio preferentially binds tropomyosin rather than IgY, reducing antigen-antibody interaction. It is most effective in the prevention model, supporting its role as a preventive epitope-masking agent.

7. ACKNOWLEDGEMENTS

Deepest gratitude to our research advisors for their guidance, Santa Laurensia Alam Sutera High School, as well as Center for Young Scientists. Special appreciation to Prof. Dr Anggraini Barlian, M.Sc., from Institut Teknologi Bandung for her constructive feedback.

8. REFERENCES

- [1] Leung, P. S. C., Chow, W. K., Duffey, S., Kwan, J. H. S., Gershwin, M. E., & Chu, K. H. (1996). IgE reactivity against a cross-reactive allergen in crustacea and mollusca: Evidence for tropomyosin as the common allergen. *Journal of Allergy and Clinical Immunology*, 98(5), 954–962.
- [2] Perkumpulan Migunani dan Mberkahi, AKATIGA, & ELSAM. (2024). Net profits, human costs: How supermarkets shape exploitation in shrimp aquaculture. AKATIGA & ELSAM.

A Bio-Responsive Gold Nanoparticle Platform with Machine Learning Integration for Intelligent Cysteine Detection

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1. INTRODUCTION

Accurate detection of L-cysteine is crucial because abnormal levels of it are linked to liver dysfunction, cardiovascular diseases, and neurodegenerative disorders. However, conventional detection methods, such as UV-Vis Spectrometry often require expensive instrumentation and specialized laboratory environments, limiting accessibility in low-resource settings. Gold nanoparticles (AuNPs) are suitable for colorimetric sensing applications, due to surface plasmon resonance (SPR) and their property of covalently binding thiol (-SH) groups, such as the one of L-cysteine, enabling simple visual detection and supporting early disease identification.

2. AIMS

The purpose of this project was to demonstrate that knowledge accumulated from chemistry, physics, biology, and computer science can be combined to develop a platform to centralize the solution analysis process. The project also sought to integrate experimental data into a machine learning model and develop a web-based application for rapid and portable L-cysteine quantification, supporting biomarker monitoring, with potential

biological and medical applications and a social impact.

3. METHODS AND MATERIALS

The AuNPs were synthesized using the Turkevich method [2], forming the colloidal gold solution. Subsequently, 600 μ l of 2% tetrachloroauric acid solution (HAuCl_4) was diluted in 98 ml ultrapure water, to which 2 ml of 1% trisodium citrate dihydrate ($\text{Na}_3\text{C}_6\text{H}_5\text{O}_7 \cdot 2\text{H}_2\text{O}$) was added at near boiling temperature, reducing Au^{3+} into Au^0 , forming a ruby-red colloidal suspension.

For colorimetric detection, 800 μ l of the gold colloid was mixed with L-cysteine in the range of 10^{-8} to 10^{-3} M concentration.



Figure 1. HAuCl_4 solution, heating mantle, L-cysteine form used and initial colloidal solution formed

UV-VIS spectrometer (Jasco V-630) was used to detect the AuNPs SPR changes in the presence of L-cysteine.

In parallel, a machine learning ensemble was implemented in a web-based application to quantify L-cysteine based on photos of the mixtures captured within an eco-friendly illuminating box.

4. RESULTS

The addition of L-cysteine exceeding 10^{-5} M led to a color change of the AuNPs/L-cysteine mixture towards purple-black color (Figure 2).

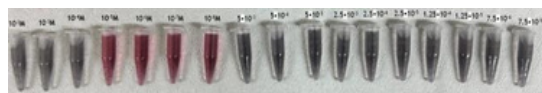


Figure 2. AuNPs mixtures with L-cysteine 10^{-8} M - 10^{-3} M showing the color change.

UV-VIS absorbance measurements confirmed that modification in color results in AuNPs aggregation, as the SPR band at 525 nm decreases with L-Cysteine concentration and a new band above 600 nm is formed as NPs aggregate due to L-cysteine binding to the AuNPs surface.

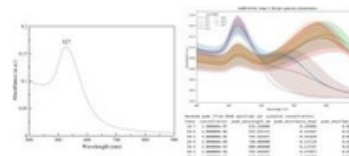


Figure 3. Absorbance spectrum showing the SPR peak at 527nm (~ 20 nm NPs). UV-VIS absorbance band of AuNPs/L-cysteine mixtures presented as mean and standard deviation.

Photos of the mixtures were made and uploaded into a web-based application which converts the photos into RGB scaling (Figure 4). Based on this dataset a Random Forest & Gradient Boosting ensemble was trained resulting in a $R^2=0.86$, $RMSE=0.015$ respectively.

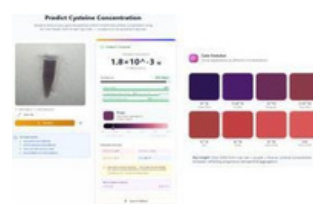


Figure 4. L-cysteine sensor results and a visual cue of the possible detectable solutions.

5. DISCUSSION

The performance of the platform demonstrates a high potential for Point-of-Care (PoC) diagnostics. However, a Limit of Detection (LOD) was observed at 10^{-6} M, indicating that lower concentrations do not lead to NPs aggregation.

6. CONCLUSIONS

Therefore, RGB image recognition combined with AuNP-based colorimetric sensing enabled the development of a portable platform for L-cysteine detection, capable of rapid quantitative analysis. These findings provide a framework for future biomedical applications, demonstrating a practical approach for point-of-care monitoring of thiol-containing biomolecules.

7. ACKNOWLEDGEMENT

I sincerely thank Assist. Prof. Ștefania Iancu (Babeș-Bolyai University of Cluj-Napoca), as well as Prof. Violeta Sarca (Avram Iancu Theoretical High-School of Cluj-Napoca) for their invaluable guidance and support. I'm also grateful for my family's support emotionally, as their encouragement was the cornerstone of this project's success. And lastly, this project would not have been possible without UBB Physics Laboratory and the provided equipment.

8. REFERENCES

- [1] Nguyen T., Han O., E. Bi Lim, Haam S., Park J. and Lee S. (2021) *The effect of pH and transition metal ions on cysteine-assisted gold aggregation for a distinct colorimetric response* The Royal Society of Chemistry in Volume 11, Issue 19
- [2] Kimling, J., Maier M., Okenve B., Kotaidis V., Ballot H. and Plech A. (2006) *Turkevich method for gold nanoparticle synthesis revisited* The Journal of Physical Chemistry B 2006 110 (32), 15700-15707 DOI: 10.1021/jp061667w

Sustainable Valorisation of Black Chokeberry (*Aronia melanocarpa*) and Sea Buckthorn (*Hippophae rhamnoides*) By-Products through the Development of an Antimicrobial Sticker

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1. INTRODUCTION

Plastic stickers are commonly used for labeling fresh produce, but they contribute to environmental pollution and microplastic contamination. At the same time, the fruit processing industry discards large amounts of by-products, despite them containing valuable bioactive compounds. Black chokeberry and Sea buckthorn by-products are rich in phenolic compounds, known for their antimicrobial and antioxidant potential [1]. Valorising these residues by reintroducing them in the production cycle could provide sustainable alternatives for food packaging while reducing food waste.

2. AIMS

The aim of the research was to develop a biodegradable, antimicrobial sticker that can be applied directly on fruit by incorporating phenolic extracts from chokeberry and Sea buckthorn pomace and then evaluate its chemical and microbiological properties. [2, 3]

3. METHODS AND MATERIALS

Fruit by-products were obtained by mechanical pressing, using a juicer. The material was then freeze-dried at -55°C for 72 hours and ground to obtain a homogeneous powder. The phenolic compounds were extracted using ultrasound-assisted extraction (20 kHz, 30 W, 30 min) [4, 5], followed by centrifugation and filtration of the suspension. The extracts were characterized using high-performance liquid chromatography (HPLC) to identify the present phenols. The separation was achieved using water + 0.1% acetic acid (A) and acetonitrile + 0.1% acetic acid (B) as mobile phases. An alginate-based biofilm was prepared using sodium alginate (2%), glycerol (1.5%), and phenolic extracts as active compounds. The films were shaped into stickers and applied to apples. The antimicrobial activity was evaluated by determining the Total Bacteria Count (TBC) and the Total Yeasts and Molds Count (TYMC).

4. RESULTS

The stickers significantly reduced the microbial activity on the apple's surfaces, achieving a decrease of up to 96–100% of the bacterial load after treating them with the biofilm.

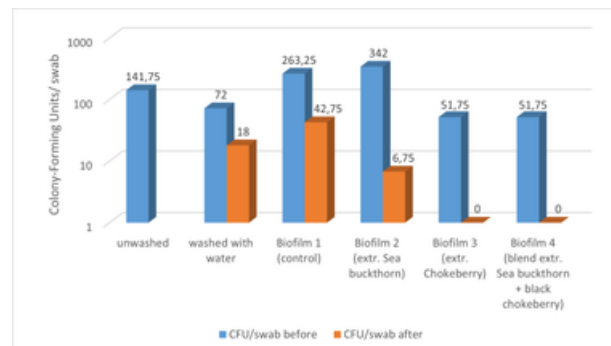


Figure 1. Bacterial load before and after treatment.

5. DISCUSSION

The results we have obtained so far demonstrate that phenolic-rich fruit residues can be successfully incorporated into biodegradable alginate matrices to create antimicrobial materials. These alternatives could replace conventional plastic fruit labels while contributing to the circular valorisation of agri-food waste.

6. CONCLUSIONS

Alginate-based stickers containing chokeberry and Sea buckthorn extracts effectively reduced microbial contamination on fruits. The developed biodegradable antimicrobial sticker represents a promising sustainable alternative for active food packaging.

7. ACKNOWLEDGEMENT

We thank our coordinator, Mrs. prof. dr. Alexandrina Aldea, Chemistry Department CNGC, and the research team at the Institute of Life Sciences, Department of Food Science, prof. dr. Dan C. Vodnar and dr. Diana Plămadă, for their support and expertise.

8. REFERENCES

- [1] Vasile Coman, Bernadette-Emőke Teleky, Laura Mitrea, Gheorghe Adrian Martău, Katalin Szabo, Lavinia-Florina Călinoiu, Dan Cristian Vodnar, Bioactive potential of fruit and vegetable wastes, 2020
<https://doi.org/10.1016/bs.afnr.2019.07.001>
- [2] Drăghici-Popa, A.-M.; Părvulescu, O.C.; Stan, R.; Brezoiu, A.-M. Optimization of Ultrasound-Assisted Extraction of Phenolic Compounds from Romanian Blackthorn (*Prunus spinosa* L.) Fruits Antioxidants, 2025
<https://doi.org/10.3390/antiox14060680>
- [3] Wu, D.; Yang, Z.; Li, J.; Huang, H.; Xia, Q.; Ye, X.; Liu, D. Optimizing the Solvent Selection of the Ultrasound-Assisted Extraction of Sea Buckthorn (*Hippophae rhamnoides* L.) Pomace: Phenolic Profiles and Antioxidant Activity, 2024
<https://doi.org/10.3390/foods13030482>
- [4] Nora Pap, Pertti Marnila, Juha-Matti Pihlavan, Jenni Tienaho, Optimization of ultrasound-assisted extraction of the Sea buckthorn leaves, characterization of the phenolic compounds, and determination of bioactive properties of the extracts, 2024
<https://doi.org/10.1016/j.tifs.2024.100487>
- [5] Milica Ramić, Senka Vidović, Zoran Zeković, Jelena Vladić, Aleksandra Cvejin, Branimir Pavlić, Modeling and optimization of ultrasound-assisted extraction of polyphenolic compounds from *Aronia melanocarpa* by-products from filter-tea factory, 2015
<https://doi.org/10.1016/j.ultsonch.2014.10.002>

Polymorphism of the PER3 gene and its association with sleep-wake preference

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1. INTRODUCTION

In the human body, circadian rhythms are regulated by specific genes. One of such genes is PER3. The coding region of the PER3 gene contains a variable number of tandem repeats (VNTR), differing from person to person. Studies have shown that individuals who prefer evening activity (“owls”) are more likely to carry the PER3 allele with 4 repeat copies, whereas those who prefer morning activity (“larks”) more commonly have the allele with 5 repeat copies. The frequency of alleles in humans depends largely on demographic history and natural selection acting on circadian phenotypes. Additionally, PER3 gene is known to influence sleep duration, quality, and vulnerability to sleep deprivation.

2. AIMS

The aims of the work were to find a correlation between human chronotypes and the PER3 gene allele variants of the population in Moscow and the Moscow Region and find out, what sleep disorders PER3 gene is mostly associated with.

3. METHODS AND MATERIALS

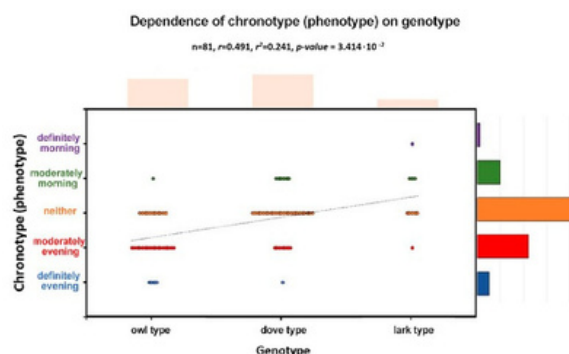
1. I selected participants (students, teachers, social workers) aged 15-35 at the Skolkovo innovation center territory and identified their phenotypes based on the results of the Horn-Östberg chronotype questionnaire;
2. Then I identified participants' genotypes through PCR and gel electrophoresis (performed under the supervision) of DNA samples taken from participants' buccal epithelial cells;
3. Later I calculated Pearson correlation coefficient (r), r^2 , p -value for the sample group;

$$r = \frac{\sum (x - \bar{x})(y - \bar{y})}{\sqrt{\sum (x - \bar{x})^2 \sum (y - \bar{y})^2}} \quad (1)$$

4. Lastly, I built a biological knowledge graph for the PER3 gene using the PandaOmics database to identify diseases PER3 gene is mostly associated with.

4. RESULTS

38 out of 81 participants had genotypes “dove” and were heterozygous. Participants in the sample group were in the Hardy-Weinberg equilibrium: frequency of PER3 4-repeat allele was 0.638; frequency of PER3 5-repeat allele was 0.35. There was a moderate correlation ($r = 0.491$) between PER3 gene variants and sleep-wake preferences of participants. Also, statistical significance of data (p -value $3.414 \cdot 10^{-2}$) was observed.



According to PandaOmics Indication Prioritization (Fig. 1), PER3 is most associated with unipolar depression, colorectal cancer, obesity, type II diabetes, and inflammatory bowel disease.

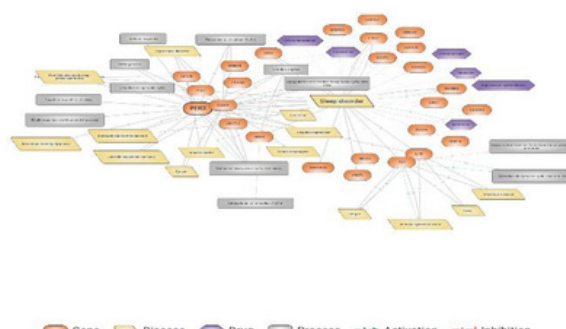


Figure 4. The biological knowledge graph

5. DISCUSSION

1. To refine the results and identify a more reliable correlation, the sample size needs to be increased to a greater extent. Research can be conducted among different age groups, as adolescents often experience shifts in their sleep-wake patterns.

6. CONCLUSION

The hypothesis that PER3 gene polymorphism correlates with chronotypes of people living in Moscow and the Moscow Region was confirmed. Applications for the work could include implementing genetic tests for chronotype identification with further recommendations related to personalised daily routine and/or associated health risks.

7. ACKNOWLEDGEMENT

I would like to thank my supervisor, Kholkina Arina, for help and support during project preparation.

8. REFERENCES

Archer S.N., Robilliard D.L., Skene D.J., Smits M., Williams A., Arendt J., von Schantz M. A length polymorphism in the circadian clock gene Per3 is linked to delayed sleep phase syndrome and extreme diurnal preference // Sleep, 2003, V. 26, № 4, p. 413–415.

A study of the ability of birds to visual categorical learning on a «bead floor»: the effect of the size of the visual insentives

1. INTRODUCTION

In typical visual categorization research, there is extended training that prevents identifying the moment when new categories emerge. Therefore a fast-learning model based on innate features of birds has been proposed.

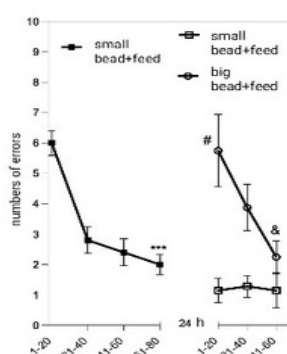
2. AIMS

The aims of this work is to study aspects of visual categorical learning in birds on a beading floor model.

3. METHODS AND MATERIALS

Chickens and zebra finches were trained in a laboratory. Pigeons were trained in natural conditions. The latency period, total session time and number of errors were recorded. The «bead floor» represents beads with a diameter 2 or 4 mm located in 12 rows of 15 in each, at a distance of 15 mm from each other, are glued to the floor of the experimental chamber.

4. RESULTS AND DISCUSSION



***p <.001 compared to the 1st block;

#p <.05 compared to the "small beads+ feed" group;

&p <.05 compared to the 1st block for «large beads+feed».

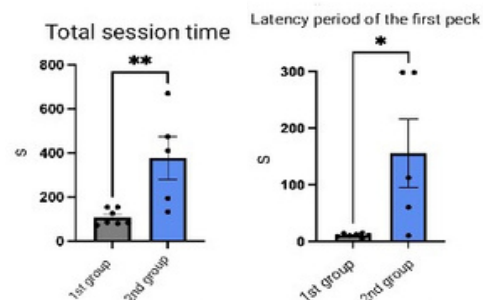


Figure.2 Pigeons, experiments with which were conducted inside the third transport ring of Moscow, show a smaller level of neophobia, expressed in a smaller latent period of the first peck, compared with birds ranged outside of the Moscow Ring Road ($P < 0.05$). It means that the presence of people reduces level neophobia.

5. CONCLUSIONS

1) Three-day-old chicks can form a new visual category during a single learning session, but they cannot include larger objects in it. 2) The presence of people reduces neophobia. 3) Vocalization ability doesn't affect categorization.

6. ACKNOWLEDGEMENT

I express my gratitude to the administration of the Institute for Advanced Brain Research for providing the opportunity to work, as well as to Anna Alexandrovna Tiunova and Ekaterina Andreevna Diffiné for their scientific guidance and valuable advice in this work.

7. REFERENCES

Figure.1 Successful chicken training and testing.
Each point represents the average number of errors
(SEM) in training and testing.

Güntürkün O., Rose J. Learning and
memory in avian species: from
behavior to brain mechanisms.
Neurosci. Biobehav. Rev. 2009;33:1–
17.

Asymmetric triarylantimony dicarboxylates as potential antileishmanial agents: synthesis and structure

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1. Introduction

Compounds containing Sb(V) are widely used to treat *Leishmaniasis*, but the emergence of resistance to antimony therapy requires the development of new antimony-based drugs. In this context, the chemistry of new triorganoantimony carboxylates of the type $\text{Ar}_3\text{Sb}(\text{O}_2\text{CR})_2$ presents particular interest. The

addition of asymmetric ligands is especially promising, as it allows for the combination and fine-tuning of key properties such as lipophilicity, solubility, stability, macrophage penetration, and potential for further structural modification, thereby opening up new opportunities for the development of more selective and less toxic drugs. In this study, three new asymmetric tri-*para*-tolylantimony dicarboxylates were synthesized by disproportionation and transacylation of symmetric starting dicarboxylates and characterized using several analytical methods.

2. Aims

The aim of this work is to obtain various tri-*para*-tolylantimony dicarboxylates, as well as to study the composition and structure of these compounds for further investigation of their antiparasitic properties against *Leishmaniasis*.

3. Methods and materials

Symmetrical dicarboxylates were obtained via oxidative addition by reaction between tri-*para*-tolylantimony and the corresponding acids in the presence of peroxide. Asymmetrical were obtained by two different approaches [Figure 1]:

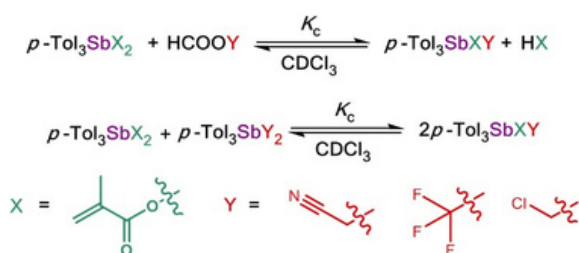


Figure 1. – Schemes of obtaining triorganoantimony dicarboxylates.

4. Results

A series of 9 tri-*para*-tolylantimony dicarboxylates were identified by NMR spectroscopy. For some compounds, single crystals were obtained and their structures were determined by X-ray diffraction. A new reversible reaction of partial transacylation of a symmetrical dicarboxylate with a stronger carboxylic acid has been described. An important result is the demonstration of the correlation between product yield and the pK_a of the acids used [Figure 2].

R	CH_2Cl	CH_2CN	CF_3
Kc	5.6	11.4	39.3
pKa	2.86	1.59	0.23

Kc increasing with pKa decreasing →

Figure 2. – Dependence of the equilibrium constant on the strength of the acid.

The solvent (CD, DMSO- d_6 , and others) also contributes to the reaction equilibrium.

5. Discussions

Five new tri-*para*-tolylantimony dicarboxylates have been synthesized for the first time. The obtained compounds may theoretically possess antileishmanial activity due to the presence of pentavalent antimony.

6. Acknowledgment

Thanks to Nizhny Novgorod State University for providing equipment and materials.

7. References

«Investigations into a Change of Aryl Group on the Cytotoxicity and Anti- Leishmanial Activity of a Series of Tris-Aryl Sb (V) Pentafluoropropionates» / E.V. Artem'eva, R.N. Duffin, S. Munuganti, A.N. Efremov, P.C. Andrews, O.K. Sharutina, V.V. Sharutin // Polyhedron. 2022. Vol. 213. P. 115627–16742.

Effects of intermittent theta burst stimulation on neuron-like SH-SY5Y cell phenotype

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1. INTRODUCTION

The human central nervous system is composed of highly specialized neurons responsible for signal transmission and cognitive function. Due to their ability to differentiate into neuron-like cells, the human neuroblastoma cell line SH-SY5Y is widely used for studying neuronal function as an in vitro model in Parkinson's disease research.^[1] This was the main motivation for this research, as a close family member was affected by this disease. Transcranial magnetic stimulation (TMS) is a non-invasive neuromodulation technique that alters neuronal activity through the application of time-varying magnetic fields. Intermittent theta burst stimulation (iTBS) is a patterned form of TMS designed to mimic endogenous theta-gamma neuronal activity and induce long-lasting modulatory effects.^[2]

2. AIM

The aim of this study was to evaluate the effects of intermittent theta-burst magnetic stimulation on SH-SY5Y cells and to determine if iTBS alone can induce differentiation and promote neuronal-like characteristics in vitro.

3. METHODS AND MATERIALS

SH-SY5Y cells (used up to 10th passage) were cultured in DMEM with 10 % fetal bovine serum (FBS), 1 mM sodium pyruvate, penicillin (100 IU/mL) and streptomycin (0.1 mg/mL) at 37 °C in a humidified 5 % CO₂ atmosphere. Three experimental groups were established: undifferentiated SH-SY5Y cells cultured under standard conditions (SH-CTRL), undifferentiated cells exposed to iTBS (SH+ITBS), and differentiated SH-SY5Y cells maintained under differentiation conditions (10 µM retinoic acid (RA) in 1 % FBS + 80 nM phorbol 12-myristate 13-acetate (PMA)^[3]; not stimulated, SH-DIF). All cells were seeded on poly-L-lysine-coated coverslips or standard petri dish plates and the medium was changed every two days. iTBS was delivered to SH+ITBS cells with a figure-of-eight coil (600 pulses: 20 trains of 3 pulses at 50 Hz, repeated at 5 Hz; 2 s stimulation, 8 s inter-train interval; 35 % maximal output^[2]) four times daily for 7 days. Non-stimulated SH-SY5Y controls were handled identically. Differentiation was evaluated by immunofluorescence for MAP2, TH, D1DR and D2DR, using confocal imaging and neurite length by light microscopy image evaluation. Western blotting was performed on total proteins separated by SDS-PAGE, transferred to PVDF membranes, blocked with 5 % BSA in TBST, incubated overnight with primary antibodies BDNF (1:2000) and TRK-B (1:1500), then with HRP-conjugated secondary antibodies. The detected chemiluminescence signals were quantified in ImageJ and normalized to the housekeeping protein.

4. RESULTS AND DISCUSSION

Following 7-days iTBS application, SH-SY5Y cells exhibited neuron-like morphological features, including elongated neurite-like extensions, resembling those in SH-DIF group (Figure 1), which proves the beneficial effects of iTBS on neuron-like phenotype induction.

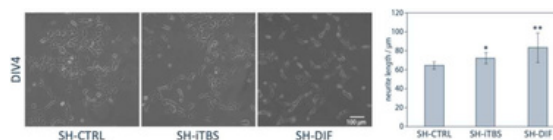


Figure 1. Brightfield micrographs of cell cultures at DIV4 with graph of quantified neurite length

Immunofluorescence analysis revealed changed expression of neuronal markers TH and MAP2, and D1DR and D2DR. It was shown that iTBS treatment induced morphological changes in the cells, such as neurite extension and cell body rounding.

Western blot analysis showed an increase in BDNF expression in SH+ITBS group compared to SH-CTRL (Figure 2), while TRK-B expression remained unchanged. This indicates that the signalization through the existing receptors is possible and, hence, the differentiation was enhanced.

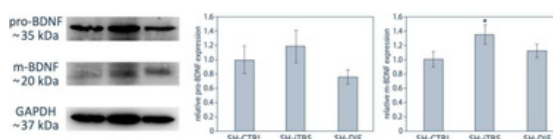


Figure 2. Western blot bands for pro-BDNF, m-BDNF and endogenous control GAPDH with graphs of relative quantification of pro-BDNF and m-BDNF

5. CONCLUSIONS

This research findings confirm successful, albeit partial, neuronal differentiation of SH-SY5Y cells after exposure to iTBS protocol for 7 days, supporting the use of magnetic stimulation as a tool for neuron differentiation enhancement in diverse therapeutic approaches such as in regenerative neurobiomedicine. This work could be expanded to the level of in vitro nervous system in order to fully understand the effects of iTBS on its functioning as an ensemble of neurons.

6. REFERENCES

- [1] Martens et al. 2017. Mol. Neurodegener. 12(1), 10.
- [2] Rothwell et al. 2005. Neur 45(2), 201.
- [3] Haleagrahara et al. 2020. Mol. Biol. Rep. 47(11), 8775.



Examination of the antibacterial activity of the homeopathic preparation "Antisept M" against ESKAPE pathogens



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1. INTRODUCTION

The problem of antibiotic resistance is widespread and represents an increasing challenge in treatment. A particular problem is posed by bacteria from the ESKAPE (*Enterococcus faecalis*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, *Escherichia coli*) group of pathogens, since these strains are prone to developing new resistance mechanisms, and the discovery of new antibacterial compounds is necessary. In traditional medicine, plants have a long history of use in the treatment of various ailments, and their action is based on the diversity of compounds that produce numerous effects, including antibacterial. Literature findings indicate that the essential oil of mint (*Mentha pulegium*) and basil (*Ocimum basilicum*) individually exhibit activity against Gram-positive [1] and Gram-negative [2] bacteria, respectively, served as the basis for testing the commercially available homeopathic preparation Antisept M, which contains these oils.

2. MATERIALS AND METHODS

To test the antimicrobial effect of the aforementioned preparation against ATCC (*American Type Culture Collection*) strains of the ESKAPE group of pathogens, the microdilution method, i.e., the MIC assay, was selected. (Minimum Inhibitory Concentration) [3]. Antisept M was tested in a range of 0.39 to 50%, while the antibiotics vancomycin (0.19-25 µg/mL) and gentamicin (0.006-25 µg/mL) were used as positive controls. Minimum inhibitory concentrations were defined using the bacterial metabolic activity indicator, resazurin, where the last wells with the unchanged (purple) indicator color were declared as the MIC. Additionally, minimum bactericidal concentrations were determined by plating the contents of the wells onto solid medium.

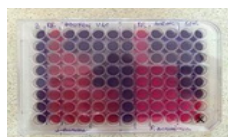


Figure 1. Example of MIC assay on *S. aureus* and *P. aeruginosa*

3. RESEARCH RESULTS

The Antisept M preparation has achieved significant antibacterial effect against all tested strains, with a clear emphasis on better activity against Gram-negative strains. The highest sensitivity was shown by *A. baumannii* with an MIC value of 6.25%, while a slightly higher MIC value was recorded for *K. pneumoniae* and *E. coli* in the range of 6.25-12.5%. *P. aeruginosa* emerged as the most resistant Gram-negative strain tested, with an MIC of 12.5%. For the Gram-positive strains, *S. aureus* and *E. faecalis*, MIC values of 12.5-25% were recorded.

4. CONCLUSION

Antisept M demonstrated significant antibacterial activity against all tested ESKAPE pathogens, with a notable effect on Gram-negative strains. The significant efficacy of the tested preparation warrants further investigation into the mechanisms underlying its effect, particularly against the *A. baumannii* strain.

5. REFERENCES

- [1] Jirovetz, L., Buchbauer, G., Bail, S., Denkova, Z., Slavchev, A., Stoyanova, A., Schmidt, E. & Geissler, M. (2009). Antimicrobial activities of essential oils of mint and peppermint as well as some of their main compounds. *Journal of Essential Oil Research*, 21(4), 363–366.
- [2] Sienkiewicz, M., Łysakowska, M., Pastuszka, M., Bienias, W. and Kowalczyk, E. (2013). The Potential of Use Basil and Rosemary Essential Oils as Effective Antibacterial Agents. *Molecules*, 18(8), 9334-9351.
- [3] Đukanović, S., Cvetković, S., Lončarević, B., Lješević, M., Nikolić, B., Simin, N., Bekvalac, K., Kekić, D. (2020). Antistaphylococcal and biofilm inhibitory activities of *Frangula alnus* bark ethyl-acetate extract. *Industrial Crops and Products*, 158, 113013.

Colloidal stability and response-surface modeling of laser-induced heating in quercetin-loaded hollow porous iron oxide nanoparticles

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1 Introduction

hyperthermia-based cancer therapy relies on localized heating to destroy tumor cells while reducing damage to healthy tissue. Hollow porous iron oxide nanoparticles (HPIONPs) are suitable for this approach because they can efficiently generate heat under near-infrared light and maintain good compatibility in biological systems. A major limitation of hyperthermia, however, is the presence of heat shock proteins (HSPs), which allow cancer cells to tolerate thermal stress and decrease treatment effectiveness. To overcome this, we incorporated quercetin into HPIONPs. Quercetin is known to interfere with HSPs' activity, and by combining it with HPIONPs.

2 Research Methods

This project involved synthesizing hollow porous iron oxide nanoparticles (HPIONPs), loading them with quercetin (Que), and evaluating their colloidal stability and photothermal performance. HPIONPs were produced using a hydrothermal reaction of iron salts, citrate, and urea under high temperature and pressure, then magnetically purified, lyophilized, and redispersed in ultrapure water for 48-hour stability assessment. Particle size, zeta potential, and polydispersity were monitored using Dynamic Light Scattering (DLS) to confirm batch reproducibility and dispersion stability. Que loading was performed by mixing HPIONPs with Que solutions at different concentrations, followed by sonication and shaking to promote diffusion into the porous structure; unencapsulated quercetin in the supernatant was quantified using UV-Visible spectrophotometry to calculate encapsulation efficiency and loading capacity. Stability measurements were repeated for HPIONPs-Que to compare with unloaded particles. Photothermal behavior was examined by exposing nanoparticle suspensions to an 808 nm near-infrared laser and recording temperature changes using a thermal camera. Finally, a Box-Behnken response surface model was developed to quantify the effects of nanoparticle concentration, laser power, and exposure time on temperature elevation and to predict thermal outcomes under different experimental conditions.

3 Results

The synthesized HPIONPs showed consistent particle size and zeta potential across batches, and both unloaded and quercetin-loaded nanoparticles remained stable in dispersion

over 48 hours without signs of aggregation. Que loading analysis indicated that lower initial drug amounts produced higher encapsulation efficiency, while the 1 mg quercetin- to-1 mg nanoparticle ratio yielded the highest absolute drug mass per milligram of HPIONPs, making it the most suitable ratio because the encapsulated amount is comparable to reported IC50 values for many tumor cell lines. Photothermal measurements confirmed that quercetin loading did not interfere with heat generation, as HPIONPs and HPIONPs-Que showed similar temperature increases under near-infrared irradiation. The Box-Behnken model, summarized in Image 1, accurately predicted the experimental temperature outcomes and matched the validation tests closely, confirming that laser power and nanoparticle concentration were the dominant factors influencing thermal elevation, while exposure time contributed minimally after thermal equilibrium was reached. Overall, the nanoparticles demonstrated reproducibility, colloidal stability, effective quercetin loading, and predictable photothermal performance.

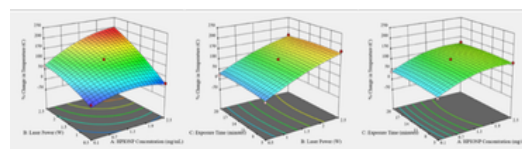


Image 1 – Response surface model of HPIONPs to laser exposure.

4 Conclusion

Quercetin-loaded HPIONPs were successfully synthesized, remained colloidally stable, and carried therapeutically relevant amounts of quercetin. The nanoparticles showed consistent heating under NIR laser irradiation, and the Box-Behnken model accurately predicted temperature changes based on concentration and laser power. These results indicate that HPIONPs-Que have strong potential for controlled, targeted hyperthermia therapy.

5 References

[1.] Malabanan, J. W. T., Alcantara, K. P., Jantaratana, P., Pan, Y., Nalinratana, N., Vajragupta, O., Rojsitthisak, P., & Rojsitthisak, P. (2023) "Enhancing Physicochemical Properties and Biocompatibility of Hollow Porous Iron Oxide Nanoparticles through Polymer-Based Surface Modifications." <https://doi.org/10.1021/acsabm.3c00657>

Preparation of cannabidiol-loaded transethosomes for improved transdermal delivery in psoriasis treatment

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1 Introduction

Psoriasis is an autoimmune condition causing rapid production of skin cells leading to plaques covered with silvery scales. This condition leads to a significant reduction in quality of life of over 125 million patients worldwide. Current therapeutic approaches, such as, topical and oral medications still face limitations in terms of adverse effects and therapeutic efficiency. Consequently, cannabidiol (CBD), a compound known for its anti-inflammatory and antioxidant properties was proposed as an alternative therapeutic agent. However, due to its hydrophobic nature and low skin permeability, the development of an appropriate delivery system is required.

2 Aims

In this study we aim to develop a transethosome-based delivery system that utilize the hydrophilic characteristics of the vesicular system to enhance the transdermal delivery of CBD.

3 Methods and Materials

Transethosomes were prepared with varying the ratios of phospholipids, Tween 80, and CBD, along with investigating multiple concentrations of chitosan solution. Each formulation was characterized in terms of particle size, polydispersity index (PDI), zeta potential, and encapsulation efficiency to identify the optimal formulation for transdermal delivery.

4 Results

Table 1. Particle Size, PDI, Zeta Potential, and %EE of the Optimal Formulation

Particle Size (nm)	Polydispersity Index (PDI)	Zeta Potential (mV)	%EE
108.06 ± 4.66	0.268 ± 0.031	2.36 ± 1.38	77.64 ± 3.52

5 Discussion

The results demonstrated that the formula containing 15 mg of CBD, 210 mg of phospholipids, and 150 mg of Tween 80 in a 0.1 mg/mL of chitosan solution yields an average particle size of 108.06 ± 4.66 nm, a PDI of 0.268 ± 0.031, a zeta potential of +2.36 ± 1.38 mV, and an encapsulation efficiency at 77.64 ± 3.52%. These parameters fall within the optimal range for skin permeation while maintaining its colloidal stability.

6 Conclusion

In conclusion, the CBD-loaded transethosome formulation developed in this study demonstrates strong potential for further development of pharmaceutical products for psoriasis. Nevertheless, additional studies, in vivo animal experiments, and clinical trials in human volunteers, are required to confirm its safety, efficacy, and clinical applicability.

7 Acknowledgement

This project was completed with the guidance and support of several individuals. The authors greatly acknowledge Associate Professor Dr. Pornchai Rojsitthisak (Department of Food and Pharmaceutical Chemistry, Faculty of Pharmaceutical Science, Chulalongkorn University) for providing facilities, expert guidance, and valuable insights throughout this study. We also thank John Wilfred T Malabanan and Natchaya Daengkasem for their assistance with experimental design, technical support, and problem-solving during the research process. Special thanks are extended to Nisa Viriyasitaporn and Chuthaporn Kheawkaew (Science and Technology Department, Bodindecha (Sing Singhaseni) School) for their continuous guidance and constructive feedback. We sincerely appreciate the support and encouragement from our parents and friends throughout this project. The authors apologize for any limitations or errors in this work.

8 References

- [1.] Healthline. (2024). Psoriasis facts and statistics: What you need to know. <https://www.healthline.com/health/psoriasis/facts-statistics-infographic#prevalence>
- [2.] National Institute of Arthritis and Musculoskeletal and Skin Diseases. (2023). Psoriasis. <https://www.niams.nih.gov/health-topics/psoriasis>
- [3.] Mayo Clinic. (2025). Psoriasis: Diagnosis and treatment. <https://www.mayoclinic.org/diseases-conditions/psoriasis/diagnosis-treatment>
- [4.] Sunda, F., & Arowolo, A. (2020). A molecular basis for the anti-inflammatory and anti-fibrosis properties of cannabidiol. The FASEB Journal, 00, 1–10. <https://doi.org/10.1096/fj.202000975R>
- [5.] Souto, E. B., & Carbone, C. (Eds.). (2019). Nanobiomaterials in clinical dentistry (2nd ed.). Elsevier.
- [6.] Chowdary, P., Padmakumar, A., & Rengan, A. K. (2023). Exploring the potential of transethosomes in therapeutic delivery: A comprehensive review. MedComm – Biomaterials and Applications, 2(4), e59. <https://doi.org/10.1002/mba2.59>

Saliva Pops: Development of Artificial Saliva from Okra Mucilage Enhanced with Antimicrobial Efficacy of Chrysanthemum Extract Using Spherification Technique

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1. INTRODUCTION

Xerostomia (dry mouth) is a prevalent condition that significantly impairs oral health, ingestion process, and overall quality of life. Many commercial artificial saliva products lack activity, natural rheological properties, antimicrobial and user acceptability. To address these limitations, there is increasing interest in the development of alternative formulations derived from natural biomaterials with enhanced functional properties. Okra mucilage provides viscoelastic properties similar to natural saliva, while chrysanthemum extract contributes antimicrobial and antioxidant activities. The formulation was designed as a spherical gel (“Saliva Pops”) using spherification techniques to enable controlled release and improved retention in the oral cavity, thereby enhancing functional performance.

2. AIMS

- To develop Saliva Pops from okra mucilage and chrysanthemum extract.
- To evaluate its efficacy.
- To compare Saliva Pops with commercial artificial saliva.

3. METHODS AND METRIALS

Okra mucilage was extracted by soaking dry sliced okra in 95% ethanol, followed by filtration to obtain a polysaccharide-rich solution. Chrysanthemum extract was prepared via 95% ethanol at 25°C, then filtered and concentrated

The formulation consisted of 0.6 g of okra mucilage and 3 g of chrysanthemum extract, dispersed in 100 mL of 20 mM phosphate buffer (pH 7.4). Electrolytes, including potassium chloride (KCl), sodium fluoride (NaF), and calcium chloride (CaCl₂), were incorporated to simulate the ionic composition and physicochemical characteristics of natural saliva. The viscosity was 8.9 ± 0.2 cP to achieve lubrication with non-Newtonian fluid behavior. Anti-inflammatory antimicrobial agents were incorporated to enhance therapeutic efficacy.

Spherical gel formation was achieved using a spherification technique, where the artificial saliva formulation combined with calcium lactate was introduced into a sodium alginate solution to form a thin gel membrane. Physicochemical stability tests (pH, viscosity, and structural integrity) were conducted under storage conditions at 4°C, 25°C, and 40°C for 7 days. All experiments were conducted in triplicate to ensure reproducibility.

4. RESULTS

The formulation exhibited viscoelastic and non-Newtonian properties similar to natural saliva, providing effective oral lubrication. The gel in spherical shape enabled controlled release and prolonged retention in the oral cavity. Microbiological analysis demonstrated inhibitory activity against *Staphylococcus aureus*.

5. DISCUSSION

The findings suggest that okra mucilage is an effective natural polymer for replicating saliva properties due to its high polysaccharide content. Chrysanthemum extract enhances the formulation by providing antimicrobials. The use of spherification technology improves product performance through controlled release and better retention compared to conventional liquid formulations. This may enhance patient compliance and overall effectiveness. Further studies should focus on long-term stability and clinical evaluation to confirm efficacy in real-world applications.

6. CONCLUSION

Saliva Pops is a novel herbal-based artificial saliva that demonstrates suitable physicochemical properties, safety, and stability

7. ACKNOWLEDGEMENT

We would like to express our sincere gratitude to our supervisor and advisor from the Faculty of Science, Naresuan University for their guidance, support, and resources, and to our teacher from Phitsanulok Pittayakom School for their invaluable support. We also extend our appreciation to the Development and Promotion of Science and Technology Excellence Classroom Project and the Institute for the Promotion of Teaching Science and Technology for their support.

8. REFERENCES

1. BioSpace. Xerostomia treatment market: Increase in the incidence of Sjogren's syndrome to drive the market [Internet]. 2022 [cited 2024 Nov 1]. Available from: <https://shorturl.asia/9FdiS>
2. Yookhum N. Prevalence of xerostomia among the elderly in Mueang District, Roi Et Province. *J Res Dev Health Syst*. 2022;15(1):129–141. Available from: <https://he02.tci-thaijo.org/index.php/RDHSJ/article/view/254322/175113>

Smart Chemotherapy Strategy: Engineering a Dual-Stimuli Responsive (pH and Temperature) Doxorubicin Delivery System Using Layer-by-Layer (LbL) Polymer Films

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1.INTRODUCTION

Many chemotherapeutic drugs suffer from low targeting efficiency and severe side effects due to uncontrolled distribution in the body. To address this limitation, stimuli-responsive drug delivery systems have gained increasing attention. In this study, pH- and temperature-responsive multilayer polymer films were engineered using the Layer-by-Layer (LbL) technique with PIPOx and tannic acid complexes loaded with doxorubicin (DOX). The developed nanostructured films exhibited controlled drug release behavior, with significantly faster DOX release under acidic conditions (pH 5.5) compared to physiological conditions (pH 6.5). These findings highlight the potential of multilayer polymer films as smart platforms for targeted and controlled drug delivery in cancer therapy.

2. AIM

To design ultrathin Layer-by-Layer (LbL) polymer films capable of pH- and temperature-responsive controlled release of doxorubicin (DOX) for targeted drug delivery under tumor-like conditions.

HYPOTHESIS PIPO_x/TA multilayer films will

trigger rapid

doxorubicin release under tumor-like conditions (low pH and elevated temperature) while remaining stable under physiological conditions.

3. MATERIALS AND

METHODS

(PIPOx), tannic acid (TA), and doxorubicin hydrochloride (DOX) were used as the main materials to construct the multilayer system. Ultrathin multilayer films were fabricated on cleaned glass or quartz substrates using the Layer-by-Layer (LbL) assembly technique through sequential deposition of PIPOx and TA solutions. The

deposition cycle was repeated multiple times to obtain stable multilayer structures. After film formation, DOX was loaded into the multilayer matrix by immersing the films in a DOX solution under controlled conditions.

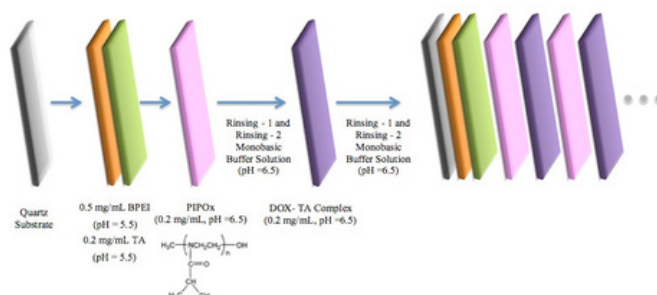


Figure 2. Illustration showing the formation of the multilayer structure composed of PIPOx and DOX-TA complexes.

The drug release behavior of the films was

evaluated under different conditions to simulate physiological and tumor like environments. Release experiments were conducted at different pH values and temperatures to investigate the dual-stimuli responsiveness of the system. The amount of released DOX was monitored using UV-Vis spectroscopy, and the release profiles were analyzed to evaluate the responsiveness and efficiency of the designed drug delivery platform.

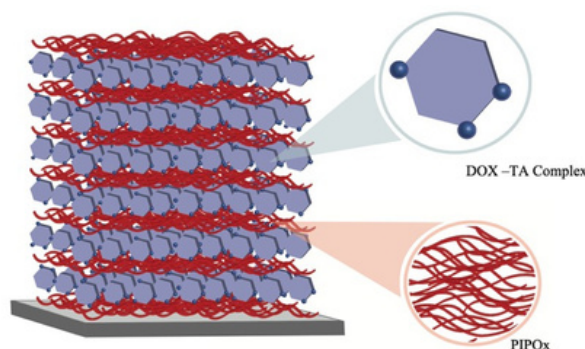


Figure 3. Schematic representation of the drug-loaded multilayer structure.

4. RESULTS

The fabricated PIPOx/TA multilayer films were successfully formed using the Layer-by-Layer (LbL) technique. The results demonstrated that doxorubicin release significantly increased under acidic pH and elevated temperature conditions that mimic the tumor microenvironment. In contrast, drug release remained relatively low under physiological conditions, confirming the dual-stimuli responsive behavior of the designed multilayer system.

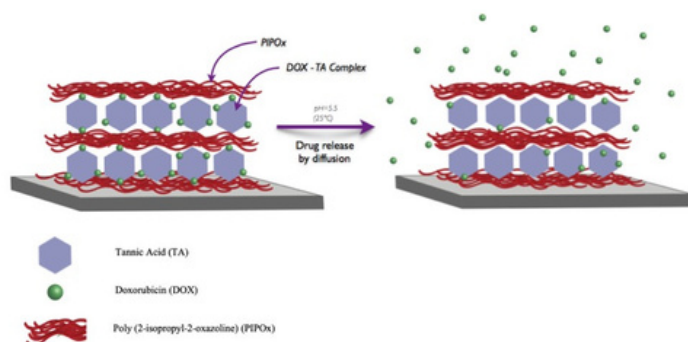


Figure 5. Schematic representation of DOX release under pH 5.5 conditions.

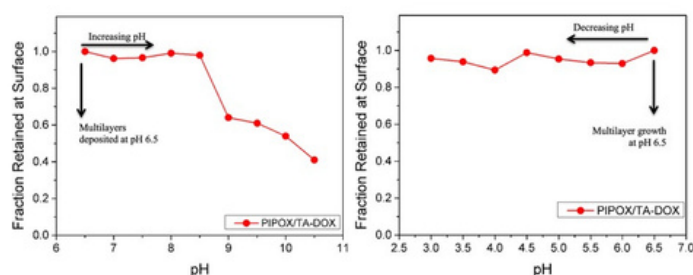


Figure 6. pH Stability of the PIPOx/TA Multilayer Film Containing Doxorubicin (DOX) Under Increasing and Decreasing pH Conditions

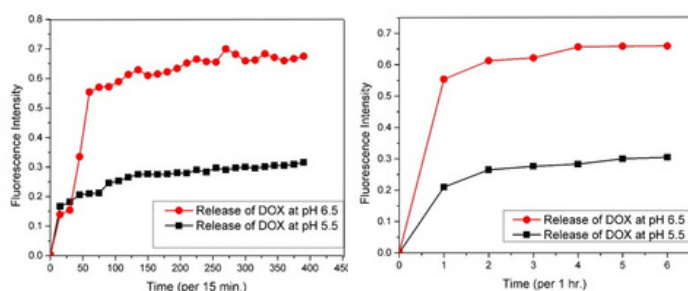


Figure 7. Comparison of DOX release at pH 5.5 and pH 6.5 in PBS solution. Data were collected every 15 minutes and 1 hour.

5. DISCUSSION

The results demonstrate that PIPOx/TA multilayer films exhibit clear pH-temperature-responsive behavior. The increased DOX release under acidic conditions indicates that the system can effectively respond to tumor-like environments.

6. CONCLUSION

The developed multilayer polymer films provide a promising platform for controlled and stimuli-responsive drug delivery, offering potential for chemotherapy more targeted applications.

7. ACKNOWLEDGEMENT

I would like to thank Prof. Dr. İrem Erel Göktepe, Research Assistant at the Department of Chemistry, Middle East Technical University (METU), for her valuable support and guidance. I also sincerely thank my teacher Süleyman Atilla for his contributions and continuous encouragement throughout this study.

8. REFERENCES

- Kim, S. H., Lee, J., Park, S., & Kim, J. (2023). *Tannic acid-based functional biomaterials for biomedical applications*. 33(5), Advanced Functional Materials, 2210405. <https://doi.org/10.1002/adfm.202210405>
- Wang, Y., Zhang, X., & Li, M. (2022). *Layer-by-layer assembled nanofilms for controlled drug delivery: Mechanisms, design strategies, and biomedical applications*. Journal of Controlled Release, 347, 4160. <https://doi.org/10.1016/j.jconrel.2022.04.032>
- Zhang, R., Li, C., & Chen, F. (2021). *Tumor microenvironment-responsive drug delivery systems in cancer therapy*. Nano Today, 38, 101119. <https://doi.org/10.1016/j.nantod.2021.101119>
- Aguilar-Arteaga, K., Mendoza, S., & Méndez-Armenta, M. (2020). *Thermoresponsive polymers for drug delivery applications*. Progress in Polymer Science, 106, 101253. <https://doi.org/10.1016/j.progpolymsci.2020.101253>

Toward Sustainable Plastics:

Bioplastic (PHB) Production Using Genetically Engineered Bacteria

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1. INTRODUCTION

The rapid increase in plastic production and the challenges. As a result, there is a growing need for biodegradable and sustainable alternatives. Polylactide and polylactide-co-polyhydroxybutyrate (PHB) are naturally produced by certain microorganisms and have emerged as promising eco-friendly plastic due to its biodegradability and biocompatibility. In this study, the *phaA*, *phaB*, and *phaC* genes responsible for PHB biosynthesis were introduced into *Escherichia coli* in order to enhance bioplastic production and develop a more efficient microbial system for sustainable PHB synthesis.

2. AIM

The aim of this study is to enhance the biodegradable (PHB) by introducing the *phaA*, *phaB*, and *phaC* genes into *Escherichia coli* and evaluating the effect of genetic modification on PHB yield.

HYPOTHESIS

It is hypothesized that introducing the *phaA*, *phaB*, and *phaC* genes with the non-modified strain.

3. MATERIALS AND METHODS

In this study, *Escherichia coli* was used as the host microorganism for PHB production. PHB biosynthesis was introduced into competent *E. coli* cells using the heat-shock transformation method. Transformed cells were selected on LB agar plates containing ampicillin (100 µg/mL). Positive colonies were used to prepare a pre-culture in 50 mL LB broth, which was then transferred into a 100 mL carbon-rich, nitrogen-limited production medium.

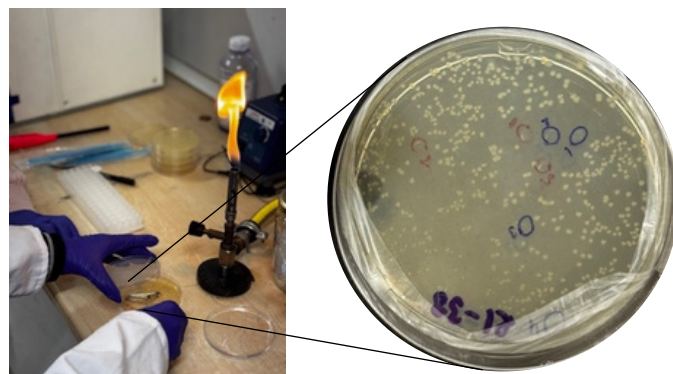


Figure 1. Spreading of the cell suspension onto the surface of antibiotic-containing LB agar and the colonies grown on selective LB agar plate.

Selected bacterial colonies were inoculated into LB broth to prepare a pre-culture and then transferred into a production medium rich in carbon but limited in nitrogen to promote PHB accumulation. Cultures were incubated at 37 °C in a shaking incubator at 180 rpm for 48–72 hours to promote PHB accumulation.

After fermentation, bacterial cells were harvested by centrifugation and dried. PHB was extracted using a chloroform-based solvent extraction method followed by ethanol precipitation to recover the polymer. The recovered polymer was dried and weighed to determine PHB yield relative to the dry cell mass. In addition, PHB accumulation inside bacterial cells was confirmed through microscopic observation using Sudan Black B and Nile Red staining.

4. RESULTS The transformation of *Escherichia coli* with the plasmid carrying the *phaA*, *phaB*, and *phaC* genes was successfully confirmed by the growth of colonies on antibiotic-containing selective LB agar plates. During the fermentation process, both the control and the genetically engineered strains showed similar cell growth; however, the recombinant strain accumulated significantly higher amounts of PHB.

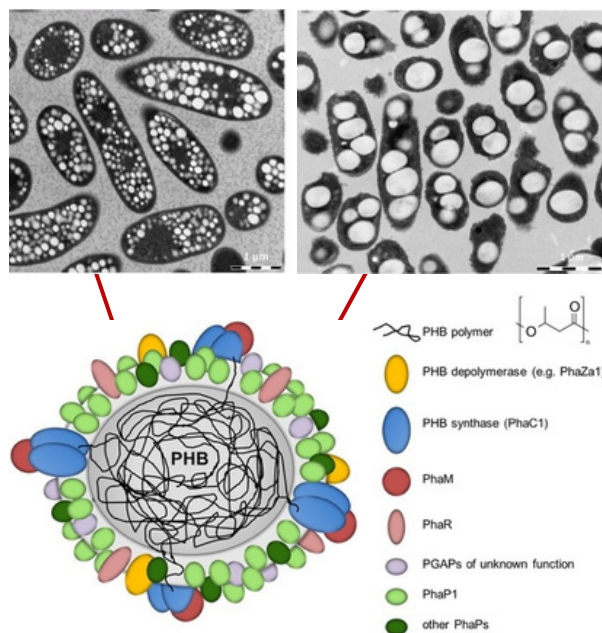


Figure 2. Morphology of intracellular PHB granules in recombinant *Escherichia coli*.

Microscopy revealed cytoplasmic inclusions, while electron microscopy confirmed dense, spherical granules with a hydrophobic polymer core.

Extracted PHB was quantified after solvent-based extraction. The engineered *E. coli* strain showed significantly higher PHB production than the control strain.

Quantitative analysis revealed that the PHB yield increased from approximately 1–2% in the control strain to nearly 18–20% in the engineered strain. Microscopic observations using Nile Red and Sudan Black B staining further confirmed the presence of dense intracellular PHB granules in the genetically modified bacteria. These results demonstrate that genetic modification significantly enhances PHB production in *E. coli*.

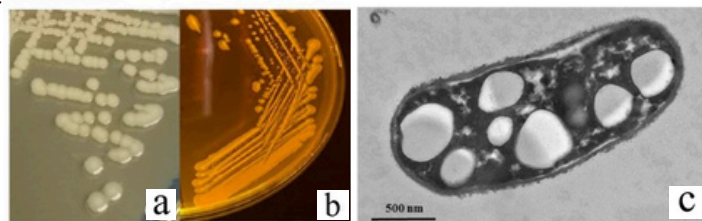


Figure 3. PHB accumulation in recombinant *Escherichia coli*. Colony morphology is shown in panel (a). Nile Red fluorescence imaging (b) indicates active intracellular PHB biosynthesis. Transmission electron microscopy (TEM) images (c) further confirm the presence of electron-dense PHB inclusions within the cytoplasm of cells grown in medium containing 2% (v/v) PPH.

5. DISCUSSION

The results show that introducing the *phaA*, *phaB*, and *phaC* genes into *E. coli* significantly increased PHB production. The engineered strain accumulated much higher intracellular PHB than the control strain, confirming that genetic modification enhances microbial bioplastic synthesis.

6. CONCLUSION

The results show that introducing the ***phaA*, *phaB*, and *phaC*** genes into *E. coli* significantly increased PHB production from **1.2% to about 18–20% of dry cell mass**. These findings demonstrate that genetic engineering can effectively enhance microbial bioplastic production and support the potential of engineered bacteria for sustainable PHB synthesis.

7. ACKNOWLEDGEMENT

The author gratefully acknowledges Prof. Dr. Yeşim Soyer Küçükşenel (METU, Department of Food Engineering) and Chemistry teacher Süleyman Atilla for their support and guidance.

8. REFERENCES

- Chen, G. Q., & Jiang, X. R. (2020). Engineering improving polyhydroxyalkanoate biosynthesis. *Current Opinion in microorganisms* for *Biotechnology*, 65, 190–197. <https://doi.org/10.1016/j.copbio.2020.06.001>
- Reddy, C. S. K., Ghai, R., Rashmi, & Kalia, V. C. (2003). Polyhydroxyalkanoates: overview. *Bioresource Technology*, 87(2), 137–146. [https://doi.org/10.1016/S0960-8524\(02\)00286-0](https://doi.org/10.1016/S0960-8524(02)00286-0)

Σ

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Mathematics

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On asymptotic density of certain sets with pseudo-linear closure

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1. Introduction

Additive combinatorics is a rapidly developing branch of mathematics with applications ranging from number theory to cryptography. The field investigates sets endowed with specific structural properties, including bounds on Minkowski's sums, closure properties, and representation functions.

2. Aims

While Szemerédi's theorem establishes that every subset of positive integers with positive asymptotic density contains arbitrarily long arithmetic progressions [1], the present research pursues a complementary objective.

Given a set S with some ordered linear closure within a normed finite-dimensional vector space, we investigate bounds for the counting function $A_S(n) := |\{s \in S \mid p(s) \leq n\}|$, where p denotes an arbitrary norm.

3. Main results

For arbitrary positive integer Δ , consider the normed vector space $(\mathbb{R}^\Delta, \mathbb{R}, +, \cdot, \|\cdot\|)$ defined by the equalities $(x_1, \dots, x_\Delta) + (y_1, \dots, y_\Delta) = (x_1 + y_1, \dots, x_\Delta + y_\Delta)$ and $c(x_1, \dots, x_\Delta) = (cx_1, \dots, cx_\Delta)$ holding for any vectors $(x_1, \dots, x_\Delta), (y_1, \dots, y_\Delta) \in \mathbb{R}^\Delta$, and arbitrary scalar $c \in \mathbb{R}$, and equipped with the norm $\|\cdot\|$. Also, consider an arbitrary norm $p(s)$ of the space.

Let $X := (\mathbb{N} \cup \{0\})^\Delta \setminus \{0\}^\Delta$ and $r \geq 2$ be some positive integer. A triple (K, S, v) is called *wonderful* for the r -tuple $K = (k_1, \dots, k_r)$ of r positive integers, subset $S \subseteq X$ and a vector $v \in (\mathbb{N} \cup \{0\})^\Delta$ if $|\{x \in S\}| \geq r$ and for every r -tuple $x_1, \dots, x_r$ of S such that $\|x_1\| < \|x_2\| < \dots < \|x_r\|$ the vector $k_1x_1 + k_2x_2 + \dots + k_rx_r + v$ belongs to S as well.

Let δ be the smallest positive integer d for which S is contained in the affine subspace of the dimension d . Finally, define $A_S(n) := |\{s \in S \mid p(s) \leq n\}|$.

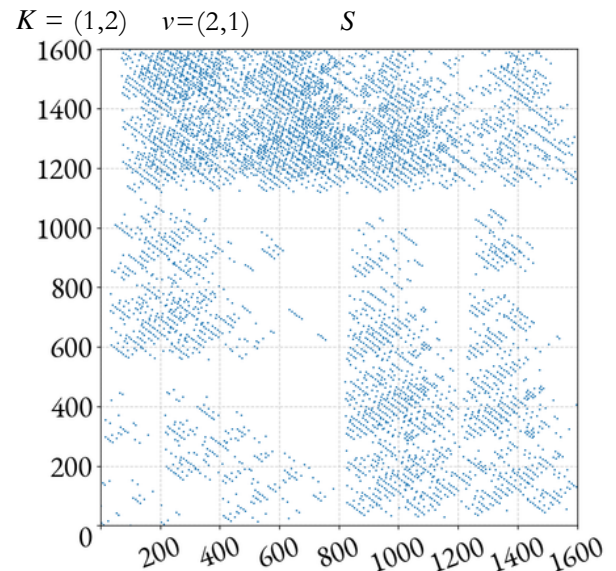
The main result of our paper is the following:

Theorem 1. For every wonderful triple (K, S, v) there exist some real numbers $c > 0$ and d such that

$$A_S(n) > cn^\delta + d$$

for all positive integers n .

The following figure illustrates the case $\Delta = r = \delta = 2$ with Chebyshev norm $p(s) = \max(s_1, s_2) \leq 1600$, $K = (1, 2)$, $v = (2, 1)$ and S generated by following points: $(10, 3), (2, 9), (100, 1), (1, 67)$:



4. Methods of research

The key idea is to find a segment with some points on it that form the dense enough structure, then generate a sequence of segments from it and combine the obtained sequences into one sequence of structures that guarantees the desired density of the set.

5. Discussion

This result opens doors into new direction in additive combinatorics. Klarner D. and Rado R. have investigated similar sets with linear closure (without attention to order) in paper about arithmetical properties of certain recursive sets [2].

6. Conclusions

We have established linear lower bound on the counting function for wonderful triples in normed finite-dimensional vector spaces.

6. References

- [1] Szemerédi E. On sets of integers containing no k elements in arithmetic progression // Acta Arithmetica. – 1975. – Vol. 27. – P. 199–245.
- [2] Klarner D., Rado R. Arithmetical properties of certain recursive sets // Journal of the London Mathematical Society. – 1973. – Vol. 2, No. 2. – P. 287–294

At the highest degree: a new approach to solving differential equations

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Background & Motivation

Linear inhomogeneous ordinary differential equations (ODEs) with constant coefficients are central to university-level analysis, engineering, and physics curricula. The standard right-hand side (forcing) functions are polynomials, exponentials, and sinusoidal functions, or combinations thereof. Classical solution methods such as the method of undetermined coefficients become increasingly laborious at higher orders.

The motivation for this project arose from a practical incident: a Mathematica computation failed to return a result within a reasonable time after a differential equation of order 44 was accidentally defined instead of one of order 4. This raised the question: is there a faster, more systematic approach for high-order ODEs?

Aims

The aim was to derive a purely algebraic, algorithm capable of computing particular solutions to linear inhomogeneous ODEs of arbitrarily high order, and to compare its runtime performance against Wolfram Mathematica's built-in symbolic solver.

Methods

The core observation is that for functions of the form

$$g(x) = e^{\alpha x} \left(\sum_{i=0}^m g_i x^i \cos(\beta x) + \sum_{i=0}^m h_i x^i \sin(\beta x) \right)$$

the particular solution shares the same structure, differing only in its coefficients. Collecting the $2(m+1)$ input coefficients into a vector, the differentiation operator corresponds to multiplication by a derivation matrix L of size $2(m+1) \times 2(m+1)$, whose entries depend only on α and β :

$$L = \begin{pmatrix} \alpha & 1 & 0 & \cdots & \beta & 0 & \beta^0 & \cdots & 0 \\ 0 & \alpha & 2 & \cdots & 0 & 0 & 0 & \cdots & 0 \\ \beta & 0 & \cdots & \alpha & 1 & \cdots & 0 & \cdots & 0 \\ 0 & \cdots & -\beta & 0 & 0 & \cdots & 0 & \cdots & 0 \end{pmatrix}$$

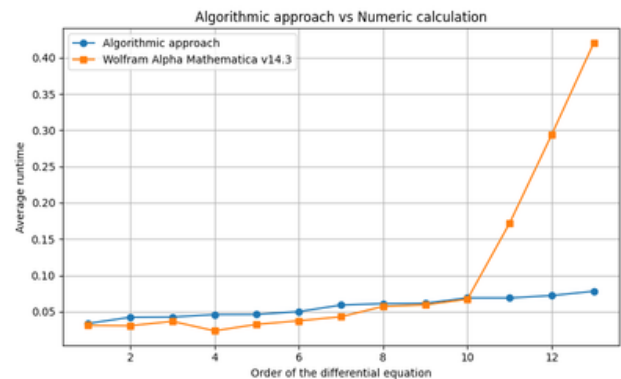
Integration is then multiplication by L^{-1} . For an ODE of order n with coefficients $a_0, \dots, a_n$, the combined system matrix is assembled as

$$L_G = a_n L^n + a_{n-1} L^{n-1} + \cdots + a_1 L + a_0 I.$$

Inverting L_G and multiplying by the coefficient vector of $g(x)$ directly yields the particular solution coefficients. The algorithm was implemented in both Python and Mathematica.

Results

The algorithm was benchmarked against Wolfram Mathematica v14.3 across ODE orders 1–13 with randomly generated coefficients and polynomial degree 6–40 (average).



Discussion

Mathematica performs reliably up to approximately order 10, where its symbolic ansatz method runs in nearly constant time. Beyond this threshold its runtime grows exponentially — estimated at $O(2^n)$ — and it could only solve ODEs within a two-minute limit up to order 19. The custom algorithm, by contrast, scales at $O(n^3)$ due to matrix inversion, making it substantially faster at high orders and capable of handling orders well beyond 30 without difficulty.

The matrix framework also unifies the three central operations of calculus — differentiation (L), integration (L^{-1}), and ODE solving (L_G^{-1}) — under a single algebraic structure, and admits natural extensions to systems of ODEs.

Conclusion

A matrix-based algorithm for solving linear inhomogeneous ODEs with constant coefficients has been successfully derived and implemented. It outperforms Mathematica's symbolic engine significantly at high orders, is mathematically rigorous, and opens pathways to handle resonance cases and systems of ODEs. The approach demonstrates that representing calculus operations as linear maps on coefficient vectors is both theoretically elegant and computationally powerful.

Acknowledgements

I sincerely thank Thomas Adamek for his invaluable guidance, extensive discussions, and the many afternoon sessions that made this project possible. I also thank Bernd Horlacher for suggesting participation and for proofreading the work, and Dr. Schmid for additional support throughout the project.

BLENDING INDIAN RAGA AND WESTERN MELODIC STYLES

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Mentor: Ninaad Adhvaryu | Pangea Society

AIM

This paper presents an interpretable framework for generating cross-cultural music by combining Indian raga-based melody with Western melodic style using Markov chains. Unlike many recent deep-learning systems, which often require large datasets and are difficult to interpret, the proposed method uses transparent probabilistic models whose musical rules can be inspected and modified directly.

A raga is treated not simply as a pitch collection but as a structured melodic system defined by characteristic note sets, directional motion in ascent and descent, and recurring phrases. This study investigates whether simple Markov-chain models can create music that seamlessly blends raga and Western melodies while preserving key aspects of both traditions.

INTRODUCTION

Algorithmic music generation has long been a space for exploring the intersection of human creativity, mathematics, and signal processing. Earlier systems were heavily rule-based, while recent methods increasingly utilize neural networks trained on vast datasets difficult to interpret, contextualize culturally, or apply in educational settings.

Indian classical raga music is underrepresented in computational music generation. A raga is more than just a scale it is a structured melodic framework defined by specific notes, ascending and descending patterns (**arohana** and **avarohana**), and repetitive melodic phrases (**pakad**).

Markov chains are highly interpretable: their transition matrices can be directly inspected, modified, and analyzed making them ideal for controlled experiments in stylistic blending. This study creates separate Markov transition matrices from both raga and Western musical examples, mixed via a weighted parameter to control stylistic influence.

APPLICATION

This framework has applications in **music education**, enabling students to explore how different musical traditions are structured mathematically. In **creative composition**, it provides composers with a controllable tool for blending styles without erasing cultural identity. It also has relevance in **ethnomusicology research**, offering a quantitative lens for comparing melodic grammars across traditions, and in **AI interpretability research**, as a case study in transparent generative modeling in creative domains.

ACKNOWLEDGEMENTS

I want to express my heartfelt thanks to my mentor Ninaad Adhvaryu and the Pangea Society for their guidance and feedback throughout this research. A big shoutout goes to the developers of open-source libraries like Librosa, NumPy, Pandas, Matplotlib, and music21. I'm also grateful for the publicly available audio resources used in this study and my peers and reviewers for their valuable insights.

METHODS

We employ a computational, experimental research design. Our sample consists of monophonic audio recordings from **Raga Mohanam** and other ragas, and a secondary corpus of Western diatonic melodies. Audio is processed using **Librosa** and the **YIN algorithm** to estimate $f_0(t)$, constrained to C2C7.

$$P(\text{mix}) = \alpha \cdot P(\text{raga}) + (1 - \alpha) \cdot P(\text{western})$$

$\alpha \in [0, 1]$ controls stylistic blending

Pipeline (10 steps):

1. Load and preprocess audio input
2. Extract pitch contours using YIN algorithm
3. Convert frequencies to MIDI symbolic note sequences
4. Segment sequences into short melodic phrases
5. Assign numerical indices to establish state space
6. Build transition matrices for raga & Western separately
7. Generate hybrid matrix via linear interpolation
8. Produce melodies via stochastic note sampling
9. Extract rhythmic patterns via onset detection
10. Integrate pitch + rhythm → MIDI/audio output

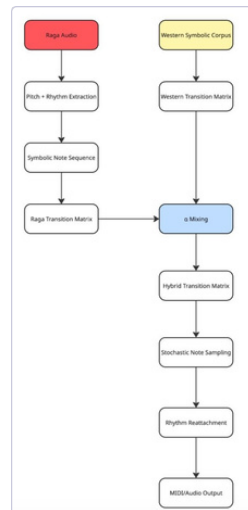


Fig 1. Processing pipeline from raga audio and Western symbolic corpus to hybrid MIDI/audio output via α -mixing.

RESULTS

Transition matrix heatmaps revealed clear structural patterns. Pentatonic ragas (Mohanam, Bhoopali) showed **sparse** transition structures. Ragas with larger pitch sets (Bhairavi, Darbari, Bageshree) exhibited **denser**, more varied patterns reflecting richer melodic movement.

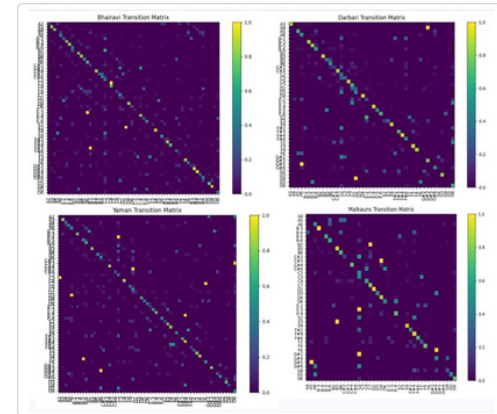


Fig 2. Transition probability heatmaps for Bhairavi, Darbari, Yaman, and Malkauns. Yellow = high probability, dark purple = near zero. Asymmetric banded structures reflect directional melodic constraints.

As α increased from 0 → 1, transition structure shifted from uniform Western patterns toward constrained raga systems. Intermediate $\alpha = 0.5$ showed mixed structures with both influences visible.

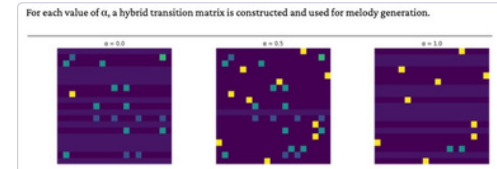


Fig 3. Hybrid transition matrices at $\alpha = 0.0$ (pure Western), $\alpha = 0.5$ (equal blend), $\alpha = 1.0$ (pure raga).

Jensen - Shannon similarity confirmed a **smooth, continuous transition** in distributional similarity as α varied. Generated melodies maintained coherence and identifiable stylistic traits at all parameter settings.

DISCUSSION & CONCLUSION

First-order Markov models proficiently capture and recreate essential melodic structure in both raga-based and Western music. The framework enables controlled cultural blending while remaining fully interpretable addressing a gap where non-Western musical systems are often overlooked or oversimplified.

Future directions include higher-order Markov models for longer-term dependencies, rule-based pakad constraints per raga, and hybrid probabilisticneural architectures.

Simple probabilistic models encode meaningful melodic structure and support controlled cross-cultural generation offering a transparent alternative to neural approaches for educational and research contexts.

LINKS

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Tools: Python · Librosa · music21 · NumPy · Pandas · Matplotlib

REFERENCES

1. S. Chakraborty et al. Hindustani classical music revisited statistically. FRSM, 2009.
2. D. Herremans, C. H. Chuan, E. Chew. A functional taxonomy of music generation systems. ACM Comput. Surv. Vol. 50, 2018.
3. H. Carvalho. An introduction to Markov chains in music composition. MusMat, Vol. III(2), 2019.
4. B. A. Hutchinson. A transformational modified Markov process for chord-based algorithmic composition. J. Humanistic Math.

KEYWORDS

Algorithmic Music Generation · Markov Chain
Indian Classical Music · Raga · Cross-Cultural
Music Information Retrieval · Jense

AIM

This paper defines a new subclass of holes termed deep holes and determines the maximum number of deep holes that a polyomino can enclose. We establish the extremal behaviour of deep holes in polyominoes. Using explicit constructions, Pick's Theorem and isoperimetric inequality, we establish tight lower and upper bounds for maximal number of deep holes in an n -omino. Furthermore, for infinitely many values of n , we compute the exact value of h_n . These results establish a sharp contrast between deep holes and classical holes.

INTRODUCTION

The term 'Polyomino', studied in combinatorial geometry and recreational mathematics, was first introduced by Solomon Golomb in 1953 to describe a plane geometric figure formed by connecting a finite number of unit squares edge-to-edge, like the pieces used in Tetris. A 'deep hole' is a hole whose boundary shares no common point with the outer boundary of the polyomino or with the boundary of another hole. This definition redefines the classical problem of holes in polyominoes by introducing a subclass of holes that have disjoint and well-structured boundaries.

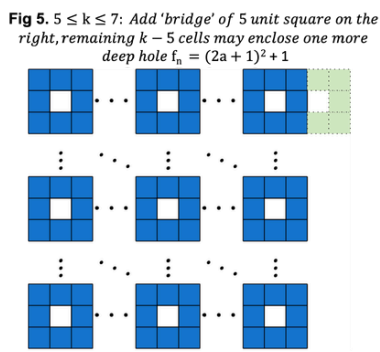
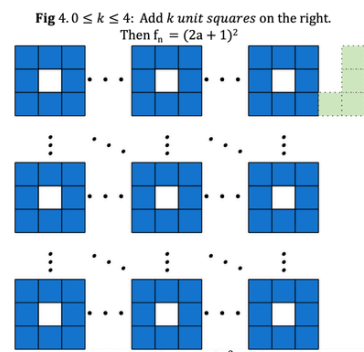
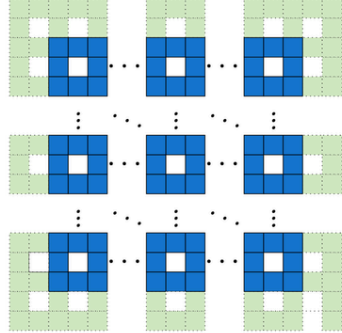
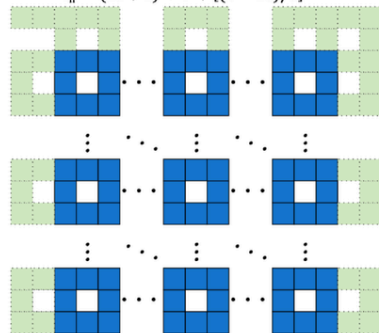


Fig 4. $0 \leq k \leq 4$: Add k unit squares on the right. Then $f_n = (2a+1)^2$
Fig 10. $|12a+14 \leq k \leq 12a+17|$: $(4a+5) \times (4a+5)$ with left added squares $f_n = (2a+1)^2 + (4a+3)$
 $12a+18 \leq k \leq 12a+20$: Left bridge, $f_n = (2a+1)^2 + (4a+4)$
 $12a+21 \leq k \leq 18a+21$: Maximise holes, $f_n = (2a+1)^2 + 4 + [(k-18)/3]^2$

Fig 11. $18a+22 \leq k \leq 18a+25$: Bottom sq $f_n = (2a+1)^2 + 6a + 5$
 $18a+26 \leq k \leq 18a+28$: Bottom bridge, $f_n = (2a+1)^2 + 6a + 6$
 $18a+29 \leq k \leq 24a+31$: Arrange bottom squares, $f_n = (2a+1)^2 + 6 + [(k-26)/3]^2$



APPLICATION

This is a problem in pure mathematics, with applications in optimising enclosed cavities in any grid-based systems such as porous material, microchip layouts, modular architecture, biology and cellular modelling educational, recreational mathematics and algorithm designing.

METHODS

The paper develops 2 main ideas: a constructive method and an analytic technique to study deep holes. First, it constructs an explicit family of polyominoes designed to contain many deep holes, which gives us the lower bound for the number of deep holes in polyominoes. Second, it applies the generalised form of Pick's Theorem from lattice geometry to polyominoes with deep holes and isoperimetric inequality to establish a sharp upper bound on the number of deep holes.

1. Formal Definitions and Setup

a. Model a polyomino as a finite, connected union of unit squares.

b. **Deep hole** is a bounded connected component of the complement, h_n : max no. of deep holes in an n -omino.

2. Lower Bound Construction

a. Construct an explicit family of polyominoes

$$\text{An: } (4a+3)^2 - (2a+1)^2 \leq n < (4a+7)^2 - (2a+3)^2$$

where $n = (12a^2 + 20a + 8) + k$ $0 \leq k < 24a + 32$ and $a \geq -1$

b. Begin with a $(4a+3) \times (4a+3)$ square (see fig)

c. Remove a centred $(2a+3)^2$ block to create deep holes.

d. Incrementally add cells while preserving deep hole isolation.

3. Upper Bound Derivation

a. Apply the generalized Pick's Theorem: $n = i + \frac{b}{2} - 1 + h_n$

where i is the number of interior lattice points and b is the number of boundary lattice points. $b \geq 4h_n + \tilde{b}$

b. Use boundary and perimeter constraints and combine with isoperimetric inequalities to bound.

4. Asymptotic Conclusion

a. Compare lower and upper bounds to conclude:

$$h_n \approx n/3 + o(n)$$

b. Confirm that the growth rate of deep holes is linear in n and fundamentally different from classical hole counts.

RESULT

We established lower and upper bounds for number of deep holes:

$$\frac{1}{3} - \frac{16}{9} \sqrt{\frac{3}{n} + \frac{1}{n^2}} + o\left(\frac{1}{\sqrt{n}}\right) < \frac{h_n}{n} < \frac{1}{3} - \frac{1}{18} \sqrt{\frac{48\pi}{n} + \frac{\pi^2 + 12\pi}{n^2}} + o\left(\frac{1}{\sqrt{n}}\right)$$

For sufficiently large n , the maximal number of deep holes in an n -omino satisfies

$$h_n \approx n/3$$

CONCLUSION

This result is analogous to Érika Roldán-Roa result for holes, that is $n/2$ while using a more restrictive and elegant geometric relationship. The constructions that were created as a part of the paper showed that polyominoes can contain a very large number of deep holes and the theoretical analysis confirmed that these examples are close to the maximum possible. Both approaches that have been used i.e. explicit constructions and boundary-based reasoning led to the same conclusion that the number of deep holes grows proportionally with the size of the polyomino.

How Long is a Hanging Cable?: An Error-Minimized Nonlinear Analytical Approximant for the Catenary Arc Length

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1. INTRODUCTION

The catenary curve describes the shape made by a cable suspended between two points under uniform gravitational force [1]. Accurate and efficient calculation of the catenary arc length is important in applications such as structural modelling and embedded systems. The arc length for a symmetrical catenary is formulated as follows.

$$L(x, a) = 2a \sinh\left(\frac{x}{a}\right) \quad (1)$$

However, this formula involves the hyperbolic function $\sinh(x)$ which calculation may be inefficient for limited-resourced systems such as microcontrollers. Common approximation methods include Taylor, Padé, and Chebyshev approximants, among others [2].

2. AIMS

This research proposes an error-minimized nonlinear analytical approximant, namely $\lambda(x, a)$, to calculate the catenary arc length which optimizes relative error (δ_R), algorithmic complexity, rate of convergence, and floating-point operation (FLOP) complexity.

3. METHODS AND MATERIALS

This study was done quantitatively through approximant formulation and comparative analysis. Graphical exploration was done using Desmos to visually examine the shape of the true function $L(x, a)$ and the basic approximant form as follows (similar to 3rd degree Taylor).

$$\lambda(x, a) = \frac{x^3}{ca^2} + 2x \quad (2)$$

Relative error (δ_R) is formulated as follows.

$$\delta_R(x) = \left| \frac{f(x, a) - L(x, a)}{L(x, a)} \right| \quad (3)$$

To determine c at $\lambda(x, a) = L(x, a)$. Approximating it while maintaining $\delta < 0.1\%$ for the widest domain gives:

$$c \approx -\frac{x^2}{7a^3} \quad (4)$$

Substituting c and rearranging the expression to minimize floating-point operations produces the following formula.

$$\lambda(x, a) = 2x - \frac{7x^3}{21a^2} \quad (5)$$

$\lambda(x, a)$ was then compared to 3rd order Taylor, Padé [3/2], and 3rd order Chebyshev in terms of δ_R , algorithmic complexity, FLOP complexity, and convergence rate.

4. RESULTS

Table 1. Relative error comparison.

Method	$\delta_R < 0.1\%$ Boundary
λ	$ x < 1.63568a$
$P_{[3/2]}$	$ x < 1.31617a$
T_3	$ x < 0.59598a$
C_3	$ x < 0.141187a$

Table 2. Algorithmic complexity, rate of convergence, & FLOP complexity comparison.

Method	Algorithmic Complexity	Rate of Convergence	FLOP Complexity
λ	$O(1)$	$O(x^7)$	$6M+1D+2A$
$P_{[3/2]}$			$8M+1D+2A$
T_3		$O(x^5)$	$5M+1D+1A$
C_3			$4M+1A$

M: Multiplication, D: Division, A: Addition/Subtraction.

5. DISCUSSION

In comparison to other approximation methods, $\lambda(x, a)$ has the widest domain in which its relative error stays below 0.1% while exhibiting $O(x^7)$ convergence. $\lambda(x, a)$ achieves a simpler FLOP complexity compared to Padé [3/2] as it was built on the form of the 3rd order Taylor series. Through further derivation, it utilizes an adaptive parameter c with respect to x and a . This provides nearly three times the accurate domain of a standard 3rd order Taylor series while using a similar amount of computational power. Nevertheless, its accurate range depends on x with respect to a , as it doesn't have other higher-degree forms.

6. CONCLUSIONS

In conclusion, $\lambda(x, a)$ achieves a wide domain of low error, able to maintain $\delta_R < 0.1\%$ when $|x| < 1.63568a$. This makes it more accurate than other methods used to approximate the symmetrical catenary arc length while exhibiting an $O(1)$ complexity, an $O(x^7)$ convergence rate, and an optimized FLOP complexity of $6M+1D+2A$.

7. ACKNOWLEDGEMENT

Deepest gratitude to our research advisors and mentors from SMA Santa Angela and Center for Young Scientists.

8. REFERENCES

- [1] Coll, V., & Dodd, J. (2016). A characteristic averaging property of the catenary. *The American Mathematical Monthly*, 123(7), 683–688.
- [2] Dalloo, A. M., Humaidi, A. J., Mhdawi, A. K. A., & Al-Raweshidy, H. (2024). Low-Power and Low-Latency hardware implementation of approximate hyperbolic and exponential functions for embedded system applications. *IEEE Access*, 12, 24151–24163.

Mathematical Modeling Based on Genetic Biomarkers for the Predictive Diagnosis of Pancreatic Cancer: Analysis and Validation Using Hypothesis Testing with Python.

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1. INTRODUCTION

Pancreatic cancer is one of the deadliest cancers, often only detected at an advanced stage due to the lack of effective early screening methods. The survival rate is only about 7.2%, so new approaches for early detection are needed. One promising method is the use of mathematical modeling based on genetic biomarkers, which is expected to increase the accuracy of predictive diagnosis and make a real contribution to efforts to save more lives. (Columbia Surgery, 2024).

2. AIM

The aim of this research is to analyze differences in candidate gene expression between pancreatic cancer patients and healthy individuals, as well as build a predictive model based on mathematical modeling and statistical analysis to provide the potential of these genes as biomarkers for early diagnosis of pancreatic cancer.

3. METHODS AND MATERIALS

Gene expression data for pancreatic cancer and normal tissue samples were obtained from the GEO database. Due to raw gene expression values often spanning several orders of magnitude and exhibiting strong skewed tendencies a logarithmic transformation was applied to stabilize variance and reduce skewness using where is the original expression value. Following this transformation, a Q-Q plot normality test was conducted to evaluate whether the transformed gene expression values approximated a normal distribution, allowing for the verification that the transformation improved distribution symmetry and reduced extreme variation in the dataset. Finally Welch's T-Test was used to prove that statistical differences between the two classes

To classify samples based on the gene expression patterns, a Random Forest model was implemented. Random Forest is an ensemble learning method that constructs multiple decision trees using bootstrap samples of the dataset and random subsets of features at each split, which improves robustness and reduces overfitting. Within each decision tree, splits are chosen to minimize node impurity, measured using the Gini impurity as the cost function.

4. RESULTS

The Random Forest ensemble model achieved an accuracy of 0.812, indicating that the model had correctly classified approximately 81.2% of the samples as either pancreatic cancer or normal tissue based on their gene expression profiles. Confirming that gene expression features contain meaningful patterns that can be used to distinguish between cancerous and healthy samples. The utilization of an ensemble method such as Random Forest improves the predictive stability.

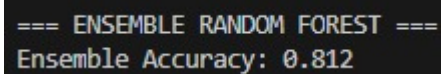


Figure1. Image of the accuracy of the random forest model trained on genetic biomarkers

5. DISCUSSION

The results indicate the utilization of mathematical methods alongside the gene expression patterns as has successfully created a model that had the capability to detect the presence of pancreatic cancer within the human body demonstrated by the Random Forest model achieving an accuracy of 0.812. This suggests that the selected gene features carry predictive information that can be used to distinguish between the two classes.

CONCLUSIONS

This study shows that a mathematically driven pipeline can be effectively utilized in order to analyze gene expression data for pancreatic cancer classification. Logarithmic transformation improved data stability, statistical testing using Welch's t-test quantified significant differences in gene expression distributions, and the Random Forest algorithm used gini impurity-based optimization to create predictive decision trees. The model achieved an accuracy of 0.812, indicating that the mathematical relationships within the gene expression data contain sufficient information to distinguish cancerous from normal samples.

7. ACKNOWLEDGEMENT

8. REFERENCES

Pancreatic cancer prognosis. Columbia Surgery. (n.d.). <https://columbiasurgery.org/pancreas/pancreatic-cancer-prognosis>

ANALYSIS OF CONVEX COMBINATIONS OF DEPENDENT BERNOULLI VARIABLES: A BIVARIATE DISTRIBUTION APPROACH. APPLICATION IN HEALTH INSURANCE PORTFOLIO

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1. INTRODUCTION

The Bernoulli distribution serves as the foundation of probability theory for binary experiments. Traditionally, this is studied in a unidimensional context. However, in real-world applications such as finance (simultaneous bankruptcy of two companies), genetics (co-occurrence of two genes), or network engineering (failure of two nodes), binary variables are rarely independent. Extending this to the Multidimensional Bernoulli Distribution (in our case, bivariate) becomes imperative. A major limitation of using only marginal distributions is their inability to model the interaction between variables. Two variables may have identical marginals but exhibit completely different behaviors regarding co-occurrence. For a more detailed study of multivariate Bernoulli distributions see [1,2].

2. AIMS

This paper investigates the stochastic properties of the convex combination $Z = aX_1 + (1-a)X_2$, where the random vector (X_1, X_2) follows a general bivariate Bernoulli distribution. Unlike classical approaches that assume independence, this study focuses on the dependency structure captured by the joint probability mass function. We derive the distribution theorem for the resulting variable Z , its moments (mean and variance), and the optimization conditions in the Markowitz (Mean-Variance) sense. Furthermore, we analyze the geometric locus of possible portfolios in the Risk-Return plane. Finally, a numerical health insurance application is presented.

3. METHODS AND MATERIALS

Let $(\Omega, \mathcal{F}, P)$ be a probability space. We consider a discrete bivariate random vector $Y = (X_1, X_2) \sim B(1; p)$.

The joint probability mass function is:

$$p_{(i,j)} = P(X_1 = i, X_2 = j), \quad \forall (i,j) \in \{(0,0), (0,1), (1,0), (1,1)\}$$

with $\sum_{(i,j)} p_{(i,j)} = 1$.

4. RESULTS

Theorem 4.1 (Distribution of Variable Z). Let $a \in [0,1]$ such that.

The random variable Z is a discrete variable with support

$\text{Supp}(Z) = \{0, a, 1-a, 1\}$, and its mass function is given by:

$$P(Z_a = z) = \begin{cases} p_{(0,0)}, & \text{if } z=0 \\ p_{(1,0)}, & \text{if } z=a \\ p_{(0,1)}, & \text{if } z=1-a \\ p_{(1,1)}, & \text{if } z=1 \end{cases}$$

Theorem 4.2 (Mean and Variance of Z).

$$E[Z_a] = a(p_1 - p_2) + p_2$$

$\text{Var}(Z_a) = Aa + Ba + C$, where the coefficients are:

$$A = \text{Var}(X_1) + \text{Var}(X_2) - 2\text{Cov}(X_1, X_2)$$

$$B = 2\text{Cov}(X_1, X_2) - 2\text{Var}(X_2)$$

$$C = \text{Var}(X_2)$$

Theorem 4.3 (Minimum Variance Portfolio).

There exists a unique point $a^* \in \mathbb{R}$ that minimizes the variance

function $\text{Var}(Z_a)$, given by the formula:

$$a^* = \frac{\text{Var}(X_2) - \text{Cov}(X_1, X_2)}{\text{Var}(X_1) + \text{Var}(X_2) - 2\text{Cov}(X_1, X_2)}$$

If $a^* \in [0,1]$, then this represents the optimal weight for minimizing the risk of the convex combination.

Theorem 4.4. The geometric locus of points (σ_Z, μ_Z) generated by the linear combination Z_a describes a hyperbola in the (σ, μ) plane.

The relationship between variance σ_Z^2 and mean μ_Z is given by a quadratic function of the form:

$$\sigma_Z^2 = \alpha \mu_Z^2 + \beta \mu_Z + \gamma$$

where coefficients α, β, γ depend exclusively on the first two moments of the vector (X_1, X_2) .

5. APPLICATION: HEALTH INSURANCE PORTFOLIO FOR DIABETES AND LUNG CANCER - DISCUSSION

We consider an individual from a specific risk group (e.g., aged 50-60) who wishes to purchase insurance covering two critical illnesses:

X1 (Diabetes): Based on global data (IDF Diabetes Atlas), the incidence is high. For this example, we assume an annual diagnostic probability of 1% ($p_1 = 0.01$).

X2 (Lung Cancer): A rarer but severe condition. Based on global statistics (GLOBOCAN), the incidence rate is significantly lower. We assume an annual probability of 0.1% ($p_2 = 0.001$).

Dependence (Comorbidity): Medical studies indicate that diabetes is a risk factor for cancer. We assume a positive correlation, such that the probability of developing both diseases simultaneously in the same year is double that of the independent case: $p_{(1,1)} = 0.00002$.

We calculate the disjoint probabilities for the vector $Y = (X_1, X_2)$:

$p_{(1,1)}$ (Comorbidity): 0.00002 , $p_{(1,0)}$ (Diabetes Only): $p_1 -$

$p_{(1,1)} = 0.01 - 0.00002 = 0.00998$, $p_{(0,1)}$ (Cancer Only): $p_2 -$

$p_{(1,1)} = 0.001 - 0.00002 = 0.00098$, $p_{(0,0)}$ (Healthy): $1 -$

$(0.00998 + 0.00098 + 0.00002) = 0.98902$

The individual has a total insured sum of $S = 10,000$ Euros.

The variable Z_a represents the effective payout ratio, where a is the proportion of the sum allocated to cover Diabetes, and $(1-a)$ is allocated to cover Cancer.

The random variable in Euros is $W = 10,000 \cdot Z_a$.

According to Theorem 1, the payout takes the following values depending on the diagnosis received during the year:

The insurer calculates the Pure Premium (Mean) and the Portfolio

Volatility (Variance): $E[W] = 10,000 \cdot (0.0099a + 0.001)$ and

$\text{Var}(W) \approx 10^8 \cdot (0.01088a^2 - 0.00198a + 0.001)$

According to Theorem 4.3 the weight $\hat{a}$ that stabilizes the payouts (Minimum Variance) is

$$a^* = \frac{0.001 - 0.00001}{0.0099 + 0.001 - 0.00002} = \frac{0.00099}{0.01088} \approx 0.091$$

Result: The optimal allocation for minimum variance is **9.1%** for

Diabetes (**910€**) and **90.9%** for Cancer (**9,090€**).

Why is determining $\hat{a}$ important?

Premium Affordability: The commercial premium price is calculated as **Price = Mean + Risk**. The "Risk Loading" fee is directly proportional to the variance. By choosing the portfolio $\hat{a}$ the risk loading is minimized, resulting in the cheapest possible premium for a 10,000 Euro coverage.

6. CONCLUSIONS

In this research, it has been demonstrated that analyzing dependent Bernoulli variables via the joint probability mass function allows for exact risk quantification, highlighting the critical role of covariance in the stability of convex combinations. By applying the derived theorems to the health insurance scenario, the model mathematically identified the optimal minimum variance allocation (for diabetes), balancing the high frequency of diabetes with the nature of the cancer risk. This optimization is essential as it reduces portfolio volatility, ensuring insurer solvency and minimizing the premium cost for the insured.

7. ACKNOWLEDGEMENT

We acknowledge the support of Prof. Dr. Luigi-Ionut Catana for guidance and valuable advice in this direction of research.

8. REFERENCES

- [1] Catana L. I. (2025). On the weak hazard rate ordering obtained using geometric transformations and multivariate Bernoulli distribution. *Gazeta Matematica*, Seria A, 3-4, 34-36
- [2] Catana L. I. (2018). The monotony in hazard rate sense of some families of multidimensional distributions. *Gazeta Matematica*, Seria A, 1-2, 45-47
- [3] https://en.wikipedia.org/wiki/Markowitz_model

On a Property of a Triangle

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1. INTRODUCTION

This project explores maximizing the area of a triangle formed by the base of a given triangle and a parallel internal segment. Its vertices are the base endpoints and where the segment meets the sides. First, equilateral, isosceles, and scalene cases with parallel bases are studied. Let $k = h/a$ be the base-to-segment ratio. We determine the value of k that maximizes the area and examine its universality. Then, a non-parallel case is analyzed, where the larger triangle's vertex is tilted at a fixed angle. An area formula is derived, and its maximum is found relative to that angle.

2. AIMS

1. Determining the area function of the constructed triangle;
2. To determine the value of $k = h/a$ that maximizes the area;
3. To verify the universality of the obtained optimal ratio.

3. METHODS AND MATERIALS

The triangle was placed in a Cartesian coordinate system. In each case, the area was expressed as a function of $k = \frac{h}{a}$, and the resulting functions were differentiated to find their maxima. For the non-parallel case, the construction was modified accordingly. After calculating the area of the constructed triangle using the ratio, a function $\omega(k)$ was obtained, which was analysed for extrema in all four problems.

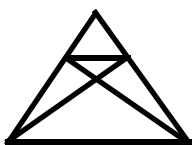


Fig.1

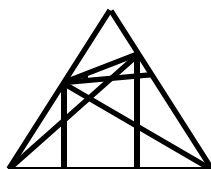


Fig.2

4. RESULTS

The derived universal formula and the conclusion that the maximum is attained at the same value $k = \frac{1}{\Phi}$ in triangles with parallel bases (see, for example, Fig. 1), with the maximum area achieved as follows:

1. For an equilateral triangle: $\frac{\sqrt{3}h^2}{4\Phi^3}$
2. $\frac{tga \cdot h^2}{2}$
3. For an isosceles triangle: $\frac{h^2 tga tgb}{(tga + tgb)\Phi^2}$

In the case of the general problem with non-parallel bases, the

area (expressed in terms of k and δ) is:

$$S_{\max} = a^2 \left[\frac{\sqrt{3}k^2 (3-2\sqrt{3}k \cdot \sin(\delta + \frac{\pi}{3})) (3-2\sqrt{3}k \cos(\delta + \frac{\pi}{3})) \sin(\delta + \frac{\pi}{3}) \cdot \cos(\delta + \frac{\pi}{6})}{9 \cdot (3 - k^2(4\cos 2\delta - 1))} \right]$$

For $\delta = \frac{\pi}{4}$, $k \approx 0,6032063565...$ the maximum area is equal to $S \approx 0,016024a^2$

For $\delta = \frac{\pi}{4}$, $k = \frac{3 - \sqrt{3}}{4}$ the maximum area is equal to $S = \frac{a^2(9 - 5\sqrt{3})}{16} \approx 0,021234a^2$

5. DISCUSSION

These results indicate the existence of a common geometric structure in the problem, expressed through a universal parameterization and the appearance of the golden ratio, which reflects the symmetry and harmonious distribution of parameters (in the case of parallel bases)

6. CONCLUSIONS

The novelty of this work lies in demonstrating the universality of the result in the context of constructing a triangle from segments on the sides of different types of triangles (excluding triangles with non-parallel bases) and providing a rigorous

7. REFERENCES

1. Pismennyi D.T., Lecture Notes on Higher Mathematics: Complete Course — 17th edition — Moscow: Iris Press, 2020. — 603 p.
2. <https://www.wolframalpha.com> Wolfram Alpha
3. Kurosh A.G., Course in Higher Algebra — Saint Petersburg: Lan, 2024.

Curried Functional Spaces

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I. INTRODUCTION

For a set of functions mapping R to R , it is possible to inductively define spaces of so-called curried functions. These spaces are of interest from the perspective of the theory of multivariate functions.

II. AIMS

Our goal is to reformulate definitions of continuity and continuous differentiability from the language of multivariate functions $R^n \rightarrow R$ to the language of topological vector spaces and, using them, obtain results for corresponding multivariate functions.

III. METHODS OF RESEARCH

The following terminology is used. We inductively construct spaces

$$H_0(R) \subset C_0(R) \subset D_0(R),$$

where

$$H_0(R) \subset C_0(R) \subset D_0(R) = R.$$

For $n > 0$ these spaces are defined inductively:

- $H_{n+1}(R) = \{f : R \rightarrow H_n(R)\}$ with the topology of
- $C_{n+1}(R) = \{f : R \rightarrow C_n(R) \mid f \text{ is continuous}\}$ with the compact-open topology;
- $D_{n+1}(R) = \{f \in C_{n+1}(R) \mid \exists R_1 \in C_{n+1}(R), \text{ where } f \text{ is the derivative of function, which is defined initial topology with respect to the maps}$

$$\begin{aligned} i : D_0^1(R) &\rightarrow C_0(R, D_0(R)) \\ d : D_0^1(R) &\rightarrow C_0(R, D_0(R)) \end{aligned}$$

For each $f \in H_n(R)$ we define its corresponding multivariate function $\tilde{f} : R^n \rightarrow R$

$$\tilde{f}(x_1, x_2, \dots, x_n) = f(x_1)(x_2) \dots (x_n)$$

In this case, $\tilde{f}$ is called the curry of f . We prove that the defined spaces are topological vector spaces. Their local

convexity is also verified. The main results of the paper are based on examining the connection between the convergence of functions in $(n+1)$ -th space and the connection of a sequence of images in n -th space. This is significant in proving that functions are continuous.

IV. RESULTS

Our main results are as follows:

- The space $H_n(R)$ is a locally convex topological vector space;
- The space $C_n(R)$ is a locally convex topological vector space;
- The set $C_n(R)$ coincides with the set of functions from $H_n(R)$ such that their corresponding multivariate function is continuous;
- All functions $f : R^n \rightarrow R$ from the class C^1 have their curried functions belonging to the set $D_0^1(R)$.

V. DISCUSSION

The proven results are used in verifying that multivariate functions are continuous or have continuous partial derivatives. They can be also applied to obtain other nontrivial results for curried functions, including m -times continuous differentiability and integrability.

VI. ACKNOWLEDGMENT

Author thanks his supervisor Roman Maksimovich (Hong Kong University of Science and Technology, Hong Kong) and the Laboratory for Continuous Mathematical Education, Saint Petersburg, Russian Federation.

VII. REFERENCES

- Beattie, R., Butzmann H.-P. Convergence Structures. Springer+Business Media, B.V., 2002. – 264 p.
- Rudin, W. Functional Analysis. 2-nd ed., McGraw-Hill, 1991. – 424 p.
- Kolmogorov, A.N., Fomin, S.V. Elements of the Theory of Functions. - 292 p.

Noncommutative Error-Correcting Codes

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I. Introduction

Error-correcting codes play a key role in ensuring the reliability of data transmission over noisy communication channels. Group codes—linear error-correcting codes with structural symmetries [1], [2]—generalize classical abelian (in particular, cyclic) codes [6], [7] and are of interest both for coding theory and post-quantum cryptography, where the security of McEliece-type schemes relies on the hardness of decoding a random linear code. Algebraically, group codes correspond to ideals of finite group algebras $F[G]$. Building on this viewpoint, we develop an efficient algorithm for enumerating such ideals, which provides a speedup of up to several orders of magnitude over existing algorithms and enables a systematic investigation of code parameters. An exhaustive computational study of all group codes of block length at most 32 over the fields F_2 , F_3 , F_4 , and F_5 is carried out, and it is shown that, in a number of cases, group codes over non-abelian groups achieve larger minimum Hamming distance than any abelian code of the same length. The obtained values match the best known linear codes (BKLC) [5].

II. Aims

The objective is to develop an algorithm for enumerating the ideals of $F[G]$ for a complete computational comparison of the parameters of group codes over abelian and non-abelian groups of the same order. An exhaustive search of all linear codes of a given length is impossible (for example, the number of linear codes of length 20 over F_5 exceeds 10^{40}). Unlike existing methods such as MTX (see Table II), the developed algorithm completes the search over all group codes of length n 32 within a reasonable time.

III. Methods and Materials

The research was carried out in the computer algebra system GAP using the GUAVA package. For each finite group G of order n , the regular module $F[G]$ is constructed, and in the semisimple case, its decomposition into primary components is computed. Submodules of each block S^m are enumerated via the description of endomorphisms $\text{End}_{F[G]}(S)$ and subspaces of the vector space D^m , where $D \simeq \text{End}_{F[G]}(S)$. Combining submodules from different blocks yields all right ideals of $F[G]$. The non-semisimple case is reduced to the former by an iterative descent along the powers of the Jacobson radical. For each ideal, its dimension k and minimum Hamming distance d are calculated (with result caching and parallel processing). For each group, the maximum value of d is recorded for a given dimension k . The developed algorithm is orders of magnitude faster than existing algorithms (Table II).

IV. Results

For groups of order $n \leq 32$ over fields F_2, F_3, F_4, F_5 , the values of $d_{\max}^{\text{ab}}$ and $d_{\max}^{\text{nab}}$ were obtained. A comparison of abelian and non-abelian $d_{\max}$ groups revealed a number of parameters for which non-abelian groups provide a strictly

greater minimum distance; some of these are presented in Table I. The efficiency of the developed algorithm is illustrated in Table II.

n	k	F	$d_{\max}^{\text{ab}}$	$d_{\max}^{\text{nab}}$	Group
14	6	F_5	4	7	D_{14}
27	7	F_2	9	11	$C_9 \rtimes C_3$
10	4	F_4	5	6	D_{10}
16	6	F_3	6	7	QD_{16}
21	10	F_2	5	6	$C_7 \rtimes C_3$
20	9	F_3	6	8	$C_5 \rtimes C_4$

Table I. Examples of non-abelian code superiority.

Group	Main, ms	MTX, ms
$C_7 \rtimes C_3$	145	13995
C_4	407	159926
C_{52}	15000	> 300000
D_{20}	72	2009
D_{22}	74	496

Table II. Runtime comparison.

Comparison with the BKLC database confirms that the found codes are optimal among all linear codes of the given length and dimension.

V. Discussion and Conclusions

The developed algorithm allows for systematic investigation of group codes of moderate block length. The discovered superiority of non-abelian groups confirms the promise of noncommutative constructions for building optimal linear codes. Further research involves extending the search to larger lengths and analyzing the possibility of using such codes in cryptographic primitives, where codes with a greater minimum distance and a rich algebraic structure that complicates structural attacks are required. Future research will also address the development of efficient syndrome-decoding algorithms.

Acknowledgments

The author expresses sincere gratitude to his supervisor A.V. Krasilnikov (HSE University) and to the LCME Research Center for guidance and support.

References

- [1] C. W. Curtis, I. Reiner, *Methods of Representation Theory*, Vol. I. Wiley, 1981.
- [2] J.-P. Serre, *Linear Representations of Finite Groups*. Springer, 1977.
- [3] GAP – Groups, Algorithms, Programming. <https://www.gap-system.org/>
- [4] GUAVA – A GAP Package for Coding Theory. <https://gap-packages.github.io/guava/>
- [5] M. Grassl, Bounds on the minimum distance of linear codes and quantum codes. <https://www.codetables.de/>
- [6] V. T. Markov, A. A. Nechaev, Group Codes Over Non-Abelian Groups, *Journal of Applied Algebra*, 16 (2013), 207–227.
- [7] M. Elia, C. Garcí'a Pillado, Ideal group codes and their syndrome decoding, In: *Proc. 21st Int. Symp. on Mathematical Theory of Networks and Systems*, 2014, pp. 1222–1229.

On an Automorphic Representation of Multivirtual Braid Group

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I. INTRODUCTION

Representations of braid groups and related braid-type groups by automorphisms of free groups go back to Artin and remain a standard source of explicit information about groups given by generators and relations. In the virtual case, such representations make it possible to compare braid and forbidden relations inside the automorphism group and to identify natural subgroups in the image. Recently, the k -multivirtual braid groups M^kVB_n were introduced in [1] and [2] as a generalization of virtual braid groups. In the same paper, the problem of constructing an automorphic representation of M^kVB_n and describing its image was stated explicitly. The present work constructs such a representation and describes several characteristic parts of its image.

II. AIMS

The aim of this work is to construct a representation of the group M^kVB_n by automorphisms of a free group and to describe the structure of its image.

III. METHODS

The work is based on methods of combinatorial group theory and the theory of automorphisms of free groups. The main construction is an explicit representation of the group M^kVB_n in $\text{Aut}(G_{n,k})$, where $G_{n,k} = F(x_1, \dots, x_n, t_1, \dots, t_{k-1})$. The generators $x_1, \dots, x_n$ correspond to the strands, and the additional generators $t_1, \dots, t_{k-1}$ correspond to the nonzero types. This places the problem in the setting of explicit automorphisms of a free group and makes it possible to study the image as a concrete transformation group. Different parts of the image are then considered in different but compatible languages. The zero-type sector is studied through its relation to the virtual and welded braid groups. For a fixed nonzero type, the corresponding part of the image is reformulated in terms of diagonal conjugations and then interpreted through the root lattice $Q(A_{n-1})$ together with the natural action of the symmetric group, that is, in the affine Weyl group setting of type A_{n-1} . Alongside this, a combinatorial language of oriented routes with nonzero types is introduced in order to describe products of the corresponding elementary automorphisms in subgroup $\mathcal{D}_n^\alpha$.

IV. MAIN RESULTS

An representation $\Phi_{n,k}: M^kVB_n \rightarrow \text{Aut}(G_{n,k})$ is constructed. It is proved that the relation

$$Q\alpha i + 1\sigma_j \sigma_{i+1} = \sigma_j \sigma_{i+1} Q_i \quad \beta$$

holds in the image of $\Phi_{n,k}$ if and only if α and β equals 0. As a consequence, the zero-type sector factors through the welded braid group, and its image coincides with the standard welded realization by automorphisms of a free group. For each fixed

nonzero type α , the subgroup $\mathcal{D}_n^\alpha$ in the pure part of the image is isomorphic to the root lattice $Q(A_{n-1})$, while the subgroup $\mathcal{H}^\alpha$ generated by $\mathcal{D}_n$ together

with the zero-type automorphisms is isomorphic to the semidirect product $Q(A_{n-1}) \rtimes S_n$. In particular, $\mathcal{H}^\alpha$ is isomorphic to the affine Weyl group of type A_{n-1} . For this oriented routes with nonzero types, a general formula for the corresponding automorphism is obtained. In the case of simple paths and simple cycles, this yields exact criteria for when the route defines a single elementary automorphism and when it acts identity.

V. DISCUSSION AND CONCLUSIONS

The constructed representation places the groups M^kVB_n in a setting where methods from the theory of automorphisms of free groups, welded braid groups, type A root-lattice symmetries, and combinatorics of routes become available. In this way, the work gives a broader structural framework for the study of multivirtual braid groups and related questions in multivirtual knot theory.

VI. ACKNOWLEDGEMENTS

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VII. REFERENCES

- [1] L. H. Kauffman, Multi-Virtual Knot Theory, arXiv:2409.07499, 2024.
- [2] V. G. Bardakov, T. A. Kozlovskaya, K. Negi, M. Prabhakar, Multi-virtual braid groups, arXiv:2507.14551, 2025.
- [3] C. Kassel, V. Turaev, Braid Groups, Springer, 2008.
- [4] V. G. Bardakov, M. V. Neshchadim, A Representation of Virtual Braids by Automorphisms.
- [5] R. Fenn, R. Rimanyi, C. Rourke, The braid-permutation group, Topology 36 (1997), no. 1, 123-135.
- [6] J. E. Humphreys, Reflection Groups and Coxeter Groups, Cambridge University Press, 1990.

DIAGONAL ORIENTED GRAPHS OF DIAMETER TWO

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I. Introduction

Magnitude homology forms a bigraded invariant of graphs. This invariant arises as a categorification of the magnitude of a metric space. Magnitude homology is actively studied in modern combinatorics and algebraic topology.

A class of particular interest is diagonal graphs. For such graphs, magnitude homology is concentrated on a single diagonal of the bigrading.

This work considers oriented graphs of diameter two. In such graphs, every pair of vertices is connected by an oriented path of length at most two. This property imposes strong constraints on the graph structure and its associated algebraic objects.

The aim of this work is to investigate the structure of oriented graphs of diameter two and to obtain conditions for their diagonality.

II. Methods

The research is based on an algebraic approach to the study of graphs. An oriented graph is associated with a graded complex. Such research may lead to a better understanding of the link algebra related to the path algebra of the graph. A chain between the combinatorial structure of graphs and their homological invariants.

$$0 \rightarrow K_2 \rightarrow K_1 \rightarrow K_0 \rightarrow S \rightarrow 0.$$

The properties of this complex reflect the combinatorial structure of the graph.

The complex admits a decomposition into a direct sum of subcomplexes:

$$K.(G) = \bigoplus_{x,y \in V} K.(x, y).$$

Each subcomplex corresponds to an ordered pair of vertices and describes the paths between them. Such a decomposition allows for a local investigation of the complex structure.

III. Results

An analysis of the structure of subcomplexes $K.(x, y)$ for various vertex configurations was carried out. A description of the kernels of the corresponding differentials was obtained via configurations of oriented paths of length two.

It is shown that for graphs of diameter two, the structure of the complex is determined by the arrangement of two-step paths and the mutual positions of vertex neighborhoods.

The results provide combinatorial conditions under which the complex is exact. These conditions allow for the identification of diagonal oriented graphs of diameter two.

The study also shows that small changes in the graph structure can significantly alter the structure of the corresponding complex.

IV. Further Research

The obtained results open possibilities for further study of diagonal graphs.

A promising direction is the investigation of oriented graphs of larger diameter. In such cases, the structure of the corresponding complexes becomes substantially more complex.

Another direction involves studying the connections between

graph diagonality and the properties of corresponding

algebras, including Koszul algebras.

homological invariants.

V. Acknowledgments

Acknowledgments: The author expresses gratitude to his supervisor L. A. Mukoseev and the LCME

References

- [1] R. HEPWORTH, S. WILLERTON. Categorifying the magnitude of a graph. *Homology, Homotopy and Applications* 19 (2017), no. 2, 31–60.
- [2] T. LEINSTER, M. SHULMAN. Magnitude homology of enriched categories and metric spaces. *Algebraic & Geometric Topology* 21 (2021), no. 5, 2175–2221.
- [3] Y. GU. Graph magnitude homology via algebraic Morse theory. *arXiv:1809.07240* (2018).
- [4] S. O. IVANOV, L. MUKOSEEV. On diagonal digraphs, Koszul algebras and triangulations of homology spheres. *arXiv:2405.04748* (2024).

QUASI-INJECTIVE FUNCTIONS

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I. INTRODUCTION

For a function from an arbitrary metric space, we can define its spread as a measure of its injectivity, that is, the measure of how far apart two different points must be in order to have the same image.

II. AIMS

This work sets two goals: studying the spread of continuous functions and inventing ways to produce high-spread functions.

Increasing the spread of a function has application to password management [3].

III. METHODS AND MATERIALS

The construction of functions with a large spread is carried out by considering modular arithmetic.

Statements about the possible values of the spread of a continuous function in a metric space are based on fundamental topological results dealing with continuous functions with compact / open domains.

Each statement is accompanied by an example demonstrating the necessity of certain conditions.

Since the spread of an arbitrary function can take almost any value, a continuity condition is introduced, which immediately limits the possible values of the spread.

The study of the spread of continuous functions is of interest because continuity is a natural property of most real processes. Unlike arbitrary maps, continuous functions obey topological laws that limit the possible values of the spread and relate it to the geometry of space.

IV. RESULTS

The main results are

- i The spread of a continuous function $f: S^2 \rightarrow \mathbb{R}^2$ is either zero or infinity;
- ii The spread of a continuous function $f: M \rightarrow \mathbb{R}^2$ from a linearly connected metric space is either zero or infinity;

- iii The existence of a non-injective continuous function on Q with a nonzero spread is proved;

- iv Given functions $f: N \rightarrow A$, $g: N \rightarrow B$, the spread of the function $h: N \rightarrow A \times B$ defined as

$$h(p, q) = (f(p, q), g(p, q)) \text{ is greater than or equal to } \max\{\text{spr } f, \text{spr } g\}$$

- v Given a compact metric space M and a Hausdorff topological space A , $f: M \rightarrow A$ is a continuous function, if $\text{spr } f = 0$ and $G_f \subset M \times M$ has no isolated points, then f is completely and uncountably;

- vi On a compact set M , the condition for non-emptiness of the fold line B_f is equivalent to $\text{spr } f = 0$.

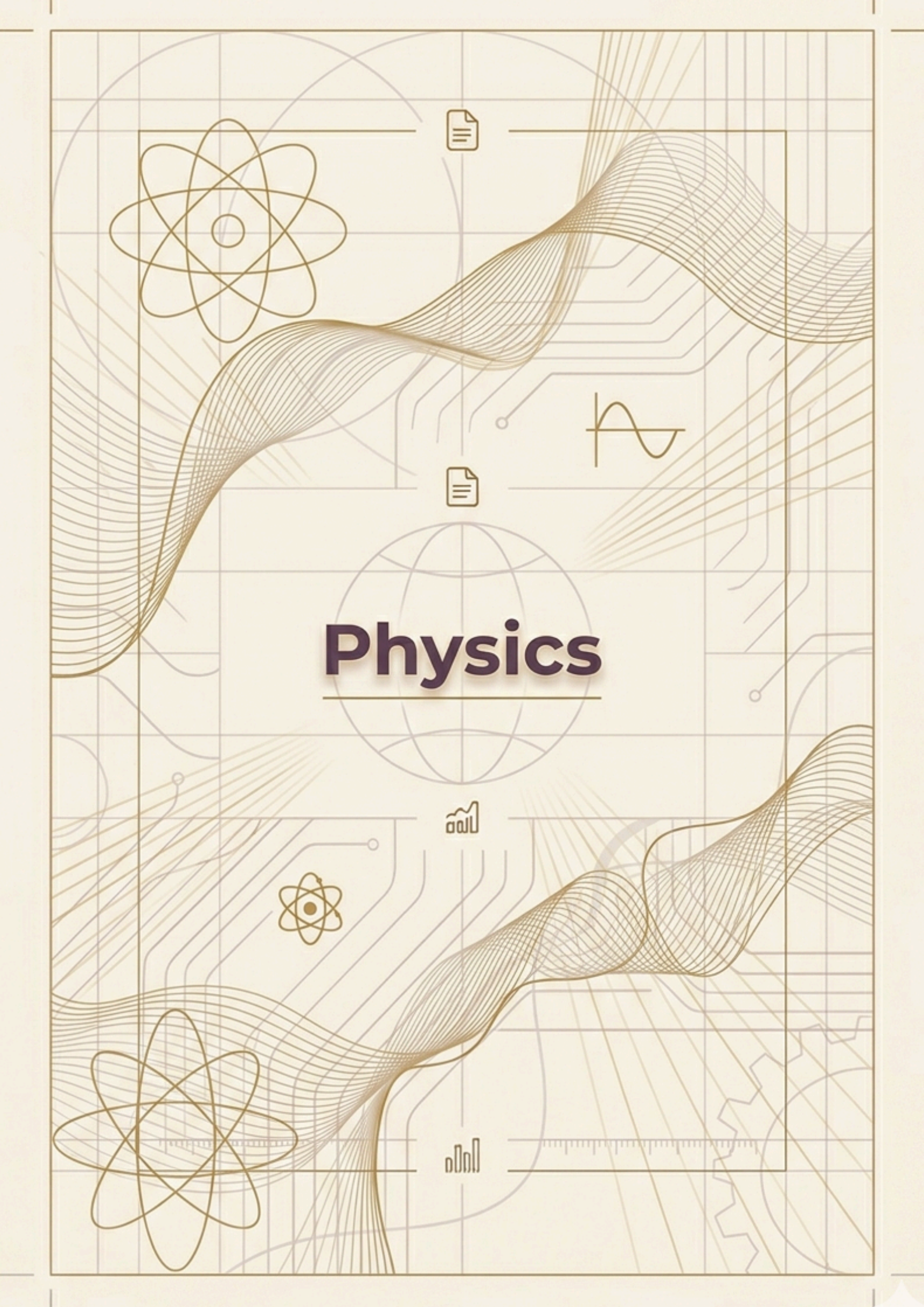
References

- [1] Willard S. General Topology. — Mineola, N.Y.: Dover Publications, 2004. — 222 p.
- [2] Viro O. Ya., Ivanov O. A., Netsvetayev N. Yu., Kharlamov V. M. Elementary topology: problem textbook. — Providence, R.I.: American Mathematical Society, 2008. — xx, 400 p.
- [3] R. Maksimovich. Selection-based minimalistic password generation [Electronic resource] // GitHub. — URL: <https://github.com/thornor/pshash/raw/master/paper/main.pdf> (accessed: 20.03.2026).

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Scientific Center "Laboratory for Continuous Mathematical Education"

The background is a light beige color with a faint grid pattern. It features several scientific and technical illustrations in a golden-brown line-art style. In the top left, there is a stylized atomic model with a central nucleus and three elliptical orbits. To its right is a document icon with three horizontal lines. A large, complex wave pattern, resembling a standing wave or a series of overlapping sine waves, flows from the left side towards the right, passing behind the central text. In the middle right, there is a simple sine wave graph on a set of axes. Below the central text is a globe with latitude and longitude lines. To the left of the globe is another document icon. Below the globe is a small bar chart with three bars of increasing height. In the bottom left, there is another atomic model. To its right is a bar chart with four bars of varying heights. In the bottom right, there is a ruler with markings and a gear. The word "Physics" is centered in a bold, dark purple font, underlined with a thin golden-brown line.

Physics

THE RESEARCH OF ELECTROPHYSICAL PROPERTIES OF PLANAR STRUCTURES WITH PERCOLATION CONDUCTIVITY ON PAPER SUBSTRATES

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Gymnasium №1 of Vitebsk named after Zh. I. Alferov, Belarus

1. Introduction. Today, a new class of electronic and electrical devices is being developed. These are paper electronics devices. According to specialists, their market share will increase rapidly. Low cost and ease of production are their main advantages. Modern paper electronics aim to create products with brand new properties. It is an excellent candidate for the creation of multifunctional, adaptive, high-performance and low-cost components in electronics. In addition, paper is an environmentally friendly raw material that can be easily recycled. **The relevance of studying** such materials lies in the creation and development of technology for producing cheap planar conductive structures on paper substrates, which can be widely used both in electrical engineering and in the training processes of students when studying physics or electronics courses. **Research novelty:** a technology has been developed for producing a composite electrically conductive paste that can be applied to a paper substrate using printing or conventional drawing techniques, creating a conductive surface when it dries.

2. The aim of the research is to develop a technology for producing, manufacturing, studying the electrical properties of planar conductive structures of graphite - sodium metasilicate ($C-Na_2SiO_3$) composites on paper substrates, and to propose areas for their practical application.

3. Methods and materials: sodium metasilicate (Na_2SiO_3), graphite powder (C) of grade GS-2 (Standard 17022–81), paper, cardboard, digital micrometer YT-72305, multimeters, power supply IPD-8132, thermocouples, Mestek IR03B non-contact infrared thermometer and Microsoft Excel software for data processing. In scientific research, we used theoretical and practical methods: analysis of published scientific research, formulation and testing of hypotheses, observation, experiment, data collection and processing, formulation of conclusions.

4. Results and discussion:

1. The technology of obtaining planar conductive structures of graphite-sodium metasilicate
2. composites on paper substrates has been developed.
The electrical properties of planar graphite-sodium metasilicate composites with percolation-type conductivity on paper substrates have been identified; it has been experimentally established that the resistivity of the obtained films can be varied within a wide range, from 10^{10} to $10^{-4} \Omega \cdot m$. The possibility of modeling electrical circuits using planar conductive structures on paper substrates has been demonstrated. Electrical properties of planar structures of different geometric shape with conducting surface have been identified under conditions of use of various methods of connection and electrode sizes. It has been proven experimentally that, with the same thickness of the conductive layer, samples of square form have the same resistance independent of their size. The distribution of electric fields in conductive planar structures of different geometric shape, including those with cutouts, is investigated. Field tension has been found to increase significantly at sharp corners of the cutout. The thermal physical properties of planar elements made of graphite-sodium metasilicate composite materials on paper substrates have been identified. It has been proven that the distribution of temperature fields follows the distribution of electric field. Demonstrated the possibility of creating film-type infrared heaters and fuses on paper substrates.
- 3.
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5. Conclusions. The research results can be used to create and improve the technology of producing environmentally friendly, low-cost planar conductive structures on paper substrates; these devices can find wide application in electrical engineering and electronics; based on these materials, it is quite easy to make safe laboratory samples for teaching students who are studying physics, electrical engineering, and electronics.

Artificial Pneumatic Muscle: Design, Theory, and Applications

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1. INTRODUCTION The pneumatic artificial muscles are in high demand in modern robotics, biomechanics and medical rehabilitation. Unlike traditional rigid and noisy electric actuators, “air muscles” are characterized by softness, flexibility and safety, which makes them the optimal choice for creating prosthetic devices, exoskeletons and systems for safe interaction with humans [1].

2. AIMS

The work aimed at establishing the basic patterns of air muscle functioning and the range of design parameters that ensure its best performance.

3. METHODS AND MATERIALS

The experimental and theoretical methods were used. Two setups were created to study the dependencies of force and relative deformation on pressure. The experimental parameters were recorded automatically. Snakeskin cable braiding and latex tubing were used to create the McKibben’s Air Muscle. The Tondou-Lopez model was used to theoretically describe the action of air muscle [2].

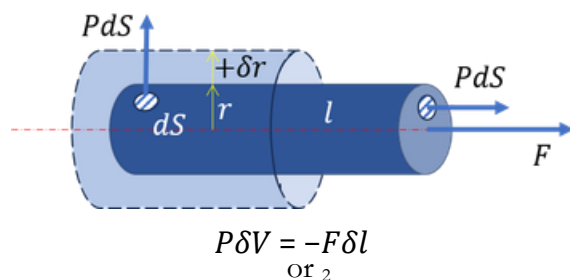


Figure 1 Tondou-Lopez model (transformation of the pressure into the longitudinal force)

4. RESULTS

A comparative analysis of the experimental results with the calculated theoretical values [Figure 2]) allows us to conclude that the used mathematical model is quite good and predictive. For two types of muscles, the maximum values of developed force, and the performed work were obtained [Table 1], which gives an idea of the capabilities of the actuators.

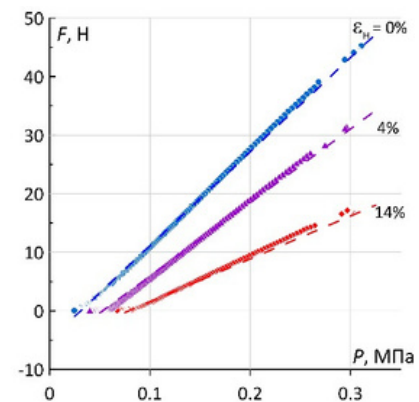


Figure 2. Comparison of experimental and theoretical dependencies $F(P)$.

Table 1. Limit values of force and work of the muscles studied

parameters	muscle I	muscle II
$F_{\max}$	46N (0.3 MPa.)	61N (0.24 MPa.)
	0,95 J (30N, 0.3 MPa .)	1,9 J (40N, 0.24 MPa .)

5. DISCUSSION

Small discrepancies between the experimental and theoretical results can be explained by several factors, namely: neglect of the elasticity of the internal chamber, deviation of the muscle shape from cylindrical, and inevitable experimental errors.

6. CONCLUSIONS

The data obtained and the identified dependencies are of practical importance for the design and optimization of modern mechatronic systems, including the development of soft robotic grips, biomechanical exoskeletons and high-tech prostheses that require smooth and natural movements.

7. REFERENCES

1. Jiang, H. et al., Bionic Design Based on McKibben Muscles and Elbow Flexion and Extension Assist Device. *Actuators*, MDPI, 2025, 15(1), 21-28.
2. Tondou, B., Lopez, P. Modeling and control of McKibben artificial muscle robot actuators. *IEEE control systems Magazine*, 2002, 20(2), 15-38.

Decoding Starlight – Stellar Analysis via Spectroscopy

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1. Introduction

Stars emit radiation whose spectrum depends primarily on their temperature and atmospheric composition. When this light is dispersed into its component wavelengths, it can be analysed. Absorption lines reveal which elements are present in the stellar atmosphere.

2. Aims

The goal of this project was to investigate whether stellar spectroscopy can be performed using amateur equipment while still providing meaningful physical insights. Another aim was to determine the temperature of stars via spectroscopy and various other helping tools.

3. Methods and Materials

Observations were conducted using a telescope equipped with an objective diffraction grating that disperses incoming starlight into a spectrum. The dispersed light was recorded with a digital camera attached to the telescope. Several stellar spectra were recorded and stacked to increase the signal-to-noise ratio. They were wavelength calibrated and atmospheric and instrumental influences were corrected.

The temperature was determined using two independent methods: a fit of the Planck function to the measured spectrum and the B–V color index using the empirical relation given by Ballesteros. A custom analysis pipeline was developed in Python for the different processes of determining the temperature of any given star.

4. Results

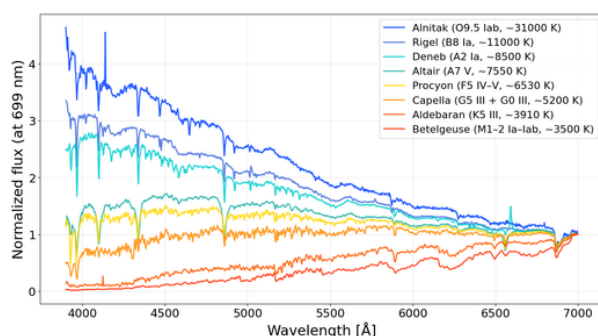


Figure 1: Multiple stellar spectra of stars with different temperatures

This resulted in spectra, showing characteristic and

distinctive features of the various temperatures.

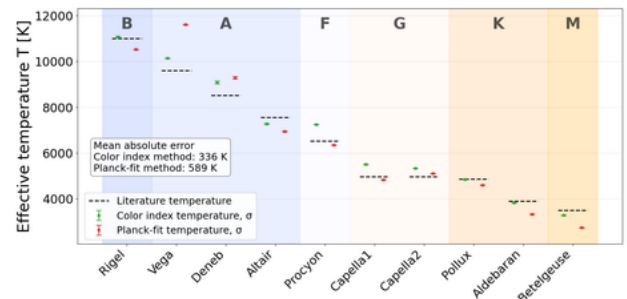


Figure 2: Comparison of the determined temperature using the Planck-fit and B–V color index

When comparing the two temperature-determination methods, it becomes clear that the B–V color index is, on average, much more accurate than the Planck fit. However, the Planck fit differs in its accuracy, depending on the spectral classes of the stars. This is because the stars' spectra differ from Planck's Law. The Planck fit prevails in G and F class stars, because their spectra is similar to a Planck curve, but loses its accuracy to hotter A-class stars, whose spectra are a lot different. For stars with temperatures higher than 20 000 K, the temperature cannot be reliably determined, since their characteristic spectra and light emission fall outside the range of our measurements. Our statistical error is very small, as seen in the graphs.

5. Conclusions

This project demonstrates that stellar spectroscopy can be performed successfully using relatively simple instrumentation combined with a self-developed analysis pipeline.

Future work could include higher-resolution gratings, improved temperature determining methods, and analysis of additional stellar targets.

6. Acknowledgments

The authors would like to thank the supervisors Thilo Glatzel and Hermann Klein and the supporting institution SFZ phaenovum for their guidance and assistance during this project.

7. References

Carroll, B., & Ostlie, D. An Introduction to Modern Astrophysics.
Gray, D. The Observation and Analysis of Stellar Photospheres.

Flipo Flip: The Physics of a Toy

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1. INTRODUCTION

The Flipo Flip is a toy that can roll for multiple turns, even though its shape is not circular. In my project I investigated why the phenomenon is possible, and how the physics behind it looks like.

2. AIMS

The aims of my research were to uncover why the motion is possible, how the motion can be modelled and what role friction plays throughout the motion.

3. THEORY AND METHODS

To model the phenomenon, the motion was split up into individual motion phases: the first phase is when it flips from one edge to the other, the second phase is when it rolls along its arc. The first phase was approached with a hexagon, and the second one was approached with a plum pit.

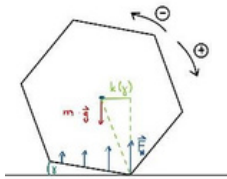


Figure 1: Hexagon

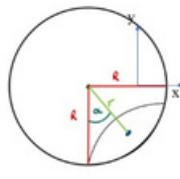


Figure 2: Plum pit rotating around imaginary circle

The equation for the first motion phase was approached with this equation (no energy losses):

$$\frac{-m \cdot g \cdot \sin\left(\frac{\pi}{6} - \gamma\right) \cdot r}{\theta} = \ddot{\gamma}$$

The second motion phase was described with this equation (no energy losses):

$$\frac{-\sin(\alpha) \cdot \cos(\alpha) \cdot \alpha^2 \cdot (R - 2 \cdot R \cdot \ddot{\alpha}) + g \cdot r \cdot \sin(\alpha)}{r^2 + \cos^2 \alpha \cdot (R - R^2 \cdot \ddot{\alpha})} = \ddot{\alpha}$$

The following term describes the losses when it rolls on its arc:

$$Q = \beta \cdot (R^2 - 2 \cdot R \cdot r \cdot \cos(\alpha))^2 \quad r \cdot \ddot{\alpha} + \lambda \cdot \sqrt{R - 2 \cdot R \cdot \ddot{\alpha} \cdot \cos(\alpha) + r}$$

For the experimental part 3D-printed hexagons and plum pits were rolled down a tilted rubber surface. The surface was tilted, since in the theory I to begin with neglected the energy losses. When the 3D-printed objects roll down the surface the losses get compensated because of the height difference. Therefore, we can compare the theory with the experiments. To test the role of friction different „Flipo Flips” were 3D-printed with different radius of curvature, height and side length.

4. RESULTS

Then the equations were simulated in Python.

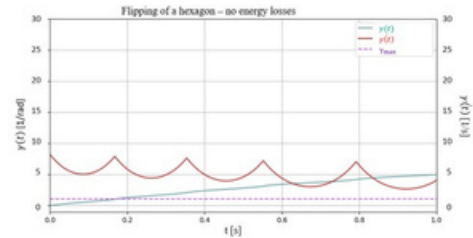


Figure 3: Flipping of a hexagon – no energy losses

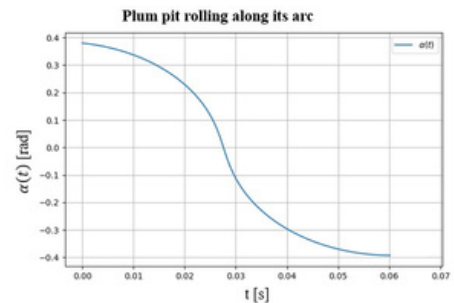


Figure 4: Plum pit rolling along its arc

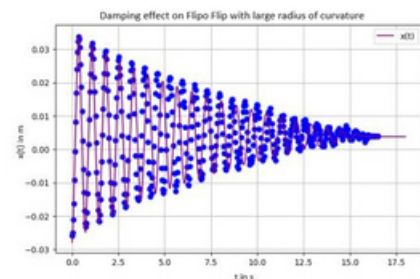


Figure 5: Damping effect on Flipo Flip with large radius of curvature

	T_simulated [s]	T_measured (n=10 average) [s]
Hexagon	0.162	0.161
Plum pit		0.050
Flipping over Side	0.060	0.033
	0.028	

5. DISCUSSION AND CONCLUSION

When we compare the experimental and theoretical approach, we can see that there is no huge difference. Therefore, we can conclude that the hexagon and plum pit is a good approach for each individual motion phase.

6. ACKNOWLEDGEMENT

Thank you to Dr. Mihály Hömöstrei and Blanka Bartók for all the help!

Ring Fountain Dynamics

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1. INTRODUCTION

This study investigates how the fountain effect is generated when a flat metal ring falls into a water tank, creating a vertical jet of water. Specifically, examining how different geometric parameters of the ring, along with its falling height, influence the maximum velocity of the resulting jet. By systematically varying the ring's shape and fall conditions, we identify key parameters that optimize jet velocity, allowing us to apply this knowledge to chemical stirring systems, where the strongest jet can facilitate efficient mixing with minimal energy input.

2. AIM

The motivation for this study is the observation that the resulting water jet can rise significantly higher than the initial falling height of the ring. This unusual behavior suggests potential practical applications, for example in mixing processes where strong fluid motion is required but energy input should remain low.

3. METHODS AND MATERIALS

My experiments utilised various flat metal washers with different internal/external radius and height. The falling height of the rings varied (2-20 cm), while the water depth in the tank was adjusted (1-10 cm) to investigate in different parameters. For small falling heights, the rings were released manually, whereas for larger, a custom-built mechanical launcher was employed to ensure a parallel impact. All experiments were recorded using a phone at 240 fps and the resulting videos were analyzed using the software Tracker. Each experiment was repeated three times.

The physical theory of the fountain effect is based on the conservation of momentum. The process can be

Approximated by momentum before the the water surface [Figure 1]. During this short interval, the ring-water system can be treated as an isolated system.

$$v_{wj} = \sqrt{\frac{m^2 + \rho A \Delta t (v + v_{wj})^2}{\rho A \Delta t (v + v_{wj}) + m}}$$

Here, m is the mass of the ring, ρ the density of the water, v the ring's velocity before the impact, A the surface of the ring, Δt the surface of the rings opening and v_{wj} is the velocity of the water jet.

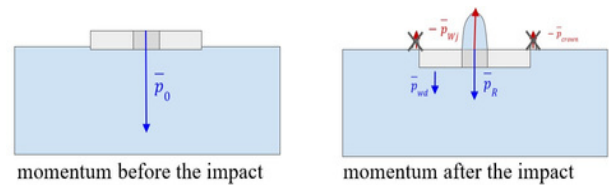


Figure 1. Momentum before and after the impact

4. RESULTS

The experiments showed that decreasing the ring's inner diameter (to an optimum) and increasing its thickness and mass generally lead to a higher maximum water jet. Increasing the falling height of the ring also increases the jet height, while water depth had negligible influence within the tested range [Figure 2].

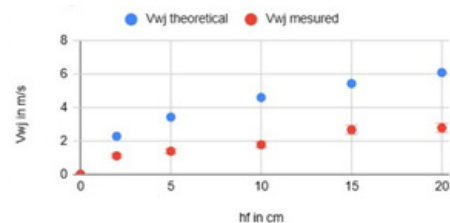


Figure 2. Jet's maximum velocity at different falling heights

5. DISCUSSION

Experimentally measured jet velocities were slightly lower than theoretical due to a model simplification, such as neglecting the momentum of the splash of the water that goes around the ring.

6. CONCLUSIONS

The maximum water jet depends mainly on the ring's geometry and falling height, while water depth has no effect. Experimental results agree reasonably with theory, with little deviations due model simplification

7. ACKNOWLEDGEMENT

I would like to thank my physics teacher Dr. Mihály Hömöstrei for his guidance and support and my father for his help with the experiment

8. REFERENCES

<https://www.leifiophysik.de/mechanik/impulserhaltung-und-stoesse/grundwissen/impuls-und-impulserhaltungssatz>
[https://de.wikipedia.org/wiki/Kontinuit%C3%A4tstheorie_\(Geschichtswissenschaft\)](https://de.wikipedia.org/wiki/Kontinuit%C3%A4tstheorie_(Geschichtswissenschaft))

Periodic Motion of the Weighted Double Pendulum

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Introduction

Double pendulums, consisting of two coupled single pendulums (the pivot of one pendulum is connected to the bob of the other), have numerous uses across fields ranging from architecture to robotics. Moreover, they are a useful introduction to chaos theory, a branch of physics that deals with non-linear, unpredictable systems of motion. The unpredictable nature of the double pendulum is due to its high dependence on numerous initial conditions, including the masses of the two bobs. Changing the ratio between the two masses of the double may cause its behaviour to mimic a single pendulum, imperfectly or otherwise.

Aims

To investigate, using a phase graph, how the ratio (n) between the two masses (m and nm) of a double pendulum (with massless rods) affects its harmonic motion (when $n=10, 20, 30, 40, 50, 60, 70, 80, 90$ and initial angle

$\theta = \pm 45^\circ, 90^\circ, 135^\circ, 180^\circ$) across 120 seconds.

Methods and Materials

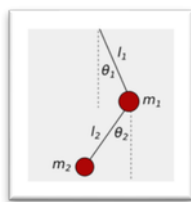


Figure 1: A diagram of a double pendulum

A simulation based on the Lagrangian Equation of a simple double pendulum (see Fig. 1) was used to determine the angles θ_1 and θ_2 across time (t), from 0 to 20 seconds. Here, the value of n was 10, 20, 30, 40, 50, 60, 70, 80, 90 (where $n = m_2/m_1$). The initial angle θ_1 was $\pm 45^\circ, 90^\circ, 135^\circ, 180^\circ$. This graph, $p(t)$, was could not be approximated as such (i.e. $p(t)$ did not correspond to any function

where $\theta \in \mathbb{R}$, within a margin of 5°). Afterwards, classified as having **Periodic Motion**, in which case the length of their period (T) was calculated; those without were classified as having **Chaotic Motion**.

In these simulations, l_1 and l_2 were equal to one meter, m_1

was equal to one kilogram, and the initial value of θ_1 was set to 0.

Results & Discussions

Type of Motion (Approx. Periodic/Chaotic): Duration of T (seconds)		Initial value of θ_2 (degrees)			
		30	45	60	90
Magnitude of n	10	Periodic: 2.580	Chaotic	Chaotic	Chaotic
	20	Periodic: 2.846	Periodic: 3.066	Chaotic	Chaotic
	30	Periodic: 2.686	Periodic: 2.976	Chaotic	Chaotic
	40	Periodic: 2.681	Periodic: 2.911	Chaotic	Chaotic
	50	Periodic: 2.656	Periodic: 2.856	Periodic: 2.675	Chaotic
	60	Periodic: 2.646	Periodic: 2.871	Periodic: 2.666	Chaotic
	70	Periodic: 2.621	Periodic: 2.896	Periodic: 2.666	Periodic: 2.861
	80	Periodic: 2.851	Periodic: 2.856	Periodic: 2.671	Periodic: 2.821
	90	Periodic: 2.801	Periodic: 2.901	Periodic: 2.666	Periodic: 2.846

The simulation revealed that the double pendulum reached approximately periodic motion for all values of n and $\theta_2 \leq 70$. Additionally, the magnitude of n for which the double pendulum's motion became periodic correlated with the initial value of θ_2 . However, there was no statistically significant correlation between n and T for any values of n .

Conclusion

Increasing the ratio between the two masses of a double pendulum increases the regularity of its motion. On the other hand, decreases the regularity of its motion, concerning initial mass and angles, is the one with the greatest difference between the mass of its bobs and the smallest value of its initial angle possible.

(1)

$$f(t) = a(\cos(b(t+c)))$$

Effects of Non-Gaussian Wave Packets on Interference and Their Implications for Electron Wave Packet Simulation in Next-Generation Semiconductors

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Introduction:

A wavepacket is a localized quantum state formed by the superposition of plane waves with a finite momentum spread, as described by Fourier analysis. Its spatial localization arises from the interference of multiple momentum components, with their distribution determining both the packet's extent and its evolution. The time evolution of a wavepacket is governed by the Schrödinger equation, where different momentum components acquire different phase shifts, causing dispersion. In a double-slit experiment (DSE), this evolution is significant because wavepacket spreading affects how the wave interacts with the slits and, consequently, the resulting interference pattern's intensity, visibility, and fringe structure.

Using the results of the study, certain interfering properties can be understood in non-relativistic contexts for the use of Electron Wave Packets (EWPs) in next generation semi-conductor design. This wavepacket-based description is directly applicable to electrons in semiconductors, where charge carriers are not treated as perfectly delocalized plane waves but as localized electron wave packets propagating through a periodic crystal lattice.

Aims:

The aim of the study lies in assessing the reliability of the textbook assumption that modelling wave propagation through Gaussian wavepackets is justified due to their nature, and as such, aims to: (a) find out the differences in this propagation when non-Gaussian wavepackets are used, and (b) analyse the reasons behind said differences. By doing so, the study assesses whether standard Gaussian-based models may overlook critical parametric behavior (I.E., the simultaneous interaction of wavepacket model and other physical parameters), with implications for the accurate simulation of electron wave packets in nanoscale semiconductor devices.

Methods and materials:

Wave propagation was analysed using two key 'observable' traits that were used to compare interference patterns throughout the study. These were fringe count and peak intensity (I_{max}).

The methodology involved numerical simulations performed in Python using NumPy, Matplotlib, and SciPy. Five condition sets were defined by varying three parameters: wave packet width (γ), slit separation (d), and wave number (k), with Gaussian packets tested first and Lorentzian packets tested under identical conditions.

The image below summarises the model:

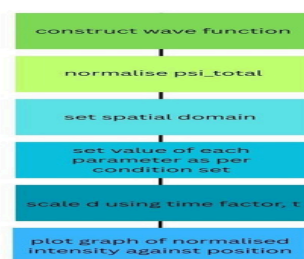


Figure 1: summary of model-construction used in the study

Results and Discussion:

Across all simulations, Gaussian and Lorentzian wavepackets displayed clear and systematic differences in how they evolve and form double-slit interference patterns. These differences are not merely quantitative but reflect fundamentally distinct interference behaviour arising from their underlying momentum distributions.

Gaussian packets transitioned from a single central maximum to two dominant peaks with time, with larger slit separations producing this transition earlier and yielding more fringes overall; however, strong early overlap caused nonlinear behaviour and suppressed minor peaks.

Lorentzian packets, with their heavy tails and broader spectral content, evolved faster; secondary maxima became competitive earlier, fringe amplitudes persisted farther out, and an unusual three-peak structure emerged under specific low-distance conditions. This behaviour is attributed to their slower spatial attenuation and enhanced high-momentum components, which redistribute interference intensity across multiple peaks.

Conclusion:

Non-Gaussian wave packets, hence, produce fundamentally different interference patterns, implying that electron wave packets in real materials cannot be accurately modeled as purely Gaussian. In nanoscale devices, this affects current, transmission, and noise. Incorporating non-Gaussian profiles into Schrödinger equation-based and quantum transport simulations can improve the accuracy of next-generation semiconductor design.

References:

[1] Ayachit, Shaarav. (2025). The effects of non-Gaussian wave packets on double slit interference patterns: A parametric comparison of Lorentzian wavepackets versus Gaussian wavepackets in double-slit experiments, using computational analysis.. 10.58445/rars.3541.

[2] Heisenberg, Werner. "Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik." *Zeitschrift für Physik* 43.3 (1927): 172-198.

[3] Fitzpatrick, Richard. *Quantum Mechanics*. World Scientific Publishing Company, 19 May 2015.

Early Epileptic Seizure Prediction Using Welch's Power Spectral Density and Machine Learning

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1. INTRODUCTION

Epilepsy is a chronic neurological disorder that is marked by recurrent seizures, affecting 50 million people worldwide [1]. With a misdiagnosis rate of approximately 30%, the consequences are severe if these events are not detected early [2]. Electroencephalograms (EEG) are utilized to monitor brain activity, but the ability to predict seizures is crucial for timely intervention and reducing injury risks. Therefore, improving EEG analysis to reliably capture pre-ictal patterns is a critical step toward accurate seizure prediction using supervised machine learning.

^AThis research aims to extract frequency features from EEG

2. IMS

signals through Welch's Power Spectral Density to classify patterns of preictal and interictal brain activity using supervised machine learning, specifically Random Forest and Gradient Boosting models. The analysis then compares statistical and spectral EEG features to identify which features contribute the highest influence on model accuracy in identifying preictal patterns.

3. RESEARCH METHODOLOGY

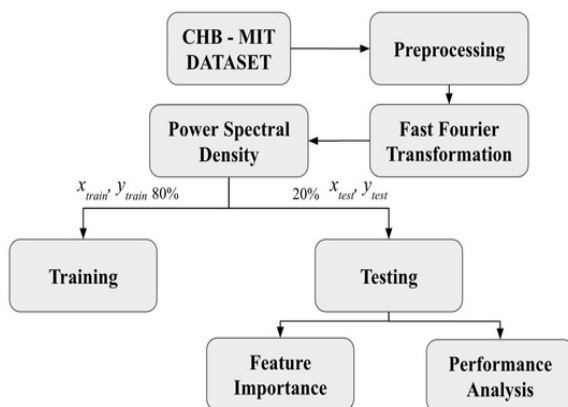


Figure 1. Seizure Prediction Methodology Pipeline

4. RESULT AND DISCUSSION

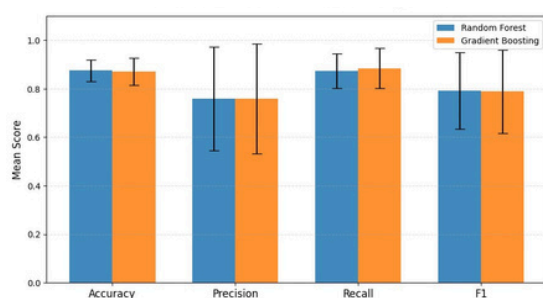


Figure 2. Performance Results

Table 1. Top 3 Features from Feature Importance

Sub	Top 3 Features					
	Map	Feat. Type	Map	Feat. Type	Map	Feat. Type
02	CZ-PZ	γ	C3-P3	β	F4-C4	α
03	CZ-PZ	γ	P4-O2	γ	P3-O1	α
05	FT10-T8	β	F3-C3	γ	FP2-F4	γ
08	P3-O1	β	C4-P4	β	P7-O1	β
12	T7-P7	γ	T7-FT9	γ	FP1-F7	α
14	FP2-F4	γ	FT10-T8	γ	FP2-F4	var
16	FT10-T8	θ	F4-C4	γ	P7-O1	β
18	P3-O1	γ	C3-P3	γ	F3-C3	β
21	FP1-F3	β	F7-T7	var	F4-C4	γ
23	F8-T8	β	T7-FT9	γ	FZ-CZ	θ

Random Forest and Gradient Boosting showed effective seizure prediction through strong classification stability, among parameters. Higher standard deviation in precision and F1 score indicates frequent false alarms, which reflects the rare occurrence of seizure events in the dataset. Strong subject specific variation was observed in feature importance across EEG channels. For the feature importance results, it is observed that the source of seizure from each subject is relatively different, which shows how seizure patterns were different for each subject. However, a generalized feature was derived from the beta and gamma frequency bands, which signals how the brain is hypersynchronous in the preictal phase. Signal variance, as a statistical feature, is not dominant compared to the frequency features, which indicates how amplitude fluctuations are not informative to identify preictal phases. Overall, it has shown that frequency features are powerful biomarkers for preictal identification.

5. CONCLUSION AND FUTURE WORKS

Supervised machine learning models are effective to identify preictal patterns, but false alarms were observed due to the rarity of seizure events within the dataset. Beta and gamma frequency bands are dominant features, which indicates powerful biomarkers. Future work should include development of a portable EEG recording device, implementation of real time seizure prediction with low latency, and the utilization of larger and more diverse EEG datasets should be included to improve the model.

6. REFERENCES

- [1] World Health Organization. (2024, February 12). *Epilepsy*. <https://www.who.int/news-room/fact-sheets/detail/epilepsy>
- [2] Smith, D., Defalla, B. A., & Chadwick, D. W. (1999). The misdiagnosis of epilepsy and the management of refractory epilepsy in a tertiary referral centre. *Seizure*, 8(6), 325-331. <https://doi.org/10.1053/seiz.1999.0310>

Investigation of Voltage and Phase Effects in an Ultrasonic Levitation System

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1. INTRODUCTION

Ultrasonic levitation uses high-frequency sound waves to suspend small objects in air without contact. Standing waves between an emitter and a reflector create nodes where acoustic force balances gravity. While previous studies focused on stable levitation devices, quantitative analyses of how amplitude and phase shift affect levitation are limited. This study investigates the influence of these parameters on ultrasonic levitation.

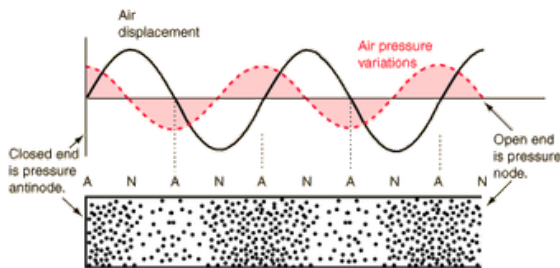


Figure 1. Ultrasonic standing wave

2. AIMS

This study experimentally investigates how amplitude (driving voltage) and phase shift affect ultrasonic levitation with 40 kHz transducers, focusing on levitated mass, ease of levitation, and vertical motion. The results aim to improve understanding and guide potential future applications of this technology.

3. METHODS AND MATERIALS

A 3D-printed levitator base held 72 transducers in opposing arrays to form a standing wave. An Arduino Nano generated a 40 kHz PWM signal, amplified via L298N, with phase shift controlled for vertical object movement. Driving voltage ranged 0–24 V.

Experiment 1: Amplitude – Average mass measured; 10 trials per voltage.

Experiment 2: Phase Shift – Phase set 0°–180°; vertical displacement measured.

$f=40\text{ kHz}$, $L=0.12\text{ m}$, $v=343\text{ m/s}$, $k=10\text{ Pa/V}$, $\lambda=v/f=8.6\text{ mm}$, $N=27$

Pressure generated:

$$p=kV \quad (1)$$

Acoustic radiation force:

$$F=4\pi a^3 E \sin(4\pi x) \quad (2)$$

Vertical displacement: $\Delta x = \frac{\lambda}{4} \sin(\Delta\phi)$ (3)

Where a is object radius, E is ultrasonic energy, x is position, $\Delta\phi$ is phase shift. Data were compared with theory to validate the levitation model.

4. RESULTS

The results in Table 1 show that ultrasonic levitation depends on both driving voltage and phase shift. Higher voltage increases lifting force and levitated mass ($m \propto k^2$, $k=0.0635$), but excessive voltage reduces stability. Adjusting phase shift moves standing-wave nodes, enabling vertical motion, though large shifts ($>120^\circ$) destabilize levitation.

Table 1. Voltage dependence of ultrasonic levitation.

Voltage [V]	Mass [mg]	Levitation count
24	36.5	8
21	27.95	10
18	20.53	10
15	13.69	9
12	9.13	6
6	2.28	2

Table 2. Phase shift effect on particle.

Phase shift [°]	Motion [mm/s]
180	3.6
150	3.13
120	2.6
90	1.98
60	1.25
30	0.59

5. DISCUSSION

The results show that higher driving voltage increases lifting force, but excessive voltage causes nonlinear oscillations, reducing stability. Optimizing amplitude and phase shift is essential for reliable levitation, while environmental factors can also affect performance. Potential errors include transducer misalignment, frequency fluctuations, and limited measurement precision.

6. CONCLUSIONS

Amplitude and phase shift affect ultrasonic levitation: higher amplitude improves lifting and stability, while larger phase shift enables vertical motion but reduces stability. Optimizing these parameters allows heavier objects to be levitated and supports applications in medicine, space research, and materials handling.

7. ACKNOWLEDGEMENT

We thank our school's physics lab and teachers, Erdenechimeg and Khuderbaatar, and Zandan B. at the Institute of Physics and Technology for their support.

8. REFERENCES

Tracy V. Wilson (2023) How Acoustic Levitation Works
[How Acoustic Levitation Works](#) | [HowStuffWorks](#)

Dynamics of a Parametrically Excited Pendulum with Finite-Range Impacts

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1. Introduction

Parametric resonance occurs when periodic modulation of a system parameter produces large oscillations. It plays a critical role both in preventing instability in engineered structures and in high-precision technologies such as quadrupole ion traps and mass spectrometers used in proteomics and atmospheric sensing.

The canonical model is the vertically driven pendulum described by the Mathieu equation, which predicts regions of stability and exponential growth. However, real systems often involve impacts or constraints, where this description may fail.

We study this effect in the clackers toy: two balls connected by a string with a vertically driven midpoint. Between impacts the motion follows a parametrically driven pendulum, while collisions introduce non-smooth dynamics, providing a minimal system for testing the limit of Mathieu theory under realistic conditions.

2. Aims

We study how finite collision radius modifies parametrically excited dynamics by mapping oscillation amplitude and identifying deviations from Mathieu stability. We established clacker toy as a minimal model for parametrically driven systems with constraints.

3. Methods and Materials

The system is modelled as a parametrically driven pendulum described by the dimensionless equation

$$\ddot{\alpha} + 2\beta\dot{\alpha} + \frac{1}{\epsilon} + \epsilon \sin \tau \sin \alpha = 0, \quad (1)$$

where $\delta = \omega/\omega_0$, $\epsilon = H/L$, and β is damping. Finite radius R introduces impacts at $\alpha_c = \sin^{-1}[R/(R+L)]$. Collisions are treated as oblique impacts, with contact geometry set by finite ball radius and normal contact described by a Hertzian model.

System response is quantified using RMS amplitude after simulations (C++) are compared with video-tracked experiments (Fig. 1), using independently measured parameters.

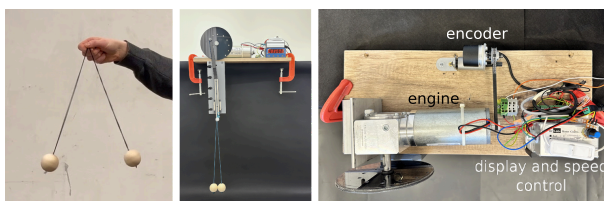


Figure 1: Clacker toy. Experimental system capable of driving frequencies in range 0–25 Hz, with driving amplitudes between 2.1 and 4.2 cm set by an eccentric mechanism.

4. Results

For zero radius, the system exhibits only classical Mathieu behavior: damped motion or unbounded resonance.

Finite radius introduces a third regime: stable oscillations

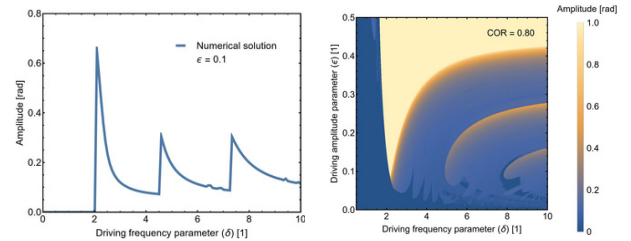


Figure 2: Left: cross-sectional geometry of the clacker toy system. Right: RMS amplitude map of oscillations for $\alpha=0.05$, damping $\beta=0.01$, and $COR=0.80$.

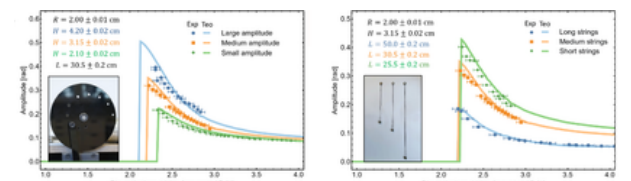


Figure 3: Comparison of numerical predictions with experimental results for different system parameters.

with finite, non-zero amplitude. This appears as bands in (δ, ϵ) space (Fig. 2, right), where oscillations persist without growth or decay. Increasing α_c broadens and shifts these regions, while dissipation reduces amplitude but preserves the effect. Numerical results agree quantitatively with experiments across all tested

parameters (Fig. 3). **5. Discussion** Finite radius alters phase-space structure, limiting ampli-

tude growth and creating stable states absent in classical theory. This is relevant for systems with impacts or constraints, where stability may be mispredicted.

6. Conclusions

Finite-size effects in a parametrically driven impact pendulum produce a third dynamical regime, stable finite-amplitude oscillations, not predicted by the Mathieu equation.

Simulations including realistic collision physics agree with experiments, demonstrating that non-smooth dynamics play a key role in parametrically excited systems. The clacker toy provides a simple experimental model for studying these effects.

7. Acknowledgement

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8. References

- [1] M. Faraday, *Phil. Trans. R. Soc.* 121, 299 (1831).
- [2] E. Mathieu, *J. Math. Pures Appl.* 13, 137 (1868).
- [3] N. W. McLachlan, *Mathieu Functions* (1947).
- [4] J. J. Stoker, *Nonlinear Vibrations* (1950).
- [5] D. D. Quinn, *Int. J. Bifurcation Chaos* 15, 1975 (2005).
- [6] H. Hertz, *J. Reine Angew. Math.* 92, 156 (1882).
- [7] K. L. Johnson, *Contact Mechanics* (1985).

The evaluation of the physicochemical properties and biocompatibility of alginate-collagen hydrogels for tissue regeneration.

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1. INTRODUCTION

Current bioengineering for skin regeneration often prioritizes rapid wound closure over functional tissue architecture, frequently resulting in dysfunctional scarring. This study evaluates the efficacy of alginate–collagen composite matrices as scaffolds designed to facilitate natural healing phases and minimize fibrous tissue formation.

2. AIMS

The research aims to develop and characterize stable alginate-collagen scaffolds for tissue engineering. Key objectives include validating ionic crosslinking across the obtained composites and quantifying structural properties—specifically pore dimensions and volumetric porosity—while evaluating degradation profiles, swelling behavior, and biocompatibility across varying concentration ratios (95:5 and 80:20).

3. METHODS

Composite scaffolds were synthesized via a two-stage lyophilization process [1,2] and stabilized through Ca^{2+} ionic crosslinking using calcium chloride, with pure alginate serving as a control. Successful crosslinking was verified using Fourier-transform infrared (FTIR) spectroscopy [3]. Structural analysis included scanning electron microscopy (SEM) and ImageJ processing to determine pore dimensions, while volumetric porosity was quantified via liquid displacement method using ethanol. Biodegradability and uptake were monitored over seven days in both ultrapure water (UPW) and simulated body fluid (SBF), in a static environment. Biocompatibility was assessed using HaCaT cells [4] and a CCK-8 assay [5], with cell viability determined by absorbance measurements at 450 nm.

4. RESULTS

FTIR analysis confirmed successful ionic crosslinking across all composite variations (Figure 1). SEM imaging analysis quantified the mean pore size across all composite concentrations (Table 1) and the ethanol displacement method demonstrated that volumetric porosity increases linearly with collagen concentration (Figure 2), with higher collagen ratios promoting an interconnected, open-pore architecture. This structural shift significantly enhanced the matrix's fluid absorption and retention capabilities. In both UPW and SBF, the 80:20 ratio exhibited an uptake capacity of almost 2500% and a 25% degradation rate over seven days—a timeline consistent with natural cellular regeneration. CCK-8 assays confirmed that all formulations are non-cytotoxic (Figure 3), with the 80:20 alginate-collagen sample providing the optimal microenvironment for HaCaT cells, maintaining high viability and promoting early indicators of proliferation.

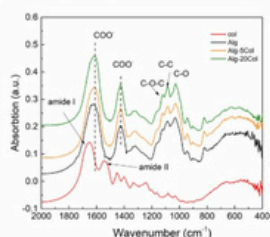


Figure 1. Chart containing the FTIR spectra

Table 1. Pore dimensions relative to collagen concentration

Ratio	Alg	(95:5) Alg-Col	(80:20) Alg-Col
Avg. Pore dimension	23±2 μm	155±6 μm	115±6 μm

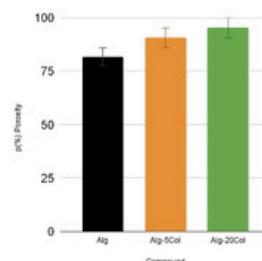


Figure 2. Graph of volumetric porosity results

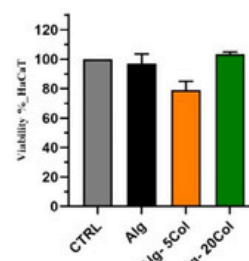


Figure 3. Graph of cell viability results

5. DISCUSSION

While the 95:5 ratio supports basic tissue regeneration, the 80:20 alginate-collagen composite demonstrates a superior balance of structural and biological properties. These findings suggest that increasing collagen concentration toward an 80:20 threshold optimizes the scaffold's performance. However, further optimization of the composite ratios and long-term stability studies are necessary to define the absolute ideal formulation for clinical application.

6. CONCLUSIONS

FTIR analysis confirmed successful ionic crosslinking, while SEM and ethanol displacement verified that the 80:20 ratio provides the most optimized macroporous architecture for its intended scope. The results indicate that collagen proportions can be used to precisely tune the composite's porosity and fluid handling. Seven-day immersion tests in UPW and SBF, alongside CCK-8 assays, confirm the scaffold is non-cytotoxic and aligns with natural cellular regeneration timelines. Ultimately, the 80:20 ratio was identified as the most effective candidate for supporting rapid cell proliferation in tissue engineering applications.

7. ACKNOWLEDGEMENT

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8. REFERENCES

- [1]. Alexandra Feraru, Alina Zăvoi, Klára Magyari, Zsejke-Réka Tóth et. al., Skeletal muscle regeneration using bioactive glass-alginate-cellulose composites, *I.J. Biol. Macromol.*, 228(2025) 138569
- [2]. Alexandra Feraru, Zsejke-Réka Tóth, Klára Magyari, Monica Baia, et. al, The effect of nanoceria on the alginate-gum arabic crosslinking mechanism and in vitro behavior as a wound dressing, *I.J. Biol. Macromol.* 288 (2025) 138569
- [3]. Karima Belbachir, Razia Noreen, Gilles Gouspillou, Cyril Petitboi, Collagen types analysis and differentiation by FTIR spectroscopy, *Anal Bioanal Chem* (2009) 395:829–837
- [4]. Kamiloglu, S., Sari, G., Ozdal, T., & Capanoglu, E. (2020). Guidelines for cell viability assays. *Food Frontiers*, 1(3), pp. 332-349. doi: 10.1002/fft2.44.
- [5]. Boster Biological Technology (n.d.). *Cell Counting Kit-8 (Catalog Number: AR1160)*. Pleasanton, CA: Boster Biological Technology.

Synthesis and characterization of CFO@BTO nanoparticles

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1. INTRODUCTION

Core-shell nanoparticles consisting of a magnetic CoFe_2O_4 core and a ferroelectric BaTiO_3 shell (CFO@BTO) represent a promising approach to combine two functionalities in a single nanostructure, thus enabling advanced multifunctional properties [1]. Understanding the relationship between the shell thickness, the magnetic core size and magnetic parameters is fundamental for designing nanoparticles with tailored properties for targeted drug delivery [2], magnetic hyperthermia [3], electronics and sensors.

2. AIMS

This study aims to investigate how the magnetic and structural characteristics of CFO@BTO systems vary depending on the size of the magnetic core and core-to-shell volume ratio.

3. METHODS AND MATERIALS

The synthesis of CFO@BTO nanoparticles was carried out by a two-stage hydrothermal synthesis method, which made it possible to vary the target parameters in a controlled manner. The formation of a two-phase structure and the crystallinity of samples with different morphologies were confirmed by X-ray diffraction analysis. The morphology and exact geometric parameters for each synthesis variant were visualized using transmission electron microscopy, which showed core sizes of 10, 20, and 30 nm and core-to-shell ratios of 1:4, 1:6. To study the properties of nanoparticles, agglomeration was prevented and hydrophilicity was achieved by functionalization with Pluronic F-127, which was confirmed by dynamic light scattering. The optimal pH for maximum system stability was identified using electrophoretic light scattering, revealing a high zeta potential consistent with good nanoparticle stability. Using a vibrating sample magnetometer (VSM), a comparative study of the magnetic properties in a series of samples with different CFO core sizes and different core-shell ratios was carried out.

4. RESULTS

VSM analysis reveals the following:

- 1) As the size of the magnetic core increases, the magnitude of its coercive force increases.
- 2) As the shell thickness increases, the magnetic moment in the samples decreases. This is due to the

shielding of the surface magnetic moment of the core.

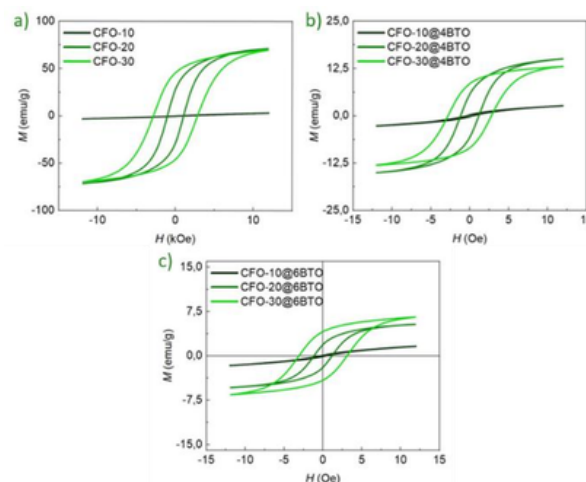


Figure 1. VSM magnetization curves of CFO@BTO nanoparticles: (a) different CFO core diameters; (b) CFO@BTO ratio of 1:4; and (c) CFO@BTO ratio of 1:6.

CONCLUSION

CFO@BTO nanoparticles with core diameters of 10–30 nm and two different core-to-shell ratios were successfully synthesized using a two-step hydrothermal method. The obtained nanoparticles demonstrate colloidal stability at physiological pH and exhibit size-dependent magnetic behavior. These characteristics make them promising candidates for biomedical applications such as targeted drug delivery and magnetic hyperthermia that require responsiveness to external magnetic fields.

5. ACKNOWLEDGEMENT

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6. REFERENCES

1. H. Schmid, "Multi-ferroic magnetoelectrics," *Ferroelectrics*, vol. 162, pp. 317–338.
2. Jadhav et al., "Field-controlled magnetoelectric core-shell CoFe_2O_4 @ BaTiO_3 nanoparticles," *Mater. Sci. Eng. C*, vol. 126, p. 112167, 2021.
3. S. Hossain, "Quantitative and Experimental Analysis of Magnetoelectric and Photothermal Properties of Cobalt Ferrite-Barium Titanate Core-Shell Nanocomposites for Biomedical Applications," M.S. thesis, Univ. Texas, San Antonio, 2023.

Research Of Diclofenac Adsorption On Charcoal Obtained From Rice Husk Ash, With The Aim Of Industrial Waste Utilization And The Production Of A Low-Cost Sorbent For Wastewater Treatment

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1. INTRODUCTION

This study is devoted to investigating the physical surface properties of adsorbent materials (a branch of physics: surface physics).

2. AIMS

The objective of this work is to examine the physical surface properties of rice husk ash and to develop a method to improve its adsorption characteristics.

This research was prompted by the need to solve two pressing environmental challenges: the valorization of industrial waste and the creation of a low-cost sorbent for wastewater treatment.

Research hypotheses:

1. Rice husk ash - an abundant agro-industrial waste - can be transformed into an inexpensive and highly effective adsorbent for the removal of pharmaceutical residues (e.g. diclofenac) from wastewater.
2. Nitrogen modification increases the basicity of the surface and, therefore, the adsorption capacity.

3. METHODS AND MATERIALS

Adsorption equilibrium was investigated on three types of carbon materials: unmodified rice husk-derived carbon (C) and two nitrogen-doped carbons - C_600_6h and C_UR.

The textural properties of the sorbents characterized by using low-temperature nitrogen adsorption on an automated surface area analyzer. X-ray photoelectron spectroscopy was used to determine surface composition and to identify and quantify surface functional groups.

Following adsorption experiments, absorption spectra of treated diclofenac solutions were recorded and adsorption isotherms were constructed [Figures 1,2].

4. RESULTS AND DISCUSSION

The following results were obtained during the research. 1. Coal was obtained from rice husk ash and aminated using various methods with urea. A sample containing 3,1% nitrogen was obtained.

2. The adsorption of diclofenac from an aqueous solution on three types of obtained carbon was studied. A high adsorption capacity of the obtained aminated carbon was established during the adsorption of diclofenac from aqueous solutions. 3. It has been shown that nitrogen doping of coal leads to an increase in the maximum adsorption capacity for diclofenac in an aqueous medium, which may be associated with an increase in the basicity of the coal surface.

Table 1. Textural properties (method of low-temperature nitrogen sorption)

Sorbent	Specific surface area (m ² /g)	S _{micropore} (m ² /g)	V _{pore} (cm ³ /g)	V _{micropore} (cm ³ /g)	Avg. pore size (nm)
C	590	60	0,6	0,06	4
C_NH ₃	620	192	0,6	0,075	4
C_Urea	590	117	0,6	0,05	4

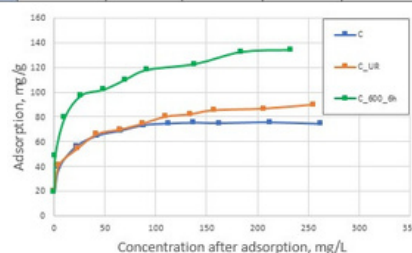


Figure 1. Dependence of adsorption on concentration after adsorption for unmodified coal from rice husk ash and two samples of nitrogenated coal - C_UR and C_600_6h at 25°C.

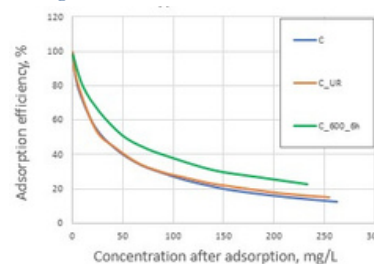


Figure 2. Dependence of adsorption efficiency on concentration after adsorption for unmodified coal from rice husk ash and two samples of nitrogenated coal - C_UR and C_600_6h at 25°C.

The best results were shown by nitrogenated coal C_600_6h (aged in an oven at a temperature of 600°C for 6 hours).

5. CONCLUSIONS

The experimental results demonstrate that aminated carbons are highly effective sorbents for diclofenac removal from water.

Potential beneficiaries of this work could be companies involved in wastewater treatment and waste disposal, as well as organizations focused on the valorization of agricultural products.

6. ACKNOWLEDGEMENT

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7. REFERENCES

1. Korobochkin V.V. et al. Activated carbon from Vietnamese rice husk pyrolysis. *Izv. Tomsk Polytech. Univ.*, 2017. T. 328. № 5, p. 6-15.
2. Thu Aung Si et al. Porous structure of activated carbon from rice husk. *Sorption and Chromatography Processes*, 2017. T. 17. № 1, p. 102-109.

Desing of Fresnel Lenses

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Introduction

This project presents a comparison between Fresnel and classical refractive lenses through the analysis of transmission, chromatic aberrations, and focal position. Fresnel lenses represent a special class of optical elements that use concentric grooves to focus light, maintaining the optical function of thick spherical lenses while significantly reducing thickness, mass, and material consumption. Based on these advantages, singlet, achromatic, and apochromatic configurations based on BK7, SF11, and F2 optical glasses were modeled. Simulations were performed using matrix optics and ray tracing, resulting in realistic optical models with reduced losses and aberrations.

Research Methodology

Optical systems were numerically modeled in Python using matrix optics and paraxial ray tracing. Classical refractive lens chains and Fresnel configurations in singlet, achromatic, and apochromatic forms were analyzed, using BK7, SF11, and F2 glasses, while Fresnel elements were based on PMMA, PC, and COC polymers. Four Fresnel configurations were considered: singlet Fresnel, ADG (Achromatic Doublet Gradient), SOG (Silicone on Glass), and APO (apochromatic). For each system, a bundle of paraxial rays in the visible spectrum ($\lambda = 486.1 \text{ nm}$, 587.6 nm , and 656.3 nm) was traced through refractive surfaces or Fresnel zones. Focal position, chromatic aberration, and transmission were determined from the intersection of output rays with the optical axis. Material dispersion was modeled using Cauchy and Sellmeier equations, while overall chromatic stability was quantified by the Abbe number:

$$V = \frac{n_d - 1}{n_F - n_C} \quad (1)$$

These relations, together with the ABCD matrix formalism and the laws of refraction and propagation, formed the basis of the numerical model used to compare Fresnel and classical optical systems.

Results and Analysis

Simulation results show that singlet refractive system exhibit a strong dependence of focal length on wavelength

due to material dispersion described by the Sellmeier equations. Combining BK7, SF11 and F2 glasses reduces chromatic aberrations; however, increasing the number of materials improves chromatic correction while decreasing overall transmission. The singlet Fresnel lens achieves the highest transmission, whereas ADG and especially APO Fresnel lenses exhibit minimal chromatic aberration and an almost constant relative focal length in the UV and near-infrared regions.

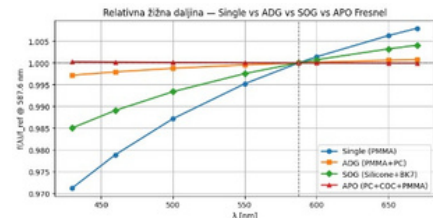


Figure 1: Dependence of focal length on wavelength for different Fresnel lenses

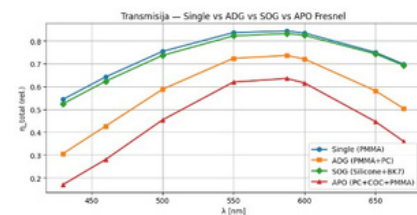


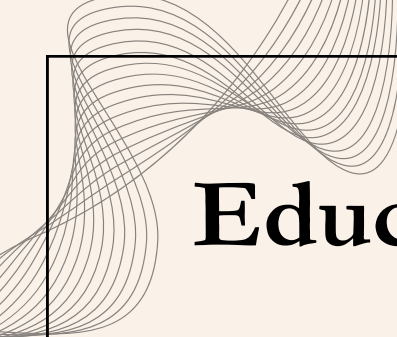
Figure 2: Transmission comparison of different Fresnel lenses

Conclusion

The analysis shows that Fresnel configurations represent an efficient alternative to classical multi-element lens systems, where the optimal choice depends on the requirements of the application. While singlet and SOG Fresnel lenses provide high transmission, ADG and especially APO Fresnel lenses enable superior chromatic correction while significantly reducing weight and dimensions. The results confirm that modern optical design requires adapting the lens architecture to specific functional requirements.

References

- Đorđe Spasojević „Geometrical Optics“, Belgrade 2021.
- Guido Vallerotto „Achromatic Doublet on Glass Fresnel lenses for Concentrator Photovoltaic Systems“, Madrid 2019.



Educator Sharing Session on ‘Biomimicry’

The Educator Sharing Session at The 32nd ICYS is an engaging platform for educators to exchange ideas, experiences, and best practices on the theme of ‘Biomimicry’. This session will explore how nature-inspired designs and processes can influence innovation across various fields, including education, science, and technology. It will highlight how observing natural systems can lead to sustainable solutions and creative problem-solving approaches in the classroom and beyond.

The session will be conducted by Ms. Ritika Anand, President ICYS 2026, whose insights and expertise will guide participants in understanding the significance and real-world applications of biomimicry.

Following the session, participants will engage in a hands-on activity on tie & dye, where they will have the opportunity to apply the concepts learned, encouraging creativity, collaboration, and experiential learning.



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