UNIVERSITY OF WAH

Pak-Turk ETSE 2024

7th Pak-Turk International Conference

on Emerging Technologies in the Field of Sciences and Engineering

14th and 15th, October 2024

CONFERENCE PROCEEDINGS

The Pak-Turk conference series is the technical event which focuses on the advancement in emerging technologies in the field of engineering sciences, computer sciences and natural sciences. The series of event was initiated in 2018 and since then these conferences have been successfully organized every year. The purpose of this conference is to provide a platform for researchers, academicians and practitioners to make them familiar with recent advancements in the various fields of engineering and sciences. The conference accepts wide range of abstracts/papers from Turkish and Pakistani participants to encourage young and experienced researches to present their work and also the possibility of initiating mutual collaboration with international repute researchers and industry personnels from Pakistan and Türkiye.

ETSE, 2024

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Editors:
Prof. Dr Syed Waqas Hassan
Dr. Faisal Nawaz
Ms. Zeenat Haq

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CONFERENCE PROGRAM

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Program Schedule Day 1

Inauguration Program Schedule (14 October 2024) Auditorium UW/ Zoom		
08:55	Arrival of Chief Guest	
08:55	National Anthem of Pakistan & Türkiye	
09:00	Recitation from Holy Quran	
09:05	Welcome Address by Secretary of the conference	Dr. Faisal Nawaz
09:10	Introductory Speech by Vice Chancellor, UW	Prof. Jameel Un Nabi
09:15	Keynote Speech: 1	Prof. Takehiko Saito
09:35	Keynote Speech: 2	Prof. Nihal Buyukcizmeci
09:55	Keynote Speech: 3	Prof. Syed Habib Bukhari VC KUM
10:15	Address by the Chief Guest	Chief Guest
10:30	Presentation of Shields	
10:35	Group Photo	
Group Photo and Tea Break 10:35-11:00 o'clock		

DAY 1 (14 October, 2024)		
Technical Session 1 (Day 1) Natural Sciences (Physics) Venue: Auditorium UW / Zoom		
Session Chair Prof. Uzma Ghazanfar **Moderator: Dr. Matti Ullah Shah**		
Keynote Talks		
11:01-11:20 AM	TALYS Nuclear Reaction code usage in Nuclear Reactions and Nuclear Models	Prof. İsmail SARPÜN **(Keynote Speech)**
11:20-11:40 PM	A Framework approach to strengthen higher education in the field of Marine Information and Engineering	Prof. Muhammad Abid **(Keynote Speech)**
11:40-12:00 PM	Wormhole Solutions admitting Karmarkar Condition	Prof. Muhammad Sharif **(Keynote Speech)**
12:00-12.20 PM	Communicating physics from the laboratory to the playground	Prof. Sabieh Anwar **(Keynote Speech)**
12:20-12.40 PM	Next-Generation Hybrid Energy Storage Devices: Overcoming Challenges and Exploring Opportunities	Prof. Zahir Iqbal **(Keynote Speech)**
12:40-01.00 PM		Prof. Yasar Ayaz **(Keynote Speech)**
Lunch/Prayer Break 01:00-1.55 PM		

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Technical Session 2 (Day 1 Parallel) Computer Engineering Venue: Seminar Hall-UW/ Google Meet		
Session Chair: Prof. Wazir Zada Khan		
Moderator: Dr. Sohaira Ahmad		
11:00-11:20 AM	Transparent EM shielding: A Glimpse into Optically Transparent Frequency Selective Surfaces	Prof. Junaid Mughal **(Keynote Speech)**
11:20-11:40 AM	AI Smart Mart	Mr. Muhammad Okasha
11:40-11:55 AM	Blockchain-Based Federated Learning for Privacy-Preserving Multi-Modal Medical Data with Secure Aggregation	Mr. Jamshaid Basit
11:55-12:10 AM	Quantum-Assisted Transfer Learning: A Hybrid Approach to Urdu Sign Language Recognition	Ms. Syeda Aqsa Habib Gilani (Online)
12:10-12:25 PM	Design of Power Management Unit for uninterruptible power to Signaling System in remotely located railway stations in Pakistan	Ms. Syeda Ezza Haider
12:25-12:40 PM	Event Venue Finder	Mr. Hammad Siddique
12:40-12.55 PM	AI-Driven Anomaly Detection and Mitigation Framework for Enhanced Security in Software Defined Networks	Mr. Muhammad Irfan (Online)
Lunch/Prayer Break 01:00-1.55 PM		

Technical Session 3 (Day 1 Parallel) Engineering Sciences Venue: LR-35/ Google Meet		
Session Chair: Prof. Shahab Khushnood		
Moderator: Dr. Zahid Iqbal		
11:01-11:15 AM	Comparative Analysis of Power Flow Simulations in the Test 10-Bus Power System Using Power World Simulator, ETAP, and PSS Software	Mr. Yousaf Ali (Online)
11:15-11:30 AM	Application of Wavelet Transform in Fault Detection of Distribution Line	Engr. Faiza Shaikh (Online)
11:30-11:45 AM	Optimization of Prosumer Based Demand Side Management (DSM) by Using K-Means Clustering Algorithm	Mr. Yousaf Ali (Online)
11:45-12:00 PM	Photovoltaic System based border Markets	Engr. Muhammad Muneeb Khan
12:00-12:15 PM	Analysis and Optimization of Protection Systems for Power System Components	Mr. Yousaf Ali (Online)
12:15-12:30 PM	Ideal Tilt angle calculation of Photovoltaic module to enhance Sindh Power Generation	Engr. Muhammad Muneeb Khan
12:30-12:45 PM	A Comprehensive Review of Fin Geometries and Their Impact on Heat Exchanger Performance	Mr. Waqas Javid
12:45-01:00 PM	A Review of Machine Learning Techniques in Vibration Analysis for Early Bearing Fault Detection	Mr. Waqas Javid
Lunch/Prayer Break 01:00-1.55 PM		

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Technical Session 4 (Day 1 Parallel) Civil Engineering Venue: LR-37/ Google Meet		
Session Chair: Prof. İsmail SARPÜN **Moderator: Dr. Sadiq Usman**		
11:00-11:15 AM	Reviving Tradition: Restoration of Katas Raj Temple's Historic Mortar	Mr. Ahmed Raza
11:15-11:30 AM	Status of Occupational Health & Safety Culture in the Construction Industry of Pakistan	Engr. Shafqat Abbas
11:30-11:45 AM	Synergistic Effects of Supplementary Materials and Fiber Reinforcement	Mr. Muhammad Saveed Ali (Online)
11:45-12:00 PM	Synergistic Effect of Waste Foundry Sand and Lime as Partial Replacement of Cement in Cement-Bentonite Slurry	Mr. Arsalan Raza
12:00-12:15 AM	A Comprehensive Review of the Status of Green Construction in Pakistan	Mr. Barkat Ali (Online)
12:15-12:30 PM	Utilizing Mangla Reservoir Silt as Partial Clay Replacement in Bricks: A Sustainable Approach to Desilting	Prof. Anwar Khitab (Online)
12:30-12:45 PM	Nearly Zero Energy Buildings – A Case Study in Pakistan	Mr. Muhammad Taimoor Ehtizaz
12:45-01:00 PM	Key Players in PPP Road Infrastructure Projects	Mehar Ali
Lunch/Prayer Break 01:00-1.55 PM		

Technical Session 5 (Day 1) Natural Sciences Venue: Seminar Hall/ Google Meet		
Session Chair: Prof. Dr. Nihal Buyukcizmeci **Moderator: Dr. Matti Ullah Shah**		
Keynote Talks		
02:00-02:20 PM	Investigation of Beta Decay Log ft Values with Schematic Model Approach	Prof. Necla CAKMAK **(Keynote Speech)**
02:20-02:40 PM	A new aspect of nanomaterial using in electrolytes for Solid Oxide Fuel Cell	Prof. YASİN POLAT **(Keynote Speech)**
02.40-03:00 PM	Study the Effect of Pairing Gaps on Astrophysical Important Nuclei using the pn-QRPA Model	Mr. Arslan Mehmood
03:00-03:15 PM	Study of β-decay properties of proton-rich odd-A Sn isotopes	Mr. Wajeeha Khalid
03:15-03:30 PM	Reinvestigation of 58,60,61,62,64Ni (p, γ) 59,61,62,63,65Cu In Stellar Environment of Type 1 Supernovae	Mr Saif Ullah
03:30-03:45 PM	Investigation of β decay properties of very neutron-rich Kr to Tc nuclei	Mr. Abuzar
03:45-04.00 PM	A Review on the Synthesis Techniques for the Photothermal Materials	Ms. Ayesha Ramzan

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Technical Session 6 (Day 1)
Computer Sciences/ Computer Engineering
Venue: LR-35/ Google Meet

Session Chair: Prof Muhammad Shakeel
Moderator: Dr. Haris Masood

Time	Title	Presenter
02:00-02:15 PM	HSK Wallet: A User Friendly Blockchain Application	Mr. Kashif Iqbal (Online)
02:15-02:30 PM	Design and Fabrication of Smart Helmet to Overcome Road Accidents	Mr. Saeed Afridi
02.30-02:45 PM	Enhancing OSPF Authentication Using Quantum Key Distribution and Software Defined Networking	Mr. Madam Hussain Shah
02:45-03:00 PM	Distributed Anomaly Detection in Networks Using Machine Learning and Federated Learning	Mr. Muhammad Irfan (Online)
03:00-03:15 PM	Vehicle And Driver Recognition for Access Control	Mr. Kashif Iqbal (Online)
03:15-03:30 PM	Innovative Framework for IoV: Enhancing Security, Privacy, and Efficiency through Blockchain, Federated Learning, and Differential Privacy in IoV	Mr. Muhammad Adnan

Technical Session 7 (Day 1)
Natural Sciences/ Chemical Engineering
Venue: LR-37/ Google Meet

Session Chair: Dr. K. S Baig
Moderator: Dr. Saleem Iqbal

Time	Title	Presenter
02:00-02:15 PM	A Novel Approach of Self Decisive Algorithm for two-step quasi-Newton Methods	Dr. Farah Jaffar
02:15-02:30 PM	Intelligent Computing Approach for Investigating Hybrid Nanofluid Flow over a Stretching Sheet	Mr. Aamra Urooj.
02.30-02:45 PM	The mathematical modeling for potentio dynamic electrochemical acetaldehyde conversion to glioxal	Mr. Volodymyr V. Tkach (online)
02:45-03:00 PM	The Commercial Efficiency of Pressure Swing Distillation of Ethanol-Ethyl Acetate Mixture	Mr. Ammar Abbas Ali Saif (Online)
03:00-03:15 PM	The mathematical modeling for tobacco-specific nitrosamines electrochemical determination in tobacco products	Mr. Volodymyr V. Tkach (online)
03:15-03:30 PM	Machine Learning and Experimental Hybrid Strategy for Optimized Nitrogen Release Urea Fertilizers	Ms. Mahzeb Saleem
03:30-03:45 PM	Innovative Pathways for Sustainable Fuel Production: Converting BioCrude into Renewable Petrol & Diesel	Mr. Nouman Mustafa
03:45-04:00 PM	Effect of ZnO NPs coating on DAP fertilizer efficiency for enhancing Soil available nutrients	Ms. Zumrah Rehman (Online)

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Technical Session 8 (Day 1 Parallel) Engineering/ Natural Sciences, Venue: LR-38/ Google Meet		
Session Chair: Prof. M Asghar Saqib		
Moderator: Dr. Kashif Iqbal		
02:00-02:15 PM	Modified Median Quartile Ranked Set Sampling for estimation of population mean	Dr. Muhammad Ahmed Shehzad
02:15-02:30 PM	Modified Quartile Ranked Set Sampling for estimation of population mean. Innovative	Ms. Anam Nisar
02.30-02:45 PM	Using of double sampling in estimating the finite population coefficient of variation using two auxillary variables	Mr. Nasir Iqbal
02:45-03:00 PM	Innovative Design for Sustainable Three-Wheeled Reverse Trikes: Advancing Safety, Efficiency, and Eco-Friendly Solutions	Mr. Mehmood ul Hassan
03:00-03:15 PM	Geotechnical Evaluation of Desert Sand and its improvements for Sustainable Developments	Mr. Muhammad Zeeshan
03:15-03:30 PM	Investigating the factors Enhancing the Industrialized Building System (IBS) in Construction Industry of Karachi Sindh, Pakistan	Engr. Abdul Rehman,
03:30-03:45 PM	Automated procedure of real-time flood forecasting in data-scare Swat River basin, Pakistan by integrating SWAT and HEC-RAS models	Ms. Alisha Qureshi
03:45-04.00 PM	Energy-Water Nexus for sustainability: A case study for Karachi focusing on Solar PV potential	Mr. Usman Umer

Posters Session Day 1 (Parallel) E-Hall-UW		
01.00-3.00 PM	Poster Presentation	All Poster Presenters

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DAY 2 (15 October, 2024)

Program Schedule Day 2

Technical Session 9 (Day 2 Parallel) Natural Sciences (Physics) Venue: Seminar Hall UW/ Zoom		
Session Chair: Prof. Necla CAKMAK **Moderator: Dr. Matti Ullah Shah**		
09:00-09:20 AM	Nucleation and growth in Ni electrodeposition: polycrystalline thin films and multilayers	Prof. Walther Schwarzacher (Keynote Speech)
09:20-09:35 AM	X-ray Diffraction Analysis of Zinc Sulphide Quantum Dots (ZnS QDs) using Scherrer and Williamson-Hall Methods	Mr. Rao Uzair Ahmad
09:35-09:50 AM	Remediation Techniques of Petroleum-Contaminated Soils and its impact on human health	Ms. Rubab Amir
09:50-10:10 AM	The Rise of Graphene Oxide: A Review on Synthesis, Properties and Recent Advances	Ms. Laiba Sheraz
10:10-10:25 AM	Examining the Effect of Crystal Dead Layer on System Performance in SPECT System	Prof. Tuncay Bayram (Online)
10:25-10:40 AM	Investigation of O(6) behavior of 188-204 Hg Isotopes within the IBM-1 Model	Prof. Mahmut BOYUKATA (Online)

Technical Session 10 (Day 2-Parallel) Biotechnology/ Microbiology/ Environmental Sciences Venue: LR 35/ Google Meet		
Session Chair: Prof. Shumaila Naz **Moderator: Dr. Muhammad Idrees**		
09:00-09:30 AM	Cultivating Earth's Future: Engineering Crop Microbiomes and designing soil amendments for sustainable crop improvement under climatic change scenario	Dr. Noshin Ilyas (Keynote Speaker) (Online)
09:30-09:50 AM	Evaluation of Total Aflatoxin Content in Dry Fruits Samples	Dr. Rakhshinda Sadiq (Online)
09:50-10:10 AM	Synthesis and Characterization of Hydrogels for Speedy Wound Healing in Diabetic Patients	Ms. Nisha Iqbal (Online)
10:10-10:20 AM	Synthesis of chitosan nanoparticle for targeted Nano-therapy against Receptor tyrosine kinases in Glioblastoma Multiform: *In vitro* assays	Ms. Fareeha Khalid Ghori
10:20-10:30 AM	Chemical analysis of essential oil of *Rosa bourboniana*	Mr. Aman Ullah Khan
10:30-10:40 AM	Optimizing rice plant growth with nanocoated urea	Ms. Arva Mehak
10:40-10:50 AM	Revolutionizing wheat (*Tritium aestivum* L.) cultivation with Nano-Coated urea for enhanced growth	Ms. Shaher Bano
10:50-11:00AM	Synthesis And Characterization of *Aloe vera*-Curcumin	Ms. Heer Memon (Online)

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	Loaded Zein Nano Fibrous Smart Dressing for Diabetic Foot Ulcer	
11:00-11:10 AM	Nano-enhanced flood resilience in wheat (*Triticum aestivum L)* with amended plant growth regulators.	Ms. Dil E Savera Kazmi
11:10-11:20 AM	Screening Soil Microbes for Cellulase Enzyme Production and Identification	Ms. Ayesha Tayyaba
Tea Break 11:30 AM		

Technical Session 11 (Day 2) **Natural Sciences (Chemistry)/ Chemical Engineering** **Venue: LR-37/ Google Meet**		
Session Chair: Dr. Saleem Iqbal **Moderator: Dr. Fawad Khan**		
09:00-09:15 AM	2D Structural Interpretation Integrated with Petrophysics, Attribute Analysis and Seismic Inversion of Rajian Area Upper Indus Basin, Pakistan	Mr. Muhammad Talha (Online)
09:15-09:30 AM	Novel AIE and Solvatochromism Exhibiting TPE Based Organic Fluorophore with Excellent Emission Properties in Solid and Solution Phase for Latent Fingerprint and Metronidazole Sensing in Real Samples	Mr. Hasher Irshad
09:30-09:45 AM	Graphene incorporated Cellulose Acetate based Mixed Matrix Membrane for Carbon dioxide Sequestration	Ms. Shahmeen Sattar
09:45-10:00 AM	Cellulose Based Membranes Doped with Zirconium Dioxide (ZrO2) Nanoparticles for Water Desalination	Ms. Saman Khan
10:00-10:15 AM	Comprehensive Review: Synthesis and Detailed Characterization of Sulfonamide Derivatives with Potent Biological Activities	Ms. Hifza Basharat
10:15-10:30 AM	A Review of Hydrogel Based pH-Sensors	Mr. Muhammad Ramzan
10:30-10:45 AM	Magnetite nanocomposites: A promising candidate for removal of contaminant from aqueous environment	Dr. Aamna Balouch
10:45-11:00 AM	Synthesis and characterization of Ni-doped ZnO Nanoparticles for potential antibacterial activity against *E.coli.*	Ms. Samreen Bibi
Tea Break 11:30 AM		

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Technical Session 12 (Day 2) Natural Sciences (Chemistry)/ Chemical Engineering Venue: LR-38/ Google Meet		
Session Chair: Dr. Humaira Razzaq **Moderator: Dr. Zaheer Ahmad**		
09:00-09:15 AM	Investigation of the Tensile Properties of EPDM Based Nanocomposites Reinforced with Nanoclay and Graphene Nanosheets	Ms. Habiba Tanveer
09:15-09:30 AM	Facile synthesis of manganese oxide as A cathode material for oxygen reduction reaction in fuel cell	Ms. Irum Jamil
09:30-09:45 AM	Synthesis, Spectroscopic Analysis, and Antimicrobial Properties of Pure and Copper Doped Cadmium Oxide Nanoparticles	Ms. Nosheen Bibi
09:45-10:00 AM	Optimized ZnS: CoS nanohybrid promising materials as asymmetric supercapacitors	Mr. Hafeez Ur Rehman
10:00-10:15 AM	Microscopic Techniques for Nanomaterials Characterization: A concise Reivew	Mr. Abbas Aziz
10:15-10:30 AM	A Comprehensive Screening of Toxic Heavy Metals in the Water of FATA (Pakistan)	Ms. Riffat Bibi
10:30-10:45 AM	A Review of Sustainable Methods for Synthesizing Zinc Oxide Nanoparticles and Their Applications	Ms. Kandeel Husnain
10:45-11:00 AM	N-doped Graphene Surfaces as an efficient electrochemical sensor-A brief review	Ms. Tayyabah Azam
Tea Break 11:30 AM		

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KEYNOTE ADDRESSES & TECHNICAL TALKS

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Hypernuclear studies with heavy ion beams, machine learning and nuclear emulsions, and application of the developed technologies to neutron imaging

Take R. Saito[1]
[1]*Chief Scientist Institution: RIKEN Japan*

Abstract—Studies of hypernuclei, sub-atomic nuclei with strange qurks, have been contributing for understanding the fundamental baryonic interactions as well as the nature of dense nuclear matters. They have already been studied for almost seven decades in reactions involving cosmic rays and with meson- and electron-beams. In recent years, experimental hypernuclear physics enters a new era. Hypernuclei can also be studied by using energetic heavy ion beams, and some of these experiments including our former experiment, the HypHI Phase 0, have revealed unexpected results on the lightest hypernucleus, the hypertriton, on its short lifetime and large binding energy. The HypHI Phase 0 experiment has also shown a signature of the unprecedented bound state with a Lambda hyperon with two neutrons. We are studying those light hypernuclear states by employing different approaches from the other experiments. We employ heavy ion beams on fixed nuclear targets with the WASA detector and the Fragment separator FRS at GSI (the WASA-FRS project) in Germany for measuring their lifetime precisely. The experiment was already performed in 2022. We also analyze the nuclear emulsions with machine learning, that were irradiated by kaon beams in the J-PARC E07 experiment. We have already uniquely identified events associated with the production and decays of the hypertriton, and the binding energy of the hypertriton is to be determined. We also search events of other single- strangeness hypernuclei and double-strangeness hypernuclei in the E07 emulsion to understand the nature of Lambda-nucleon, Lambda-Lambda and Xi-nucleon interactions. We are using Machine Learning techniques for all our hypernuclear projects with heavy ion beams and nuclear emulsions. We'll discuss on our novel development for neutron imaging by using nuclear emulsions and other solid- state materials.

Nucleosyntesis of (hyper)nuclei in central ion collisons around GeV energies

Nihal BUYUKCIZMECI[1]
[1]*Selcuk University, Department of Physics, 42130, Konya Türkiye*

Abstract—Based on the progress of the transport model evaluation, we refine nucleons by using the ultra-relativistic molecular dynamics (UrQMD) model and the Dubna cascade model (DCM) to enhance the reliability of the models. By using the both model inputs for nucleons, clustering of nuclei and hypernuclei is constructed similar to the nucleosyntesis phenomenon. These results imply that the role of the missing ingredients, such as the determination of the excitation energies of the nuclei, the coordinates and the momentum dependent distributions, should be investigated by using the probes of different mechanisms. Furthermore, theoretical results are obtained in the limits of the experimental data, even if the circumstantial constraints of the available experimental data. Our results open new windows for the further investigations both theoretical and experimental analyses at the FAIR (Darmstadt) and NICA (Dubna) facilities in future.

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TALYS Nuclear Reaction code usage in Nuclear Reactions and Nuclear Models

Ismail Hakki SARPUN[1,2,3]
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[2]Akdeniz University, Nuclear Research and Application Centre, Antalya Türkiye
[3]Akdeniz University, Faculty of Medicine, Radiation Oncology, Antalya, Türkiye

Abstract—TALYS nuclear-reaction code is a Fortran based nuclear code used to simulate nuclear reactions for heavier than lithium target nucleus using n, p, d, t, 3 He, α particles and γ ray could use as projectile in the energy region of 1keV-1GeV. Many nuclear models can be tested in this code as theory allows. In this study, information about nuclear models and reactions with application via TALYS nuclear reaction code are given.

A new aspect of nanomaterial using in electrolytes for Solid Oxide Fuel Cell

Yasin POLAT[1, 2]
[1]Program of Laboratory Technology, Department of Chemistry and Chemical Process Technologies, Acıgöl Vocational School of Technical Sciences, Nevşehir Hacı Bektaş Veli University, Nevşehir, Turkey
[2]Director of Vocational School, Nevşehir Hacı Bektaş Veli University, Nevşehir, Turkey

Abstract—In recent years, many researches have mostly focused on studying of the nanomaterial-based electrolytes. Because of their wide technological applications in devices with high economical interest such as oxygen sensors, ceramic membranes for oxygen separation, oxygen pumps, catalyzing of some heterogeneous reactions, partial oxidation of the hydrocarbons and additive material in paints. One of the technological applications for this material is to be electrolyte of the Solid Oxide Fuel Cells (SOFC). Nano-Bi-based electrolytes which have high oxide ionic conductivity at low temperatures and better performance as alternatives to traditional stabilized zirconia has taken place. Generally, these systems are much better solid electrolytes than well-known stabilized zirconia, because some of the Nano-bismuth trioxide phases exhibit higher ion conductivity than other oxide ionic conductors. Doped-Nano-Bi_2O_3 materials of solid electrolyte systems are good oxygen anions O2- conductors which have collected much attention as potential solid ceramic electrolytes for solid oxide fuel cells (SOFCs) because of their relatively high oxygen ionic conductivity at lower temperatures. Some of our study is about Nano-Rare earth oxides doped Nano-Bismuth trioxide solid solutions, the Nano-$(Bi_2O_3)_{1-x-y}(X_2O_3)_x(Y_2O_3)_y$ (X: Sm, Eu, Dy; Y: Yb, Ce, Er, Tm) [1-4] systems were obtained chosen dopant concentrations have been synthesized by solid state synthesis method in air atmosphere and electrical conductivity properties of the samples have been investigated by 4-point probe technique. The crystal structure of the Nano-$(Bi_2O_3)_{1-x-y}(X_2O_3)_x(Y_2O_3)_y$ has been determined by X-ray powder diffractions (XRD) measurements before and after electrical conductivity measurements of the samples. Thermal behavior and thermal stability of the phases were investigated by differential thermal analysis (DTA). The samples which synthesized in this study can be used in diverse industrial applications such as electrolytes of the SOFC.

Keywords— Solid Oxide Fuel Cells, Solid state synthesis method, Nano-Bismuth trioxide, Nano-Rare earth oxides

Investigation of Beta Decay Logft Values with Schematic Model Approach

Necla Çakmak[1]
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Abstract—Nuclear beta (β) decay plays an important role in the understanding of nuclear structural properties in the era of nuclear physics. Nuclear β-decay is a kind of radioactive decay. In such radioactive decay, a fast, high-energy beta ray is emitted from the nucleus in the form of an electron or positron. This leads to charge-changing transitions for the transformation of one nucleus into another. In the present study, the allowed and first-forbidden beta transition properties of some nuclei that make a significant contribution to the r-process were calculated with the schematic model approach in the framework pn-Quasi Random Phase Approximation (pn-QRPA). The Woods-Saxon (WS) potential was employed as a mean-field basis in this study. The obtained results were compared with the corresponding experimental data and the other calculation results.

Keywords—Allowed and First-forbidden

Need of Computer Aided Engineering for Real World Engineering Problems

Muhammad Abid
Director Interdisciplinary Research Center, COMSATS University Islamabad, Wah Cantt, Pakistan.

Abstract — Real world engineering problems are observed complex based on many factors and applications and cannot be solved with the exact solutions or experimental tests. Keeping in view the interdisciplinary nature of the problems and required boundary conditions, geometries, materials, climate impacts, large data etc; for optimized solutions with higher accuracy and performance and reduced computational cost, the option of Computer Aided Engineering (CAE) with numerical solution is observed the need of the time. This paper presents applications of CAE in solving real world problems of complex engineering problems including but not limited to performance of bolted pipe joints during bolt up and operating condition and welding of flange and pipe joints to ensure no leak conditions; design energy efficient buildings, water and sediment flow simulations through tunnels and reservoirs for their life predictions; optimized renewable energy systems; optimization of critical industrial structure such as overhead cranes, industrial trusses and lightweight hybrid structure; flood and drought Modeling using RS and GIS tools and others. In all above cases, applications of Big Data, AI and Machine Learning and others are discussed.

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Investigation of O(6) behavior of 188-204Hg Isotopes within the IBM-1 Model

Osman Ülker[1] and Mahmut Böyükata[2]

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[2] *Kırıkkale University, Faculty of Engineering and Natural Sciences, Physics Department, Kırıkkale, Türkiye*

Abstract — In this proceeding, the behavior of even-even 188-204Hg isotopes within interacting boson model-1 (IBM-1). The energy ratios (R4/2) of these isotopes in the ground state bands were analyzed along the isotopic chain. The given Hg isotopes close to O(6) limit according to their energy ratio. The Hamiltonian parameters were fitted by comparing the calculated energy ratios with the experimental ones. The band structure were also investigated by analyzing their RL=E(L)/E(2) values as a function of angular momenta in the ground state band to see their behavior and we obtained that they show the O(6) behavior.

Keywords— Hg isotopes, energy ratios, O(6) symmetry.

Examining the Effect of Crystal Dead Layer on System Performance in SPECT System

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[2] *Department of Health Physics, Institute of Health, Karadeniz Technical University, 61080 Trabzon/Türkiye*

Abstract — Single Photon Emission Tomography (SPECT) is an effective diagnostic imaging device. Itsmworking principle is basically based on the principle of counting the gamma rays emitted from the radiopharmaceutical substance administered to the patient's body and creating cross-sectional images by processing them in the computer system. The quality of the images obtained is very important for the correct diagnosis of diseases. One of the important factors affecting image quality in SPECT applications is the dead layer that may form over time in the scintillation crystal, one of the detector components. In this study, the effect of dead layers that may form in the NaI(Tl) scintillation crystal used in SPECT on the system performance was examined. For this purpose, GATE simulation code based on GEANT4, a simulation package based on the Monte Carlo method, was used. First, SPECT performance parameters (Sensitivity, spatial resolution, energy resolution, contrast) were examined by simulating the standard SPECT model at low, medium and high gamma energies. Then, dead layers of different thicknesses were created on the simulated crystal and the effect of the dead layer on the performance parameters was investigated for the same energies. As a result, it was revealed that significant deterioration occurred in the image quality parameters of the SPECT system due to the increase in the dead layer of the scintillation crystal.

Keywords— GEANT4, SPECT System Performance, Cyrstal Dead Layer

Nucleation and growth in Ni electrodeposition: polycrystalline thin films and multilayers

A. Mubshrah[1], N. G. Sousa[2], P. De Lima-Neto[2], A. Correia[2], W. Schwarzacher[1,2]
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Abstract — Metal electrodeposition will contribute to a zero-carbon future through its roles in rechargeable batteries, electrocatalyst production, and resource conservation through corrosion protection. This presentation focuses on Ni electrodeposition, firstly to understand how the morphology of a polycrystalline Ni film evolves during growth, and secondly to investigate the growth of short-period Ni/Cu multilayers on various substrates. For the former, we apply a combination of atomic force microscopy and scanning electron microscopy with slope and textural analysis. For Ni/Cu multilayers, a system that has been widely studied using aqueous electrolytes, we show that non-aqueous ethaline (1:2 choline chloride: ethylene glycol) is a promising alternative

Wormhole Solutions admitting Karmarkar Condition

Muhammad Sharif[1]
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Abstract —This paper investigates the viable traversable wormhole solutions through Karmarkar condition in the context of f(G,T) theory. A static spherical spacetime with anisotropic matter configuration is used to study the wormhole geometry. Karmarkar condition is used to develop a viable shape function for a static wormhole structure. A wormhole geometry is constructed using the resulting shape function that satisfies all the required conditions and connects the asymptotically flat regions of the spacetime. To assess the viability of traversable wormhole geometries, the energy conditions are analyzed by various models of this theory. Further, their stable state is investigated through sound speed and adiabatic index. This investigation demonstrates the presence of viable traversable wormhole solutions in the modified theory.

Communicating physics from the laboratory to the playground

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Abstract —In this talk, Dr. Sabieh Anwar present some innovative ideas that he has implemented in the teaching of fundamental physics at the university level. This includes visually appealing demonstrations inside the classroom and novel experiments for the science students inside the laboratory. An innovative quantum information laboratory using single photons and quantum light is also exemplified. The laboratory techniques also harness the use of modern smart devices and sensors such as smart phones and cameras. Dr. Anwar's work has been extended into exciting science festivals merging explorations of science with culture and language. Some of these interesting ideas in communicating physics in particular and science in general will be shared

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Transparent EM shielding: A Glimpse into Optically Transparent Frequency Selective Surfaces

Dr Junaid Mughal

COMSATS University Islamabad, Wah Cantt, Pakistan

Abstract —Previously reported Frequency Selective Surfaces (FSSs) on conventional substrates possess inherent opacity and are not suitable for shielding and providing security protection in green buildings where optical transparency is required for energy savings. Optically transparent FSSs (OT FSSs) are gaining attention due to their light-transmitting properties along with electromagnetic wave manipulation and mitigation. Multiple viable methods, such as nano-silver ink printing, thin-film technology Indium Tin Oxide (ITO), and mesh technology have been opted for creating FSSs patterns on transparent surfaces. However, the uneven, and non-uniform distribution of conductive materials on optically transparent surfaces substantially influences the overall shielding properties. Also, these methods cannot be used very often because of the chemical, thermal, and mechanical constraints of conductive inks on transparent substrates. As an alternative to screen printing and mech technology, use of self-adhesive copper foils for direct printing of FSSs periodic patterns on optically transparent substrates such as glass efficiently shields various communication bands and can withstand harsh environments. This keynote speech delves into the direct-printing technology of the OT-FSSs by elucidating the dual- and triple-band designs. The design considerations and shielding characteristics of dual-band FSSs retrofitted on ordinary glass while maintaining 86% transparency for sufficient light passage shall be explored. In addition, a comprehensive novel framework for retrofitting FSS design patterns on ordinary double-glazed windows to mitigate GSM-1800, Wi-Fi 2.5, and Wireless LAN 5.6 signals shall be succinctly explored. Experimental demonstrations of the realization technique for single-glass, sandwiched glass, and air-filled double-glazed glass shall also be elucidated.

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ABSTRACT FOR ORAL PRESENTATIONS

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The Commercial Efficiency of Pressure Swing Distillation of Ethanol-Ethyl Acetate Mixture

Ammar Abbas Ali Saif[1], Aqeel Ahmad Taimoor[1], Saad Al-Shahrani[1], Usman Saeed[1], Sami-ullah Rather[1], Majed A Alamoudi[1]

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Abstract—Commercially available methods such as pressure swing distillation (PSD) have been developed to separate azeotropic mixtures. PSD provides solvent-free operation by adjusting pressure to pass azeotropic points without the need for an entrainer. This method is used for the mixing of ethanol and ethyl acetate to assess the process's commercial viability by calculating the energy needs and Total Annual Cost (TAC). A process simulation has been carried out using Aspen Plus software. The effectiveness and viability of the potential commercial process in separation may be assessed with the use of this benchmark study and process simulation. PSD is an azeotropic system that separates ethanol from ethyl acetate and has a high energy efficiency, a tolerable TAC, and high purity **.**

Keywords—Azeotrope; Aspen Plus; Data; property model; Energy; Total Annual Cost

Facile synthesis of manganese oxide as A cathode material for oxygen reduction reaction in fuel cell

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Abstract—Manganese oxide (MO) was synthesized using a single-step co-precipitation method with various morphology-directing agents. The tailored nanostructures of MO were utilized as the cathode material to catalyze the oxygen reduction reaction (ORR) occurring within fuel cells. The obtained MO with various structures were characterized via X-ray diffraction (XRD) analysis, and morphological characterizations were carried out via scanning electron microscopy (SEM). All the nanostructures of MO were used to modify the surface of the glassy carbon electrode (GCE) to enhance its efficacy in catalyzing the ORR. Amongst five different nanostructures and the conventionally used Pt/C catalyst, MO@NH3OH has shown excellent performance with a higher current density of -0.854 mA/cm2 and a shifted overpotential of -0.44 V. Methanol solution with a higher concentration of 0.5 M was used for the tolerance study and it was observed that MO@NH3OH had shown adequate tolerance and remained unsusceptible to methanol passed towards the cathode side. The stability of the nanostructures was assessed over ~3000 s using chronoamperometry (CA) and it was found that nanostructures exhibited an impressive 97 % retention of current, which is comparable to the Pt/C electrocatalyst. Therefore, the nanostructure of MO could be regarded as a promising Pt-free electrocatalyst via a facile one-step process offering remarkable selectivity and stability while maintaining cost effectiveness.

Keywords: Co-precipitation, XRD, SEM, ORR.

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Synthesis, Spectroscopic Analysis, and Antimicrobial Properties of Pure and Copper Doped Cadmium Oxide Nanoparticles

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Abstract—The present investigation utilized the co-precipitation method to synthesize nanoparticles of cadmium oxide (CdO) and copper-doped cadmium oxide (Cu-CdO). The synthesized samples underwent various analyses, including Fourier transforms infrared (FT-IR), energy-dispersive X-ray (EDX), field emission scanning electron microscopy (FE-SEM), UV–Visible spectroscopy and XRD. Both samples had simple cubic structures and average grain sizes of 54 and 28 nm, respectively, based on the XRD analysis. The samples' surface textures were investigated using a FE-SEM. The EDX method was employed to examine the samples' elemental compositions. The vibrational modes were found using the FT-IR technique. Upon obtaining the diffuse reflectance mode UV-Vis spectra, the CdO and Cu-CdO samples' optical bandgaps were determined to be 2.83 eV and 4.52 eV, respectively. The antibacterial efficacy of the synthesized nanoparticles against gram-positive Micrococcus luteus and gram-negative Escherichia coli bacteria at different concentrations was evaluated using the Agar-well diffusion technique. In the present investigation, both samples exhibit noteworthy antibacterial activity against the two bacterial strains.

Keywords: Co-precipitation, XRD, UV–visible, FE-SEM, EDX, Agar-well diffusion.

ZnO Nanoparticles for potential antibacterial activity against *E. coli.*

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Abstract—The physiochemical characteristics and antibacterial activity of highly ionic metal oxide nanostructures make them promising. Zinc Oxide (ZnO) nanostructures are known to have pathogen-inhibiting activity. When ZnO doped with different metals its activity enhanced. Ni-doped ZnO nanoparticles (NPs) were synthesized and investigated their antibacterial properties against E. coli. Ni-doped ZnO nanoparticles were synthesized by the co-precipitation method and subsequently characterized by different techniques such as scanning electron microscopy (SEM), X-ray diffraction (XRD), UV-visible spectroscopy, and Fourier transform infrared spectroscopy (FT-IR) and Energy Dispersive X-ray (EDX).The analysis of presenting a functional group of synthesized Ni-doped ZnO nanoparticles confirmed by FTIR spectra. Ni-doped ZnO nanoparticles have smooth surfaces in their morphologies, as proven by SEM image, and EDX analysis has verified the elemental presence of Ni, Zn, and O. The average grain size of 42 and 60 nm of the synthesized Ni-doped ZnO nanoparticles confirmed by SEM image. The antibacterial activity of Ni-doped ZnO nanoparticles was investigated through the Agar-well diffusion method. The synthesized Ni-doped ZnO nanoparticles showed better antibacterial activity against E. coli as compared to pure ZnO nanoparticles.

Keywords: Metal oxides, Doped, XRD, EDX, SEM, Co-precipitation, Agar-well diffusion.

A Review of Sustainable Methods for Synthesizing Zinc Oxide Nanoparticles and Their Applications

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Abstract—This article provides a comprehensive review of sustainable methods for synthesizing zinc oxide nanoparticles (ZnO NPs) and their diverse applications. Green synthesis approaches using plant extracts, microorganisms, and other environmentally benign sources are discussed, highlighting their advantages such as low cost, ecofriendliness, and scalability. The synthesis methods are categorized based on the mechanisms involved, including biological, chemical, and physical approaches. The review also covers the characterization techniques commonly used to analyze the synthesized ZnO NPs. Furthermore, the applications of ZnO NPs in various fields such as biomedical, environmental remediation, and catalysis are discussed in detail, emphasizing their unique properties and potential benefits. Finally, future perspectives and challenges in the sustainable synthesis of ZnO NPs and their applications are discussed, providing insights for further research and development in this promising field.

Keywords: Plan extract, Microorganisms, ZnO NPs, Eco-friendliness, Environmental remediation.

N-doped Graphene Surfaces as an efficient electrochemical sensor-A brief review

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Abstract—Toxic analytes (NO, SO2, HCN, COCl2, PH3, CO2 etc.) are extensively discharged due to agricultural, industrial and domestic effluents. Current review investigates efficient, reliable, with enhance surface area, fast in response, inexpensive N-doped graphene surfaces as an electrochemical sensor. The adsorption of toxic analytes on these surfaces was acquired by energy of interaction NBO, FMO, NCI, QTAIM and EDD analyses. Increased values of interactional energies e.g. -15.99 kcalmol-1 indicate that toxic analytes physiosorbed onto the surfaces. The maximum reduction in HOMO-LUMO energy gaps toward toxic analytes indicates excessive sensitivity of these surfaces. NCI and QTAIM results also confirm that N-doped graphene surfaces exhibit high chemical activity toward the adsorbed toxic analyte as compared to pristine graphene. The distinctive dimensional structure, ultra-high stiffness and semiconductor characteristics build nitrogen doped graphene surfaces as auspicious candidates for future applications in electrode materials, molecular sieves and nano-scale gas sensing devices.

Keywords— N- doped, electrochemical sensor; interaction energy; Electron density differences (EDD)

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Evaluation of Total Aflatoxin Content in Dry Fruits Samples

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Abstract—The total aflatoxins content of a variety of dry fruits purchased from Mardan, Pakistan local markets is evaluated in this research. Additionally, it suggests various detoxification-based risk reduction techniques. Appropriate methods were used in the analysis to precisely determine each sample's overall aflatoxin (AF) concentration. The results showed that none of the samples of branded dry fruit contained AFs. On the other hand, AFB1 contamination was discovered in open samples of coconut, figs, raisins, apricots, walnuts, and almonds at levels higher than those recommended by the EU guidelines. Moreover, samples of dry fruit obtained from reputable companies did not contain any AF-contamination. These results point to the possible serious health concerns associated with consuming dried fruits from public marketplaces. This information highlights the significance of detoxification techniques even more.

Keywords: *Aflatoxins, Dry fruits, ELISA, Thin layer chromatography*

Cultivating Earth's Future: Engineering Crop Microbiomes and designing soil amendments for sustainable crop improvement under climatic change scenario

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Abstract—Soil microbial diversity is a key indicator of soil health and fertility. The main drivers of soil ecosystems include plant and soil type, and environmental conditions govern all factors. There is a dire need to explore beneficial microbial responses for managing the risks to sustainable agriculture in an environment threatened by climate change. To check the effect of environmental stresses like drought, salinity, and heavy metal on soil microbial biodiversity and testing the efficacy of tolerant Plant Growth Promoting Rhizobacteria alone and in combination with effective soil amendment techniques for improving plant growth under predicted abiotic stresses of climatic change. Experiments were conducted to isolate and characterize stress-tolerant Rhizobacteria and to check their stress mitigation potential. Modified plant biomasses like compost, biochar, and bio-organic fertilizer were used as soil amendments techniques. Microbial strains were isolated from the stressed region. The identification of isolated microbial strains was carried out by physiochemical and 16s rDNA sequencing and phylogenetic analysis. Inoculation of seeds with PGPR along with compost, biochar, and bio-organic fertilizer improved all growth and productivity parameters, increased nutrient status, and improved osmolyte production and hence helping the survival and growth under stress conditions. Building our understanding of the interdependence of microorganism communities, ecological pressures, and plant responses will be necessary for understanding climatic effects on soil health and plant growth. Our new understanding of microbial diversity in response to environmental stresses will allow us to cure and conserve our environment and grow more food.

X-ray Diffraction Analysis of Zinc Sulphide Quantum Dots (ZnS QDs) using Scherrer and Williamson-Hall Methods

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Abstract—Zinc Sulphide quantum dots (ZnS QDs) are semiconducting nanocrystals with various applications because of their inexpensiveness, wide bandgap (~3.6 eV), non-toxicity, water insolubility, and strong thermal stability. These unique properties of the ZnS QDs make them promising candidates for use in light-emitting diodes (LEDs)[1], solar cells[2], sensing technologies[3] and photocatalysis[4]. Due to their non-toxicity and high luminescence, these nanoparticles are also suitable for biological applications such as high-resolution cellular imaging, targeted drug delivery, fluorescence probes, and diagnostics[5] [6]. This study presents the synthesis of colloidal ZnS QDs and their characterization using X-ray Diffraction (XRD). The synthesis of the polyethylene glycol (PEG) capped QDs was carried out by the reaction of Zinc Nitrate and Sodium Sulphide in the aqueous solution in the presence of PEG as a surfactant. The resulting ZnS QDs were characterized using XRD to determine their crystalline properties. Characteristic diffraction peaks were observed corresponding to the (111), (220), (311), and (331) planes of cubic ZnS which confirmed the formation of the cubic Sphalerite structure of ZnS (JCPDS # 005-0566). From the XRD patterns, the average crystallite size was estimated using the Scherrer equation ($D = \frac{k\lambda}{\beta cos\vartheta}$). Subsequently, the effect of reaction time on the crystallite size of the nanoparticles was also studied by synthesizing the QDs with different reaction times. The results showed that by increasing the reaction time from 01 hour to 24 hours the crystallite size increased from 3.12 nm to 4.93 nm. To study the effect of PEG capping on the crystallite size, the QDs were synthesized with different concentrations of PEG. The QDs synthesized with 0.05 mM and 0.15 mM concentrations of PEG showed a reduction in size from 4.02 nm to 3.48 nm with increasing PEG concentration. This reduction in size can be attributed to the stabilizing effect of PEG which effectively limits the growth of QDs during the synthesis. In most cases, the calculated particle sizes are lower than the Bohr exciton radius of ZnS (3.95 nm)[7]. Therefore, the quantum confinement effect in ZnS QDs is also confirmed. The Scherrer method relies only on the peak width for the size of the crystallite. However, it is well-known that the width of the peaks is also related to lattice strain ($\beta_{total} = \beta_{crystallite size} + \beta_{strain}$) [8]. Therefore, further analysis of the XRD data was done by Williamson-Hall plot to check whether the peak broadening is due to the smaller crystallite size or the strain. After removing the contribution due to strain in the peak broadening the average crystallite was from 3.9 nm to 5.8 nm and the calculated strain was 3.2-14 $\times 10^{-3}$. It was also observed that increasing the concentration of the capping agent increased the lattice strain and increase in the reaction time reduced the lattice strain of the material. In this study by effectively utilizing the Scherrer equation and Williamson-Hall plot, we have not only quantified the reduction in particle size due to PEG capping but also accounted for lattice strain. This offers a comprehensive study of structural characteristics and synthesis parameters of these nanoparticles, paving the way for their potential applications in optoelectronics, bio-imaging, and other nanotechnology fields.

Keywords—Zinc Sulphide Quantum Dots (ZnS QDs), Colloidal Synthesis, PEG capping, XRD analysis, nanoparticles

Chemical analysis of essential oil of *Rosa bourboniana*

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Abstract—This manuscript reports essential oil extraction from the flower petals of Rosa bourboniana by steam distillation and solvent extraction methods, and its physico-chemical analysis. Yield of concrete oil was 0.203 and absolute oil 0.198%, on the basis of fresh flower weight, respectively, were as absolute oil was 9.826% on concrete oil basis. The extracted oil was yellowish in colour with refractive index 1.44 at 25 oC, congealing point 15 oC, optical rotation -32.51 + 45.26, specific gravity 0.8 at 20 oC, acid number 12 and ester number 25.21. The chemical components of the essential oil of Rosa bourboniana were determined by Gass chromatography mass spectrometry (GCMS). Fifteen compounds were identified in essential oil. Major constituents were phenyl ethyl alcohol (48.31%), geranyle acetate (15.78%), citronellol (13.09%), benzyl acetate (1.27%) citronellyle acetate (12.18%) and geraniol (5.72%).

Keywords: Chemical composition, essential oil, gass chromatography mass spectrometry (GCMS), Rosa bourboniana.

Enhancing OSPF Authentication Using Quantum Key Distribution and Software-Defined Networking

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Abstract—Open Shortest Path First (OSPF) is a foundational routing protocol in modern networks, Till now its traditional authentication method, such as MD5, are increasingly susceptible to sophisticated and quantum-based cyberattacks. This paper introduces a novel approach to enhancing OSPF authentication security by integrating Quantum Key Distribution (QKD) with Software-Defined Networking (SDN). By utilizing QKD, we achieve secure key generation and distribution, while SDN offers centralized control and dynamic configuration capabilities. Our method significantly improves key management, enables real-time eavesdropping detection, and fortifies overall network security. Experimental results demonstrate substantial security enhancements, including a reduced probability of cryptographic key compromise over time. For instance, after 100 hours, the probability of key compromise drops dramatically from approximately 99.33% with traditional MD5 authentication to just 4.98% approx. with our QKD and SDN integration. Additionally, our approach enhances network performance, with key metrics showing a reduction in convergence time from 15s to 10s, packet loss from 1.2% to 0.8%, average latency from 20ms to 15ms, and an increase in throughput from 100Mbps to 120Mbps.These results highlight the dual benefits of our solution, offering both heightened security and improved network efficiency, making it an optimal choice for securing OSPF in the face of emerging threats. This work paves the way for the adoption of QKD and SDN in securing future network infrastructures.

Keywords— OSPF, QKD, SDN, network security, quantum computing, cryptography

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Design of Power Management Unit for Uninterruptible Power to Signaling System in Remotely Located Railway Stations in Pakistan

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Abstract—Mobility is crucial for economic growth, improving job matches, reducing business costs, and speeding up product deliveries. Railways are essential for commuting and cargo transport. However, Pakistan Railways suffers delays and financial losses due to unreliable power supply affecting remote signaling systems. This paper proposes a Power Management Unit (PMU) to optimize power delivery and enhance operational efficiency. By integrating Variable Frequency Drives (VFDs) to reduce inrush currents and implementing a smart monitoring system, the PMU aims to improve reliability, train punctuality, and lower operational costs while utilizing renewable energy sources.

Keywords— *Power Management Unit, Variable frequency Drive, Point Machine*

Innovative Framework for IoV: Enhancing Security, Privacy, and Efficiency through Blockchain, Federated Learning, and Differential Privacy

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Abstract—The IoV landscape requires resilient solutions to guarantee integrity, security, and privacy. This paper presents an innovative framework for the integration of blockchain technology, federated learning, and differential privacy to advance IoV systems. Blockchain technology promotes decentralization, particularly in trust management, ensuring tamper-proof records with transparency and eliminating the risk of single points of failure. Federated learning enables collaborative model training to occur directly on vehicles, meaning data does not have to be shared, thereby maintaining privacy. Differential privacy further enhances the security of sensitive information by adding noise to the data, preserving privacy even in aggregated data. This holistic approach addresses essential challenges in IoV, such as security, privacy, and trust for data in transit, while also realizing performance improvements and business opportunities within the constraints of stringent data protection regulations. The proposed resilient cyber threat framework, with its scalable solution for the next generation of vehicular networks, promises to enhance security and privacy without compromising performance.

Keywords— *Internet of Vehicles (IoV), Blockchain Technology, Federated Learning, Differential Privacy, Cybersecurity*

Quantum-Assisted Transfer Learning: A Hybrid Approach to Urdu Sign Language Recognition

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Abstract—The recognition of Urdu Sign Language (USL) is pivotal for enhancing communication tools for the deaf, fostering inclusivity, and bridging significant communication gaps. This study introduces a novel hybrid quantum-classical approach to improve USL recognition accuracy, leveraging the strengths of quantum computing and classical machine learning. We employed the InceptionV3 model, pre-trained on the ImageNet dataset, to extract features from USL images, which were subsequently encoded into quantum states using a custom-designed quantum circuit. The integration of quantum parallelism in our hybrid model resulted in a remarkable validation accuracy of 94.65% over ten epochs, surpassing the performance of traditional classical models. This research not only underscores the transformative potential of quantum-enhanced machine learning but also sets the stage for future advancements in hybrid models for real-world applications. Our findings suggest that quantum computing can significantly optimize feature extraction and model training processes, particularly in scenarios where data is limited, as demonstrated in the context of USL recognition.

Keywords—Transfer Learning, Urdu Sign Language Recognition, Hybrid Quantum-Classical Models, InceptionV3, Quantum Circuits

Remediation Techniques of Petroleum-Contaminated Soils and its impact on human health

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Abstract—The soil contamination by gas and petroleum seriously threatens human health, living organisms, and the ecosystem, making it a serious environmental problem. However, the oil leaks into the soil during extraction and transportation, degrading the soil structure, and its qualities and even affecting the health of living organisms. This review examines the effectiveness of physical, chemical, and biological approaches employed in current methodologies used for the remediation of gas and petroleum-contaminated soil while highlighting human health impacts and, future aspects.

Keywords: Petroleum-contaminated soil, remediation techniques, impacts on human health.

Comparative Analysis of Power Flow Simulations in the Test 10-Bus Power System Using Power World Simulator, ETAP, and PSS Software

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Abstract—Power flow analysis plays a pivotal role in understanding and managing complex power systems. The accurate assessment of electrical parameters such as voltage, real, and reactive power is vital for both utility companies and consumers. This paper investigates the power flow analysis of the test 10- Bus power system utilizing three industry-standard software packages: PowerWorld Simulator, ETAP, and PSS. The study aims to provide insights into the performance and accuracy of these tools in simulating power flow within the network. Through comprehensive analysis and comparison of the results obtained from each software, this research contributes to enhancing the understanding of power flow dynamics and the reliability of simulation tools in real-world applications.

Keywords—Power Flow Analysis, Voltages, PowerWorld, Simulator, ETAP, PSS.

Status of Occupational Health & Safety Culture in the Construction Industry of Pakistan

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Abstract—The construction industry significantly contributes to Pakistan's GDP, employing over 30% of the population; however, it is also the second most injury-prone industry, with workers suffering disproportionately high injuries. This research study examines the Occupational Health and Safety (OHS) culture on construction sites in Pakistan. The construction sites in different cities of Pakistan are analyzed against a checklist provided by the International Labor Organization, and the actual on-ground situation is reported. Moreover, qualitative research techniques, including stakeholder interviews and questionnaire surveys, are used for this research study. Results show that the OHS culture on construction sites is unsatisfactory in small construction companies, while larger companies have better safety cultures. Moreover, stakeholders used their perceptions and assessments to assess safety on work sites. The study identifies physical and ergonomic hazards as the top two categories among occupational hazards. These findings will aid stakeholders in enhancing OHS culture on construction sites, resulting in improved productivity and outputs.

Keywords: Construction Industry, Occupation Health and Safety, RII, Stakeholders, ILO.

Investigation of β decay properties of very neutron-rich Kr to Tc nuclei

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Abstract—The r-process is responsible for creating about 50% of the heavy elements beyond iron and is crucial for the neutronization of massive stars. Understanding the r-process path requires detailed knowledge of the β decay properties of nuclei far from stability. The most easily measurable β decay properties for such nuclei, which have low production yields, are β decay half-lives and β delayed neutron emission probabilities. This study examines the β decay properties of very neutron-rich nuclei with atomic numbers (Z) between 36 and 43, extending beyond the known nuclei boundary. The neutron excess (N - Z) in this study reaches up to 36. We present the first-ever microscopic calculation of stellar rates of these exotic nuclei in the current study. We compare our calculated results with measured values and previous calculation where possible.

Keyword: β decay rates, Gamow-Teller strength distributions, β delayed neutron emission probabilities. pn-QRPA, Stellar rates.

Reinvestigation of 58,60,61,62,64Ni(p, γ) 59,61,62,63,65Cu In Stellar Environment of Type 1 Supernovae

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Abstract—We have found the abundance of Nickel Isotopes in Type 1 Supernovae. Within the context of statistical approach (TALYS-1.97) the radiative Proton and neutron Capturing on Nickel Isotopes have been investigated. In the present work we have employed the γ- Strength Function (Hartree-Fock-Bardeen-Cooper-Schrieffer, Skyrme-Hartree-Fock-Bogoliubov, Goriely-Hybrid-Model and Temperature dependent Skyrme-Hartree-Fock-Bogoliubov) and Nuclear Level Density (Skyrme-Hartree-Fock-Bogolyubov) combinational level density for microscopic approach. The total cross-section and Astrophysical Reaction Rates in a stellar environment are calculated using these modules and comparison of Cross-section of (p, γ) and (n, γ) is shown as Ni being part of both p and s process. Observational study of resonance in (n, γ) cross-section at low energy (0.0001 – 1) MeVs and Reaction rates are computed using this Cross-section and then is compared with results obtained by (p, γ).

Keywords—Nuclear Level Density, Talys, γ- Strength Function, Reaction Rates and Cross-section.

Nearly Zero Energy Buildings – A Case Study in Pakistan

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Abstract—Nearly Zero Energy Buildings (nZEB) are critical to sustainable development, significantly reducing dependency on nonrenewable energy sources and minimizing environmental impact. This study aims to provide essential guidelines for developing nZEB through a case study of a residential project in Islamabad, Pakistan. The focus on this project is particularly urgent given Pakistan's severe energy crisis and public backlash due to heavy bills. The methodology includes passive design tactics such as optimal orientation, natural ventilation, and effective insulation, supplemented with on-site solar energy generation. Initial calculations show that combining these measures can reduce energy use by up to 70%, significantly improving the building's overall energy performance. The paper concludes with practical recommendations for applying nZEB principles, emphasizing their potential to yield major environmental, social, and economic benefits. The findings of this study will assist developing countries like Pakistan in addressing the energy concerns and also ensuring sustainable development.

Keywords—nZEB (Nearly Zero Energy Building)

Revolutionizing wheat (*Tritium aestivum* L.) cultivation with Nano-Coated urea for enhanced growth

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Abstract—The quest for enhancing wheat productivity amidst growing global food demands has prompted the exploration of innovative agricultural technologies. One such advancement is the use of nano coated urea fertilizers, which offer significant improvements over traditional urea in terms of nutrient release and plant growth. Zinc oxide nanoparticles with a size of 30nm, as determined by zeta sizer, were utilized in the coating. Further, coatings were formulated by incorporating urea with zinc oxide nanoparticle at different concentration. A pot experiment was conducted to compare the effect of coated and uncoated urea on plant growth. The results indicated that nano coated urea improved plant growth. Wheat Plants treated with nano coated urea exhibited increased root and shoot lengths, a 25% increase in fresh weight, and a 10% increase in dry weight of roots and shoots of wheat plant revealing enhanced biomass accumulation. The adoption of nano coated urea represents a promising step towards sustainable agriculture, offering a pathway to meet the increasing food demands by improving the growth of wheat.

Keywords- Nano coated urea, zinc oxide nanoparticles, agriculture technology, biomass accumulation, food security.

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Synthesis and Characterization of Hydrogels for Speedy Wound Healing in Diabetic Patients

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Abstract—An alarming global health concern is the rising prevalence of diabetes. A major portion of the world is affected by this disease, which is getting worse every year. To relieve wounds, several treatments in the form of drugs, injections, dressings, oral supplements and ointments are commercially available, but till date, no proposed solution is effective enough to progress healing mechanism in diabetic wounds efficiently. In this research work, four different hydrogels were synthesized that are Hyydrogel-1(Al-Cacl2), Hydrogel-2(Al-CS-PGA), Hydrogel-3(Al-PGA), and Hydrogel-4 (AL-PGA-MC). The objectives of these products were to increase the amount of exudate absorption, blood coagulation, and antibacterial activity at the wound bed. Through in vitro analysis, the results obtained from all four hydrogels are compared. According to the findings, Hydrogel-4 (AL-PGA-MC) demonstrated 82% absorption of exudate in up to 1 hour, with a reduction in the blood clotting time to 18 seconds. Hydrogel-4 (AL-PGA-MC) effectively inhibited the growth of E. coli and S. aureus bacteria. Its excellent antioxidant property was revealed by the value of percent radical inhibition, which was 79%. As an outcome, it can be concluded that Hydrogel-4 (AL-PGA-MC) gave the best results in comparison with other Hydrogels due to the presence of Bitter melon/*Momordica charantia* (MC).

Keywords: Hydrogel, Bitter Melon, Diabetic wound

Use of double sampling in estimating the finite population coefficient of variation using two auxiliary variables

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Abstract— In this article, we suggest a new improved class of difference type estimator in estimating the finite population coefficient of variation using knowledge of population mean and variance in simple random sampling under two auxiliary variables. The properties of estimators based on bias and MSE are derived up to first order of approximation. The results are obtained using two real data sets and simulation study. A further five estimators are obtained from a suggested class of estimators. It is observed that all proposed difference type estimators are superior as compared to all other existing estimators.

Keywords— Coefficient of variation, Simulation, Bias, MSE, Efficiency.

A Review on the Synthesis Techniques for the Photothermal Materials

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Abstract—The technique employed for the synthesis of any material is very essential, as it determines the characteristics and the controlling parameters of the prepared material which eventually affect its shape, size, electrical, chemical, magnetic and other related properties, tailored to attain exclusive properties. Photothermal materials have been used almost in every field of life due to its the ability to efficiently absorb light and convert it into heat which can be then used in different applications. The various properties of photothermal materials such as excellent light absorption, porosity, high electrical conductivity, bandgap, chemically inert, biocompatible and high surface area. These features have attracted the attention of researchers for last few years, thus a short review of the synthesis techniques employed for photothermal materials is reported.

Keywords—photothermal, bandgap, biocompatible

Investigation of the Tensile Properties of EPDM Based Nanocomposites Reinforced with Nanoclay and Graphene Nanosheets

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Abstract—Elastomeric nanocomposites (ENCs) based on ethylene propylene diene monomer rubber (EPDM) filled with mechanically stable reinforcing nano fillers polyaniline grafted sepiolite (ENC 1), polyaniline grafted graphene oxide (ENC 2) and polyaniline grafted sepiolite/reduced graphene oxide (ENC 3) were prepared by solution casting method followed by compression molding. The synthesized nano fillers were investigated by dynamic light scattering (DLS), X-ray diffraction (XRD), Raman spectroscopy and Fourier transform infrared spectroscopy (FTIR). The concentration of nano fillers influences the mechanical properties of the final composites. Morphological studies indicate that fibrous sepiolite, wrinkled sheet graphene oxide and wrapped PgS/rGO appeared to be homogeneously distributed in continuous EPDM matrix with little agglomeration. Mechanical properties revealed enhanced tensile strength and elongation at break as a function of nano fillers loading. A significant improvement was noticed in tensile strength by increasing the filler content, ranging from 0.8 MPa to an astonishing 64 MPa. These high-performance sheets, with their outstanding mechanical robustness gives the pathway for creative solutions in the design and manufacturing of sophisticated electronic and related technologies.

Keywords—EPDM, nanocomposites, polyaniline grafted sepiolite, polyaniline grafted graphene oxide, reduced graphene oxide

Effect of ZnO NPs coating on DAP fertilizer efficiency for enhancing Soil available nutrients

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Abstract—Zinc is an essential nutrient required for plant growth and development. This research study aims to formulate a slow-release fertilizer using zinc oxide nanoparticles as a micronutrient. For the research study, three different formulations were prepared comprising ZnO nanoparticles and gelatin as a binder. The surface morphology, size, and chemical composition of the developed product were determined using scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), and powder X-ray diffraction (XRD). The physiochemical properties of the prepared formulation were tested using crushing strength. The effect of three different formulations was analysed on maize in pot trials. Plant height, leaf area, number of leaves, roots yield, fresh biomass weight, and dry biomass weights were compared to analyse the effect of different treatments.

Synthesis of chitosan nanoparticle for targeted Nano-therapy against Receptor tyrosine kinases in Glioblastoma Multiform: In vitro assays

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Abstract—Glioblastoma, the fourth most aggressive brain tumor holds great diagnostic and treatment challenges. Temozolomide (TMZ) treatment has various limitations such as drug resistance, reactivation of oncogenic pathways; including Receptor tyrosine kinases (RTKs) and insufficient drug delivery across blood-brain barrier (BBB) causing increased toxicity. Stated limitations demand the development of efficient and targeted encapsulated nano-carrier therapies against GBM. The current study employed the computer-aided drug discovery (CADD) models and identified compounds that had undergone in vitro testing for their anti-GBM potential using GBM specific cancer cell lines. For stated purpose, a library of 691 compounds of various plant extracts having anti-cancerous, anti-inflammatory, and anti-proliferative characteristics was generated after thorough literature survey. Test compounds were docked against selected RTKs ligands through Molecular Operating Environment (MOE). Selected compounds were then subjected to Lipinski rule of 5 (RO5) to predict drug-likeness and after that selected compounds were analysed through ADMETSAR and Density functional theory (DFT) to evaluate pharmacokinetic characteristics and potency of compounds. Kaempferol (KPF) was found to be the most potent RTK inhibitor which was then successfully encapsulated in chitosan nanoparticles (KPF-CHI) by Ion gelation method. Physio-chemical properties were done to confirm nanoparticles shape, size, stability, monodispersity, charge, coating efficiency and drug-release rate. SEM showing the size of KPF-CHI ranging from 20nm-200nm, XRD peaks predicting its amorphous nature and FTIR peaks proving its encapsulation in NP. Anti-cancer potential of KPF and KPF-CHI were evaluated using U87, U251 and HEK293 cell lines through MTT assay. KPF showed decreased cell viability 72 hours post treatment, against both U87 and U251 cell lines but had negligible cytotoxic effect on HEK293. IC50 value of KPF was 31.41uM for U87 and 37.78 uM for U251. Formulations were tested

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for cancer cell metastatic potential using cell migration assays. KPF and KPF-CHI effectively inhibited U87 and U251 cell migration 24 hours after treatment. In-vitro results of this study marked the potential application of KPF and KPF-CHI for GBM therapy. Further validation of in-vitro results using in-vivo orthotropic xenograft models is required before proceeding with the human clinical trials.

Keywords: Glioblastoma, Blood Brain Barrier, Chitosan nanoparticles, Ion gelatin method, KPF, Cell migration assay, MTT assay

Machine Learning and Experimental Hybrid Strategy for Optimized Nitrogen Release from Coated Urea Fertilizers

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Abstract—Sustainable agriculture depends on optimizing nitrogen release from coated urea fertilizers. Machine learning (ML) models have provided technologically improved solutions for the purpose; however, high-quality and sufficient data are key challenges to implementing these models. Considering the difficulty of acquiring data, determining the best machine learning model for predicting nitrogen release rates is crucial. The objective of the study is to conduct the comparative analysis of several ML models including Support vector machine, Gaussian process regression, Ensemble learning tree, and Decision tree (DT) to better predict release rate for coated urea fertilizers. To increase the predictive capability of ML model optimization techniques are integrated with ML models. The integration facilitated the refinement of the models and selection of the most optimized one. To validate release rate prediction, data is analyzed from pot trials with a coated urea fertilizer. GPR optimized using Genetic Algorithm (GA), exhibited superior performance compared to other models, achieving an R² 0.9976 and RMSE 0.0173. Sensitivity analysis was performed, and partial dependency plots were generated to enhance understanding of the impact of coating thickness, radius, polymers, and additives on urea release rate. For ease in computing the graphical user interface (GUI) is developed to enhance the accessibility and user-friendliness of prediction function. This study emphasizes the effectiveness of integrating optimized ML models with experimentation to improve fertilizer efficiency. This methodology not only offers a reliable and economical solution for estimating nitrogen release but also demonstrates potential for widespread application in sustainable agricultural practices.

Keywords— coated urea fertilizer, nitrogen release, machine learning, sustainable agriculture, genetic algorithm

Analysis and Optimization of Protection Systems for Power System Components

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Abstract—Power systems are critical infrastructures that require robust protection schemes to ensure their reliable and safe operation. In this paper, we present the design and implementation of various protection schemes for power generation, transmission, distribution, and utilization systems using SIMULINK. The proposed protection schemes are tailored to meet the specific requirements of the system, aiming to safeguard against a wide range of faults that may occur during operation. Three distinct relays—frequency check relay, differential relay, and over-current relay—are meticulously designed to protect individual components of the power system. Through simulation and analysis, we demonstrate the effectiveness and reliability of these protection schemes in ensuring the security and stability of the power system under various fault conditions. The insights and findings presented in this paper contribute to the advancement of protective relay technology, offering practical solutions for enhancing the resilience of modern power systems.

Keywords—generation, transmission, distribution, fault, frequency check, differential protection, over-current

Optimization of Prosumer Based Demand Side Management (DSM) by Using K-Means Clustering Algorithm

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Abstract—Prosumers both generate and consume electricity, making Prosumer-based Demand Side Management increasingly appealing due to its numerous benefits for both consumers and utility companies. This study introduces a proposed model featuring four prosumers and twelve consumers. Consumers have the flexibility to procure electricity either from the utility company or nearby prosumers based on the most competitive rates available. The K-Means Clustering algorithm is employed for optimization due to its advantageous characteristics. The proposed model offers a straightforward implementation through a unified network for device communication, enhancing operational efficiency for grid operators. This streamlined approach reduces complexity and cuts down on infrastructure and management costs. Positioned as a forward-thinking solution, it integrates economic incentives, environmental benefits, and operational efficiency, addressing critical challenges in energy management and sustainability. By bolstering grid resilience and sustainability, the model meets evolving consumer needs and regulatory requirements for cleaner energy solutions.

Keywords—Prosumer, Demand Side Management (DSM), K-Means Clustering algorithm, clean energy, smart grid.

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Microscopic Techniques for Nanomaterials Characterization: A concise Review

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Abstract—Nanomaterials have been gaining interest due to their remarkable properties at the nanoscale. The surface area of particles becomes high at the nanoscale because of this virtue, they have been used in a bundle of applications like electronics, biomedical, agriculture, wastewater treatment, semiconductor industry, cosmetics, drug delivery, paints, etc. The morphology (size and shape) of nanomaterials plays an important role because each application requires the appropriate morphology for better performance. Generally, there are a few microscopic techniques used to characterize nanomaterial morphology, AFM (atomic force microscopy), TEM (transmission electron microscopy), SEM (scanning electron microscopy), and others. In this review, the principles, operations, advantages, and limitations of these microscopic techniques for nanomaterial morphology characterization have been briefly discussed. The current challenges and future direction for the development of these techniques have also been highlighted.

Nano-enhanced flood resilience in wheat (Triticum aestivum L) with amended plant growth regulators.

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Abstract—Wheat along with maize is a staple food that is widely consumed across the world, providing a significant portion of global food calories and protein. Climate change and increasing extreme weather including low or high temperature, low or high humidity, high salinity, heavy metals and ultraviolet rays are harmful to wheat and pose serious threats to agriculture and the environment and cause high yield losses. This study evaluates the impact of nano-amended plant growth regulators (PGRs) on seedling morphology and biochemistry under flooding stress, aiming to determine the optimal concentration for enhancing flood tolerance. The experiment involved selecting a wheat variety, applying flooding stress after one week of growth, treating with nano-amended PGRs via foliar application after one day of stress, and conducting statistical analysis to evaluate treatment outcomes. Significant enhancements in chlorophyll, proline, amino acid, sugar, and iron content, as well as improved root architecture, were observed in wheat seedlings treated with nano-amended PGRs, indicating improved flood tolerance.

A Comprehensive Review of Fin Geometries and Their Impact on Heat Exchanger Performance

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Abstract—Among the most widely used types of heat exchangers, finned and tube heat exchangers are essential in a wide range of industrial applications, including power plants, sewage treatment facilities, petrochemical and chemical factories, as well as cooling and heating systems for space. Enhancing the heat transfer rate while maintaining the size and weight of a heat exchanger is crucial. Various shapes and orientations of fins and tubes are utilized to improve thermal performance. The goal of this paper is to provide a comprehensive overview of the research conducted to enhance the thermal performance of heat exchangers by using different fin types, orientations, shapes, and placements. This study aims to clarify how each of these characteristics affects the enhancement of thermal efficiency and also the vibrational analysis of finned tubes under flow-induced vibration. Flow-induced vibrations can significantly impact the structural integrity and thermal performance of heat exchangers. The interaction between the fluid flow and finned tubes can lead to resonant vibrations, potentially causing mechanical failure or reduced efficiency. Understanding and mitigating these vibrations are crucial for the reliable operation of heat exchangers, especially in high-flow or turbulent conditions.

Keywords—Heat Exchanger, fins, thermal efficiency, microchannels, plate fins, pin fins, perforated fins, porous fins, contact angle, flat-tube, louvered finned tubes, flow-induced vibration, vibrational analysis.

Optimizing rice plant growth with nanocoated urea

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Abstract—Urea is widely used fertilizer for rice growth but its efficiency is limited due to rapid nutrient loss. This study focuses on the development and application of nanocoated controlled release urea utilizing zinc oxide nanoparticles to improve rice growth and productivity. Zinc oxide nanoparticles were synthesized using co precipitation method and coated onto urea particles to formulate controlled release urea which was then evaluated through pot experiments to access its impact on rice growth. Zinc oxide nanoparticles with a size of 30 nm as determined by Zeta sizer were utilized in the coating. We developed a nano coated controlled release urea particles with a composite layer of chitosan/Laponite/zinc oxide nanoparticles stabilized with CMC to regulate nutrient release and enhance agricultural efficiency. Nano-coated urea was applied to rice crops and growth parameters such as root length, shoot length, root dry weight and fresh weight were measured. Nano-coated controlled release urea treated plant showed 35% increase in dry weight and 28% increase in fresh weight. In conclusion our findings suggest that the nano coated controlled released urea is a promising tool to boost rice growth while minimizing environmental impact and holds great potential for agricultural sustainability and food security.

Keyword--Zinc oxide, nanocoated, dry weight, fresh weight, controlled, urea, agriculture

Synergistic Effect of Waste Foundry Sand and Lime as Partial Replacement of Cement in Cement-Bentonite Slurry

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Abstract—Slurry walls are widely used as vertical barriers to contain the lateral flow of groundwater and contaminants. This research presents an experimental investigation into the utilization of waste foundry sand (WFS) and lime as partial replacements for cement in cement-bentonite (CB) slurry. The primary objective was to develop a synergistic mix capable of reducing permeability while enhancing the strength of CB slurry walls. Various slurry mixtures with different proportions of cement, bentonite, WFS, and lime were prepared and tested for permeability and unconfined compressive strength (UCS). The influence of curing time on both permeability and UCS was also examined. The test results indicated that the incorporation of WFS and lime into CB slurry significantly reduced permeability and increased the strength of the mixtures. It was observed that a minimum threshold of WFS and lime was necessary to achieve notable strength improvements, although the rate of strength gain diminished beyond a certain limit. A one-way analysis of variance (ANOVA) confirmed that the partial replacement with WFS and lime had a statistically significant positive effect on the compressive strength and permeability of CB-WFS-lime mixtures across all curing periods. The study concludes that incorporating WFS and lime is a practical and environmentally sustainable approach for CB slurry wall construction.

Keywords— Cement-Bentonite Slurry, Waste Foundry Sand, Lime, Permeability, Unconfined Compressive Strength, ANOVA

Investigation of β-decay properties of proton-rich odd-A Sn isotopes

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Abstract—We examine the β-decay properties of the proton-rich odd-A Sn isotopes in the region 101≤A≤109. The calculations are performed using the proton-neutron quasi particle random phase approximation (pn-QRPA) theory. Our calculated GT strength distributions are in decent agreement with the experimental data. The calculated β-decay half-lives are reproduced within a factor 2 of the measured data. We report the microscopic calculation of electron capture, positron emission of proton-rich Sn nuclei in the interior of a star. As the density of the stellar core reaches 1011 g/cm3, the electron capture rates increase up to seven orders of magnitude. On the other hand, positron emission rates remain almost unchanged with changing values of core density and changed up to two orders of magnitude with soaring core temperatures. The reported stellar rates could prove useful for rp-process nucleosynthesis calculations and simulations of post core silicon burning phases in stellar evolution.

Keywords— β-decay half-lives, pn-QRPA model, Gamow-Teller strength distributions, Stellar rates

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Techno-Economic Analysis for Biodiesel Production through Wheat Straw Pyrolysis

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Abstract— Limited domestic resources, high fuel imports and finite access to modern fuel resulting in economic burden has led to increase in energy poverty in Pakistan. Moreover, waste management is the burning issue in the context of agricultural residue which is burned by farmers causing soil deterioration and air pollution. These significant and interconnected issues of the Pakistan that have far-reaching economic, environmental, and social implications. The primary goal of sustainable fuel production is to reduce the environmental and social harm associated with traditional fossil fuel extraction and production methods. Bio-crude is a liquid biofuel produced by thermochemical conversion of wide variety of biomass. Fast pyrolysis considered as an efficient and the most economical technique of valorization is used for the production of bio-crude from wheat straw. Catalytic upgrading methods like hydro-processing are then employed to upgrade biocrude to a variety of fuels including diesel and gasoline. In present work, techno-economic and environmental assessment is made for the process. Moreover, a complete process route is developed with detailed economic analysis to determine its feasibility. The process was also subjected to an economic study, and the results indicate that the project is fiscally feasible. With a 3.9 - year payback period and a positive present worth value, this project is the best investment. With pyrolysis being the most inexpensive route towards biofuels, the developed process can serve as a solution towards energy crisis issues of Pakistan.

Keywords— Pyrolysis; Wheat Straw; Bio-diesel, Circular Economy; Energy Crisis; Fuels

Cellulose Based Membranes Doped with Zirconium Dioxide (ZrO2) Nanoparticles for Water Desalination

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Abstract—The rapid expansion in population and rapid industrialization has led to depletion and pollution of fresh water supplies at an alarming rate, resulting in freshwater shortage. The bulk of water on Earth is saltwater, and freshwater supplies are relatively scarce and unequally distributed around the planet. To address the challenges posed by water shortage, there is a significant global interest in using Nano technology to reduce over exploitation of precious freshwater resources. This study focuses on the synthesis of cellulose acetate (CA) membranes doped with zirconium dioxide (ZrO2) nanoparticles for water desalination. Different membranes were fabricated using various combinations of nanoparticles with casting solution. Flat sheet membranes were fabricated via phase inversion method. The fabricated membrane was characterized by using SEM, FTIR and Contact angle techniques. It was found that that the membrane having 0.4wt % of ZrO2 CA shows desired hydrophilicity, porosity, water uptake. The opted membrane possesses the pure water flux of 79 Lm2/h and salt rejection of 59% making this composition a hopeful candidate for the practical implementation in saline water treatment applications.

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The Rise of Graphene Oxide: A Review on Synthesis, Properties and Recent Advances

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Abstract—In recent years, graphene oxide (GO) has appealed considerable attention in fields such as engineering, medical and dentistry. It is also the building block for producing Graphene. It is 2D sp2 hybridized carbon material with oxygenated planar molecular solid. It can be formed in different morphologies e.g., nanoparticles, nanosheets and quantum dots. Synthesis methods of GO have great effect on its properties. It is used in building materials to improve their mechanical strength. Lately, the comprehension of graphene's diverse chemical characteristics has enabled its utilization in high-efficiency gadgets that produce and retain energy. Graphene is currently extending its reach into biomedical fields like increased cell differentiation and proliferation, precise bio sensing via graphene-quenched fluorescence, and graphene assisted laser desorption/ionization for mass spectrometry. These applications go beyond electronic and chemical fields. This review discusses the synthesis methods, structure, properties, and applications of GO in orthodontics and antibacterial activities.

Keywords Graphene oxide, Synthesis, properties, antibacterial, orthodontics)

Application of Wavelet Transform in Fault Detection of Distribution Line

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Abstract—In order to detect faults using wavelet transform, this study provides a 10 km power distribution system that operates at 50 Hz and is constructed with an 80 Ω resistive fault (RF) load. When analyzing current signals under different fault situations, including single-line-to-ground (SLG), double-line-to-ground (DLG), and three-phase faults, wavelet transform is employed. The method efficiently captures fault characteristics and transient disturbances in both the temporal and frequency domains by breaking down current signals into several frequency components. The system's reaction to these faults is simulated using MATLAB/SIMULINK, and the findings demonstrate that the system rapidly converges to a stable state following the occurrence of a failure. By ensuring high accuracy in fault detection and isolation, the wavelet-based solution minimizes system downtime and drastically cuts down on fault clearance durations. This improves the distribution network's resilience and dependability and provides contemporary power systems with a strong real-time problem detection mechanism.

Keywords— Distribution System (DS), High Impedance Fault (HIF), Distribution Line (DL), Single-Line-to-Ground (SLG), Double-Line-to-Ground (DLG), Resistive Fault (RF)

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Synthesis And Characterization of Aloe vera-Curcumin Loaded Zein Nano Fibrous Smart Dressing for Diabetic Foot Ulcer

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Abstract—Diabetes is one of the predominant healthcare problems that affects the globe with high fatality and comorbidity rates and its associated complications involving diabetic foot ulcers (DFU). According to the various clinical reports, a major contributing factor to the challenges in healing the DFU is the infection, changes in the inflammatory responses, a deficiency in the extracellular matrix, and a failure of angiogenesis. Nanofibers that replicate natural materials exhibit significant porosity, excellent moisture absorption, and a greater oxygen exchange rate. These properties are highly desirable for DFU treatment. In this research, we synthesized a nanofibrous scaffold containing curcumin and aloe vera, two natural therapeutic elements, encapsulated in a biodegradable polymer named Zein. The morphology of the nanofibrous scaffold was examined, confirming that the fibers were perfectly sized and had a smooth, bead-free structure. Additionally, the presence of chemical components (C-O, C=C and S=O, and C=N groups of Cr and Av with Zein polymer) was evaluated, and the drug release profile was found to be efficient. All these outcomes were received using the SEM, FTIR, and UV-VIS characterization methods, respectively.

Keywords: Diabetic foot ulcers, DFU, Nanofibers and scaffold

Reviving Tradition: Restoration of Katas Raj Temple's Historic Mortar

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Abstract—This study focuses on evaluating the historic mortar of the Katas Raj Temple in Chakwal District, Punjab, Pakistan, a complex originally constructed between 615 and 950 CE for Hindu worship and pilgrimage. The ancient mortar, now deteriorated, necessitates restoration using a modern yet historically accurate formulation. Characterization of the original mortar revealed a composition of 1:4:8 concrete with 1.5 parts clay by mass. In response, a new mortar was developed in the lab, replicating the original's composition, and its properties were compared with those of the historical mortar. The old mortar's high porosity and significant void content render it vulnerable to further damage. By applying a modern mortar with the same composition, the longevity of the structure can be enhanced. Preserving historical sites like Katas Raj Temple is vital, as they embody our cultural heritage and the legacy of our ancestors. A scientifically informed restoration approach will ensure the site's preservation for future generations.

Keywords—Katas Raj Temple, old mortar, characterization, restoration, compatible modern mortar, heritage.

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A Review of Machine Learning Techniques in Vibration Analysis for Early Bearing Fault Detection

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Abstract—One of the most common causes of any catastrophic failure of a rotating machine is due to faulty bearing. To maintain the health of machinery we must consider early detection of faults for the safety of both humans as well as machinery so have to detect this in its initial stages. These small flaws might lead to machinery malfunctioning. From the various maintenance methods, the vibration measurement method was mostly used to access the accurate health condition of rotating machinery. This paper presents a complete road map for vibration measurement method techniques which are statistical moments of the rectified data, cyclo stationary function, HFRT and FFT method, signal processing methods, time domain, frequency domain and spike energy analysis, Partial correlation integral algorithm. Then a brief analysis of different machine learning techniques on different factors to figure out suitable for the industrial environment. Numerous approaches of machine learning like Support vector machine (SVM), relevance vector machine (RVM), artificial neural network (ANN), decision tree (DT) K-nearest neighbor (KNN), and support vector regression (SVR) are compared based on the complexity of input data, theoretical background, and its industrial applications.

Keywords—Machine learning, vibrational analysis, fault detection

Utilizing Mangla Reservoir Silt as Partial Clay Replacement in Bricks: A Sustainable Approach to Desilting

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Abstract—This study is part of a pilot project which focuses on evaluating the potential of Mangla reservoir silt as an ingredient of building materials like bricks and cementitious composites. Mangla silt was dredged from the bottom of the reservoir. The silt was dried in the sun. Clay bricks were prepared by replacing 0, 10, 20, and 30% of fertile clay with dredged material. The bricks were prepared in a local Bull's Trench Kiln. The bricks were tested in terms of weight, water absorption, compressive strength, and efflorescence. The results revealed that the replacement enhanced the density of the bricks. The water absorption was lowered by 15%, 33%, and 15% with 10, 20, and 30% respectively. The compressive strength was enhanced by 11% with 10% replacement, whereas it was reduced by 16% and 28% with 20% and 30% partial replacement. The efflorescence results revealed that only control specimens experienced the efflorescence. The bricks containing silt were free from any efflorescence. Using Mangla reservoir silt as a building material will not save the precious fertile clay but will also resolve the long-term silting issues of the reservoir.

Keywords—Mangla reservoir, silt, clayey bricks, characterization, evaluation.

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Innovative Design for Sustainable Three-Wheeled Reverse Trikes: Advancing Safety, Efficiency, and Eco-Friendly Solutions

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Abstract—This paper delves into the domain of three-wheeled reverse trike vehicles, emphasizing advancements in safety features, suspension systems, and lightweight body design. The primary objective is to enhance safety, optimize suspension performance, and incorporate cutting-edge lightweight materials. This research contributes to Sustainable Development Goals by promoting energy-efficient transportation solutions through innovative designs and eco-friendly materials. It also advances Energy Economics and Modelling, aiming for a sustainable future in transport. By integrating these elements, the study seeks to reduce carbon emissions, support the transition to a low-carbon economy, and provide a comprehensive framework for developing safer, more efficient, and environmentally friendly three-wheeled reverse trike vehicles. The primary objective is to enhance safety by 15%, optimize suspension performance by 13%, and reduce overall vehicle weight by 15% through the incorporation of cutting-edge lightweight materials and aerodynamic shape.

Keywords— Three-Wheeler, Reverse Strike, Suspension System, Aerodynamics, Economic, Light Weight Chassis, MS Body

Study the Effect of Pairing Gaps on Astrophysical Important Nuclei using the pn-QRPA Model

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Abstract—β-decay is a key factor in understanding the r-process and evolution of massive stars. The Gamow-Teller (GT) transitions drive the β-decay process. We employ the proton-neutron quasiparticle random phase approximation (pn-QRPA) model to calculate terrestrial and stellar β-decay rates. We choose the 50 top-ranked nuclei possessing astrophysical significance according to a recent survey. The list of 50 top-ranked nuclei is based on the ranking parameter $\dot{R}$. The model parameters of the pn-QRPA model affect the predicted results of β-decay. The pairing gap as a model input parameter, affects the β-decay charge-changing transitions and stellar weak rates. The current study investigates the effect of nucleon-nucleon pairing gaps on charge-changing transitions and the associated β-decay rates. Three different values of pairing gaps, namely TF, 3TF, and 5TF, were used in our investigation. It was concluded that both GT strength distributions and half-lives are sensitive to pairing gap values. The 3TF pairing gap scheme, in our chosen nuclear model, resulted in the best prediction with around 80% of the calculated half-lives within a factor of 10 of the measured ones. The 3TF pairing scheme also led to the calculation of the biggest β -decay rates in stellar matter.

Keywords—Gamow-Teller strength; pairing gaps; half-lives; deformed pn-QRPA; β-decay rates, partial half lives

Graphene incorporated Cellulose Acetate based Mixed Matrix Membrane for Carbon dioxide Sequestration

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Abstract—Carbon dioxide (CO_2) significantly impacts the environment by contributing to global warming, with emissions rising to 38 gigatons in 2024, primarily from fossil fuels. The research highlights the increasing attention towards graphene-based membranes due to their potential applications in gas separation, especially in the context of environmental concerns and energy efficiency. The incorporation of graphene oxide (GO) into Cellulose Acetate (CA) membranes enhance gas separation performance, particularly focusing on CO_2 and N_2. The membrane properties were investigated for mixed matrix membrane filled with variable filler loading. The synthesized GO and properties of fabricated membranes were characterized and studied using contact angle measurement, porosity of membranes, FTIR, SEM and Gas permeation testing, respectively. The fabricated membrane concludes that even low loading of GO significantly improves membrane performance, indicating its potential for future applications in gas separation technologies.

Synergistic Effects of Supplementary Materials and Fiber Reinforcement

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Abstract—This study was inspired from sustainable development goals of United Nations (UN), which ask to adapt responsible consumption and production. Waste rubber tires are a non-biodegradable material, and its safe disposal is beneficial to the natural habitat. Rubberized cementitious composites incorporate crumb rubber as a partial replacement for natural sand, providing a sustainable solution for the safe disposal of waste rubber tires from which the crumb rubber is derived. Present work deals with the explanation of enhancement in strength of a rubberized cementitious mortar with additives based on a water absorption test. Three types of specimens were cast and tested: one was control, the second was rubberized and the third was a rubberized sample containing a mixture of silica fumes, fly ash and polypropylene (PP) fibers. The water to binder ratio was kept constant. It was revealed that the supplementary cementitious materials (SCMs) and PP fibers enhance the strength of the rubberized samples. Water absorption tests revealed that the percentage of permeable pores decrease with the SCMs and PP fibers. The decrease in porosity is a measure of higher strength. This is also an indicator of a higher durability. It is concluded that the strength and durability of a rubberized cementitious composites can be enhanced by selecting a careful mixture of additives.

Keywords—rubberized cementitious composites, supplementary cementitious materials, fibers, strength, water absorption.

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Screening Soil Microbes for Cellulase Enzyme Production and Identification

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Abstract—The cellulase enzymes are essential for biofuel production, waste management, and the paper industry due to their role in breaking down cellulose, a major component of plant biomass. The objective of this investigation was to screen and identify soil microorganisms capable of producing cellulase enzymes. Soil samples were collected from environments with high microbial activity, and a series of enrichment and screening processes were applied to isolate cellulase-producing microorganisms. Qualitative and quantitative tests were then conducted to assess the cellulolytic activity of the isolates. The most promising strains were further characterized using morphological, biochemical, and molecular methods. The study successfully identified several bacterial strains with significant cellulase production potential, laying the foundation for further research into optimizing these enzymes. Preliminary screening using carboxymethyl cellulose (CMC) agar plates indicated cellulolytic activity through the formation of clear zones around microbial colonies. Quantitative assays, such as the dinitrosalicylic acid (DNS) assay, were used to measure cellulase activity. Additionally, morphological and biochemical characterization, along with molecular identification through 16S rRNA gene sequencing, helped identify the most efficient cellulase producers. This investigation highlights the vast microbial diversity in soil and its potential contribution to environmentally sustainable industrial processes. Future research will focus on optimizing enzyme production and exploring the industrial applications of these cellulase-producing strains.

Keywords- Cellulase enzyme, cellulolytic activity, dinitrosalicylic acid, carboxymethyl cellulose (CMC), 16S rRNA Gene Sequencing.

A Comprehensive Review of the Status of Green Construction in Pakistan

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Abstract—Depletion of natural resources is leading to environmental degradation. Furthermore, economic growth is also a growing concern in today's world. The aforementioned concern has forced countries across the globe to pursue sustainable practices such as the Green Building concept and Technologies. Pakistan like every other developing country is facing environmental and economic worries. Despite the increasing trend of following sustainable development across the world, very little effort has been made by Pakistan regarding following sustainable practices such as green building construction. This research study is an effort to review the comprehensive status of Green Construction in Pakistan. The study was divided into four phases i.e., a compilation of the existing practices related to green construction in Pakistan, determining the reason behind the slowly progressing green construction industry in Pakistan, a comparative analysis of the different types of bricks used in green construction, evaluating Telenor headquarter according to LEED as a case study. The methodology used in this research comprised of literature review, field visits, interviews with stakeholders, and the utilization of the LEED tool to evaluate the sustainability of buildings. The research study focuses on the progress and efforts being

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carried out in Pakistan regarding green construction and the reasons behind the slow progress. Government policies, the involvement of policymakers, professionals, and society at large can help bridge the gap and make the industry more effective and thus contributing towards sustainable development.

Keywords—Sustainable Development, Sustainable Development Goals (SDGs), LEED and Green Construction

A Comprehensive Screening of Toxic Heavy Metals in the Water of FATA (Pakistan)

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Abstract—Water adulteration is one of the serious concerns in Pakistan. Among 122 nations Pakistan is positioned at number 80 in order to provide water for drinking purposes. Water reservoirs including surface and groundwater are adulterated with toxic metals throughout the country. The acceptable limit set by World Health Organization (WHO), and Pakistan Environmental Protection Agency (Pak EPA), Health risk indicators are the Chronic Daily Intake (CDI) and the Health Risk Index (HRI) is consistently contravened. The main origin of heavy metals is industrial discharge, disposal of municipal waste, and use of agrochemicals are the main sources of water adulteration. This review discusses a brief layout of toxic heavy metals in water in Federally Administered Tribal Areas (FATA)Pakistan with a special insistence on heavy metal contamination. The data assembled in this review are obtained from different research articles published in national and international journals on toxic heavy metals in the particular region. Toxic heavy metals that as copper (Cu), cadmium (Cd), chromium (Cr), lead (Pb), nickel (Ni), (Fe) Iron, and manganese (Mn) are the most significant hazardous contaminants in different regions of FATA(Pakistan). The accumulation of heavy metals in the water reservoirs causes serious health risks to all living beings. This review is on the heavy metal in the water of different areas of FATA(Pakistan) in the past few years. The levels of heavy metal adulteration in different water sources were collected from various regions of FATA agencies. The research articles of respective authors helped to determine the heavy metal concentration mentioned in the standard literature. The determined concentration of some heavy metals was found safe mentioned by organizations that as WHO, USEPA, EUC, and EPA. The aim of this review paper is to study the concentration of heavy metals in water sources of FATA (Pakistan).

Keywords— Toxic Heavy metals, water quality, FATA, industrial effluent, PTEs, Risk assessment, water adulteration

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Automated procedure of real-time flood forecasting in data-scare Swat River basin, Pakistan by SWAT and HEC-RAS models

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Abstract—This study addresses the critical need for precise flood forecasting and enhancing early warning systems to manage floods. Such precise and reliable simulations incorporating hydrologic and hydraulic processes will improve in-flood forecasting and warning system. The proposed study combines different tools: a hydrological model (Soil and Water Assessment Tool, SWAT) that simulates rainfall and runoff, and a hydraulic model (Hydrologic Engineering Center-River Analysis System, HEC-RAS) that uses 1-D saint Venant Equation to assesses river flow mainly flood plain determination. These models work together in real-time, supported by data from weather stations and stream gauges, and are displayed on a web platform for easy access. An automated procedure was developed for linking dynamically terrestrial rainfall-runoff processes and river hydraulics by coupling the SWAT and the HEC-RAS models. The system is tested in the SWAT river basin, Khyber Pakhtunkhwa province, Pakistan due to extreme rainfall events, frequent and high vulnerability to flooding. The results showed a strong correlation between the predicted and actual stream flow over a twenty three-year period(R^2=0.95). Overall, the study demonstrates that this system is a reliable tool for flood forecasting with dependable computational efficiency of less than 30 minutes' processing time Overall, the study demonstrates that this system is a reliable tool for flood forecasting. Some of the practical applications of our research include Early warning system, Floodplain management, Water resource management.

Keywords— flood forecasting, HEC-RAS model, real time simulation. and SWAT

Energy-Water Nexus for sustainability: A case study for Karachi focusing on Solar PV potential

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Abstract—Karachi's rapid urbanization as well as industrialization is putting pressure on natural resources. Hence making energy and freshwater availability quite challenging. This study deals with freshwater scarcity owing to freshwater consumed during the cooling processes by Thermoelectric Power Plants (TEPP) in Karachi, the biggest metropolitan in Pakistan. Key factors influencing Solar Photovoltaics (PV) power potential are identified, including temperature, dust, tilt angle, precipitation, and wind speed. For a case study, Tapal Power plant power is considered in the study. It generates 126 MW of power and uses approximately 0.39Millions gallons per day (MGD) freshwater from Hub River for cooling purposes. Power plant is spread over an area of approximately 20 acres. After calculating meteorological corrections for Solar PV in Karachi, annual energy generation per unit area (m2) of polycrystalline solar panel is calculated as 361.35kWh. While, total yearly production of Tapal Power Plant is 1.1*109kWh This means, it requires 735 acres of land (identified nearby) to replace TEPP while producing

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solar energy from a solar park. Water scarcity in Karachi is estimated at 350 MGD. Replacing thermal power production with solar power could save around 0.4 MGD of water. While this would help provide water for the population, approximately 10,000 people. By addressing these challenges, this study contributes to sustainable practices, alleviates renewable energy, water scarcity in Karachi, and informs policy decisions for a resilient energy-water nexus.

Keywords—Energy-Water Nexus, energy demand, Karachi, sustainability, thermo electric powerplants and water scarcity.

2D Structural Interpretation Integrated with Petrophysics, Attribute Analysis, and Seismic Inversion of Rajian Area Upper Indus Basin, Pakistan

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Abstract—The Rajian Oil field, situated in the Eastern Potwar Basin, is considered the main target for a source of hydrocarbons in the Potwar Sub Basin. This under-discussed study focuses on the interpretation, petrophysical analysis, and seismic attributes of hydrocarbons derived from seismic and well-log data. The study utilized SEG-Y seismic data from lines QZN-07 and QZN-09, as well as log data in LAS format from the Qazian-01 well, provided by the Directorate General of Petroleum Concession (DGPC). The study area is a part of the Potwar sub-basin, well known for its hydrocarbon (oil and gas) structural traps. The Rajian field is located approximately 60 km southeast of Islamabad and was discovered in 1994 by OGDC. It has been in regular production since 1994. Two reverse faults F1and F2 were marked on given sections. Time and depth contour maps were prepared at a specific level to analyze variations based on time and depth. Structural modelling of the interpreted digital geological cross-section was performed using SMT Kingdom software. Petrophysics is one of the most reliable tools for confirming the types of hydrocarbons and determining the proper zones of interest for the presence of hydrocarbons by combining different log results. In this regard, petrophysical analysis was conducted on the QAZIAN-01 well, and different zones were marked where there is a chance of hydrocarbon presence. Data was transformed to the acoustic impedance domain using an accurate seismic-to-well tie and background impedance model.

Keywords— Rajian Oil Field, Eastern Potwar Basin, hydrocarbons, Potwar Sub Basin

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ABSTRACTS FOR POSTER PRESENTATIONS

Chemically synthesized manganese oxide nanorods for effectual organic dye removal and energy storage application.

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Abstract—A simple chemical co-precipitation and reflux-assisted co-precipitation approach with different annealing temperatures and reflux times, respectively, are successfully used to synthesize manganese oxide nanoparticles (MnO2). XRD, FTIR spectra, UV-Visible spectroscopy, Thermogravimetric Analysis are used to examine the structural, optical, and thermal properties of the synthesized samples. The prepared samples' average crystallite sizes, fall between 6–8 nm and 6–7 nm for the reflux-assisted approach and 15–30 nm and 20–46 nm for the co-precipitation method, respectively. The FTIR spectra revealed peaks connected to Mn-O bonds, which validated the production of MnO2 nanoparticles. The nanorod-type morphologies of the materials were revealed by FESEM tests. The environmentally sustain method of photocatalysis has shown promise in replacing traditional methods for the degradation of various organic contaminants. The synthesized material shows significant photocatalytic degradation of 82 % brilliant green dye.

Keywords—Mn oxide nanoparticle, Co-precipitation, Photocatalytic degradation, Brilliant green dye

Plant Based bioactive compounds and their Role in diabetes management

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Abstract—Herbal medicine, known for its extensive use in treating various diseases, has a long history dating back to Mesopotamia around 2600 B.C. Medicinal plants remain integral to modern medicine, with about a quarter of prescription drugs derived from plants. The herbal product market is growing significantly due to increasing consumer interest. Herbal medicine, a key component of complementary and alternative medicine (CAM), offers an effective and sustainable alternative to conventional therapies. This article explores herbal treatments for diabetes, summarizing extensive research on their efficacy and potential. Diabetes mellitus (DM) is a complex metabolic disorder with prolonged high blood glucose levels due to insufficient insulin. Plant-derived bioactive compounds, such as terpenes, tannins, flavonoids, saponins, and alkaloids, have shown promising anti-diabetic properties with minimal toxicity. These compounds work through mechanisms like inhibiting digestive enzymes, mimicking insulin, reducing oxidative stress, and enhancing glucose uptake and insulin secretion, making them valuable for future diabetes treatments. Herbal medicine, with its long history in treating and preventing diseases including diabetes, offers potential in managing hyperglycemia and its complications through various natural remedies. This article examines the blood glucose-lowering mechanisms of these herbal treatments and highlights marketed herbal products for diabetes management.

Keywords—Medicinal plants, Diabetes, Natural Plants, Herbal Medicines, Bioactive compounds.

Modified the Structure of Co-Doped Hydroxyapatite Nanoparticles for the Treatment of Methylene Blue Containing Waste Water

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Abstract—Methylene blue is most commonly used in a variety of colors for anthropogenic activities, colouring, printing, silk, plastics, food, textile, tannery, cosmetics, and paper industries. Methylene blue dye have several negative effects on the environment and human health, like irritation of the skin etc. Finding efficient ways to remove synthetic dyes from wastewater, including Methylene Blue, has produced innovative techniques using advanced substances. In order to improve the removal of Methylene Blue from contaminated water, we sintered the cobalt (Co)-doped hydroxyapatite (HAP) nanoparticles using hydrothermal method. Scanning electron microscopy (SEM) and X-ray diffraction (XRD) were used to identify the modifications of the surface properties, morphology, and crystal structure brought about by cobalt doping. Results of our research indicated that the Co-doped HAP nanoparticles showed significant efficiency for adsorption of Methylene blue. It showed that improved structure of the Co-doped HAP nanoparticles contributed to their increased efficacy during the purification of wastewater polluted with MB. The results of this research provide new horizons in the removal of toxic dyes like Methylene Blue from contaminated water.

Keywords—cobalt doped hydroxyapatite, wastewater, dye, methylene blue, nanoparticles.

Electrochemical Studies of Cadmium Sulfide Based Nanoparticles

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Abstract—CdS nanoparticles are renowned for their distinctive electrochemical characteristics, which are crucial for advancements in solar cells and photocatalytic systems. For the first time, we prepared the Pb2+, Cu2+ co-doped CdS nanoparticles that were prepared by a simple chemical precipitated method. Structural and lattice parameters were determined by XRD. It was found that mixed cubic-hexagonal crystal structure for the co-doped nanoparticles. Polyvinylpyrrolidone (PVP) was used as a surfactant to control particle size. The organic functional group's presence in the surfactant was identified by FT-IR. Two distinct morphologies were found for the co-doped sample that was studied by TEM. CV analysis was used to determine the potential window of oxidation and reduction of the sample. In addition, We found that the excellent electrochemical properties of the co-doped CdS nanoparticles can be used for electrochemical energy storage applications.

Keywords—CdS nanoparticles, Co-doping, Crystal structure, Particle size control, Electrochemical properties, Energy storage applications

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Recent Trends in Electro Catalytic Activity on Barium Based Nanoparticle

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Abstract—This study focuses on the comprehensive electro-catalytic activity of Barium Oxide Nanoparticles (BaO-NPs) synthesized via a cost-effective co-precipitation method. Emphasis is placed on the nanoparticles' catalytic efficiency, particularly in oxygen reduction reactions (ORR) which are crucial for energy conversion technologies. The electro-catalytic performance of BaO-NPs was extensively studied, revealing their high activity and stability. The large surface area, high crystallinity, and uniform particle size distribution significantly contributed to their superior electro-catalytic properties. In ORR, BaO-NPs demonstrated remarkable efficiency by facilitating the four-electron reduction pathway, which is essential for enhancing the performance of fuel cells and metal-air batteries. These attributes highlight the potential of BaO-NPs in improving the efficiency and durability of electrochemical devices. The mechanisms underlying the electro-catalytic processes were thoroughly analyzed, with a focus on the interaction of BaO-NPs with reactant molecules and the role of surface properties in enhancing reaction kinetics. The findings underscore the potential of BaO-NPs as efficient and cost-effective catalysts for large-scale applications in energy conversion and storage, paving the way for advancements in sustainable and renewable energy technologies. The electro-catalytic activity of BaO-NPs was extensively studied, highlighting their efficiency and potential in catalysis. The large surface area, high crystallinity, and uniform particle size distribution contributed to their superior electro-catalytic performance. The study delvep into the mechanisms underlying the electro-catalytic processes, emphasizing the role of BaO- NPs in enhancing reaction rates and improving overall efficiency. The cost-effective synthesis method, combined with the high performance of BaO-NPs, positions them as promising can idates for large-scale applications in energy conversion and storage, environmental remediation, and other industrial processes. This review aims to provide a comprehensive understanding of the electro-catalytic activity of BaO-NPs, paving the way for future research and development in this field.

Keywords—catalytic activity, nanotechnology, renewable energy. Oxidation reduction reaction

Polymeric Nano-Emulsion in Functional Textile Finishing

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Abstract—Advancements in nanotechnology have transformed textile finishing, a process that adds functional properties to textiles for enhanced comfort. Modern textile manufacturers aim to produce smart, functional textiles with features like antifouling, anti-wrinkle, water-repellent, and flame-retardant properties to ensure consumer safety and well-being. Nano-emulsions play a key role in creating these advanced finishes using natural and synthetic polymers on fibers like cotton, wool, and polyester. This innovation not only enhances the inherent qualities of textiles but also boosts the economic growth of the functional textile market.

Keywords-, Nanoparticles, Drug Loading, Drug Delivery, Nano-Emulsion

Synthesis and Biological Application of Titanium Doped Hydroxyapatite

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Abstract—Infectious diseases are becoming difficult to treat due to antimicrobial resistance in pathogens. Hydroxyapatite (HAp) is considered important for medical uses because it can break down naturally. It is compatible with living tissues and promotes biological activity. The incorporation of metal nanoparticles in HAp can improve the absorption property in visible light which in turn can boost the efficiency of ROS formation resulting in the antimicrobial effect. The aim of current work was to synthesize and characterize Titanium doped Hydroxyapatite for biological applications like antibacterial properties. Ti-HAp nanocomposites were prepared by hydrothermal method. UV Visible spectrophotometry, Fourier Transform Infrared spectroscopy, Scanning Electron Microscopy and X-ray diffraction were used to check the structural properties of Ti-HAp nanocomposites. Antibacterial activity was checked by Disc Diffusion method. Our results revealed that Ti- HAp nanoparticles showed good antibacterial activity against Staphylococcus aureus and Escherichia coli. The antimicrobial effects of Ti-HAp nanocomposites will be helpful in treating the infections resistant to standard antibiotics.

Keywords—antibacterial, Titanium, nanoparticles, Hydroxyapatite, Antibacterial

A Study on Carbonaceous Material for Efficient Removal of Chromium

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Abstract—Heavy metals like Arsenic, Lead and Chromium released as a result of rapid industrialization have detrimental effects on the health of humans, animals, as well as plants. Wastewater from numerous industries like leather tanning, textile dyeing and printing contain harmful levels of chromium, which cause respiratory disorders, renal and hepatic damage. A bio adsorbent was prepared from crushed ovules of Phoenix dactylifera. SEM analysis of the prepared bio adsorbent revealed its porous nature while XRD and FTIR were employed the physical properties and functional groups. Atomic absorption spectrophotometry was used to check its efficiency. In this study varying concentrations of bio adsorbent were checked against 60 ppm chromium. The results revealed that more than 90% of chromium was effectively removed using the prepared bio adsorbent. This study will pave a way for the proper treatment and disposal of industrial wastewater.

Keywords—bioadsorption, chromium, heavy metal removal, activated carbon

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Synthesis and Biological Application of Aluminium Doped Hydroxyapatite

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Abstract—In recent years, the rapid surge in drug-resistant infections involving viruses, fungi and bacteria has emerged as a significant global health concern. Nanotechnology has established a robust foundation for creating antibiotic alternatives to combat bacterial infections. The metal nanocomposites have good antimicrobial activity due to their small size. The aim of present work was to synthesize and characterize Aluminium (Al) doped Hydroxyapatite (HAp) for biological applications like antibacterial properties. The Hydrothermal method was deployed to synthesize Al-HAp nanocomposites. The characterization of Al-HAp nanocomposites was done by Fourier Transform infrared spectroscopy, X-ray diffraction, Scanning Electron Microscopy and UV Vis spectrophotometry. Disc Diffusion method was used to determine antibacterial activity. Our results revealed that Al- HAp nanoparticles showed good antibacterial activity against Staphylococcus aureus and Escherichia coli. The results of this study will be utilized for the clinical applications of Al- HAp in treatment of bacterial infections resistant to other antimicrobial agents.

Keywords— Aluminium, nanocomposites, hydroxyapatite, antimicrobial, resistant

Decreased Serum Paraoxonase 1 Activity in Cardiac Patients with Diabetes Type 1.

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Abstract—Antioxidant properties are reportedly present in paraoxonase 1. Paraoxonase 1 has a role in the pathophysiology of several diseases, including atherosclerosis; and it prevents the oxidation of low-density lipoprotein (LDL) and high-density lipoprotein (HDL). The present study was aim to evaluated the level of paraoxonase 1 in cardiac patients with diabetes type 1 and effects of medication on serum level of these patients. Equal number of cases (n = 100) and control participants (n = 100) were taken in this case-control study. Blood samples were collected and serum was separated. Spectrophotometry was used to measure paraoxonase 1 activity. Paraoxonase 1 concentration and activity were both markedly reduced in patients by 19·2% and 16·7%, respectively. Our findings indicated a remarkable lower level of serum paraoxonase 1 in patients. There is evidence that some medications, food items, and lifestyle choices raise paraoxonase 1 activity.

Keywords—paraoxonase 1, atherosclerosis, spectrophotometry

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Biosynthesis of copper nanoparticles using Solenostemma argel and their effect on enhancing salt tolerance in barley plants

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Abstract—Salinity stress is a significant environmental challenge that adversely affects agricultural productivity, especially in arid and semiarid regions. Salt stress impacts approximately 50% of irrigated land and about 20% of global cropland, leading to severe reductions in crop growth and yield. To address this issue, this article gives an innovative approach to enhance salt tolerance in barley plants through the biosynthesis of copper nanoparticles (CuNPs) using Solenostemma argel. Copper (II) sulfatepenta hydrate ($CuSO_4·5H_2O$) was used as the precursor for CuNP synthesis. Solenostemma argel, a medicinal plant known for its rich phytochemical profile, served as the reducing agent in the green synthesis process. The plant material was prepared by boiling dried leaves in deionized water, followed by mixing the extract with a copper sulfate solution. The formation of CuNPs was confirmed by a color change in the solution. Methodology involved the biosynthesized CuNPs were characterized using UV–Vis spectroscopy, XRD, FTIR, and TEM to determine their size, shape, and crystalline structure. Barley seeds were planted in controlled conditions and exposed to different levels of salt (0, 100, and 200 Mm NaCl) and CuNPs (0, 25, and 50 mg/L). Growth parameters, gas exchange, and biochemical responses were measured to assess the impact of CuNPs on salt-stressed barley plants.As a result, findings demonstrated that CuNPs significantly improved salt tolerance in barley plants. Application of CuNPs reduced oxidative damage and electrolyte leakage while enhancing growth, photosynthetic pigments, and antioxidant enzyme activities. This study presents a sustainable strategy to enhance plant resistance to salinity stress, potentially improving agricultural productivity in saline-affected regions. These findings suggest that integrating nanotechnology in agriculture could revolutionize stress management strategies, improving crop productivity and sustainability in saline environments.

Keywords— CuO nanoparticles, Biosynthesis, Copper(II) sulfatepenta hydrate, Solenostemma argel, Green synthesis, Cytotoxicity, salinity stress

Cellulose Acetate based Membranes Incorporated with Inorganic Salts for CO2 Capturing

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Abstract—CO_2 emission resulting from rapid urbanization and industrialization is a significant contributor to global climate change, arising from conventional fuels combustion such as oil, fossil gas, petroleum and coal. Membrane technology is a promising solution for CO_2 sequestration due to the fundamental engineering and cost effectiveness over challenging separation techniques. A novel membrane design is developed by fabrication of Cellulose Acetate polymer matrix with Inorganic salts to enhance CO_2 separation from mixed gas streams. Experimental results demonstrate good CO_2 permeation performance of synthesized Polymer-Inorganic blended

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membranes. The proposed Membrane Technology offers a promising solution for CO_2 capture with potential applications in power plants, industrial processes, and Carbon Capture Utilization and Storage systems (CCUS).

Enhancing the Shelf Life of Perishable Foods with Biodegradable Films and Coatings

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Abstract—The development of the safety and quality of minimally processed foods is of great interest to both consumers and the food industry. The demand for food supplies must urgently be expanded to meet the needs of future generations, as the world's population is projected to exceed ten billion by the year 2050. Preventing food loss in the post-harvest phase is proving to be a crucial aspect in maintaining global food security. To prolong the shelf life of food products, active edible coatings have the potential to slow down the decay of non or minimally processed food items. In the current study we have reported the manufacture, characterization and the application of edible biofilm to increase the shelf life of unprocessed chicken meat. Three coatings with different compositions were prepared: protein and glycerol in a 1:1 ratio, protein and glycerol in a 2:1 ratio, and a mixture of protein, glycerol, and gelatin. Raw chicken meat is treated with a single coat, double coat, triple coat, and a control group. Coated chicken samples were stored in the fridge and at room temperature for three days, and results are recorded daily. Coated chicken stored in the fridge retains its quality and safety longer than those kept at room temperature, which exhibit rapid spoilage and microbial growth. The bio coating has shown excellent properties to retain antioxidants, flavors, colors, nutritional supplements, and aroma. It is concluded that protein-based coating can be quite advantageous as preserving materials because have the potential to extend the shelf-life of food products by decreasing their respiration rates, and exhibit better results as compared to other biopolymeric packaging.

Keywords- Edible coatings, minimally processed food, Biodegradable packaging, Food safety, Food quality, Food shelf life.

Exploring the antibacterial Potential of Gabapentin Sulphonamide Analogues: Synthesis and Characterization

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Abstract—Gabapentin Sulfonamide (2-(1-((4-methylphenylsulfonamido) methyl) cyclohexyl acetic acid) (3F) and their novel derivatives were synthesized. Gabapentin (1F) reacted with other reactant 4-methyl benzenesulphonyl chloride (C7H7ClO2S) (2F) in the presence of 10% Na2CO3 to synthesize the 2-(1-((4-methylphenylsulfonamido) methyl) cyclohexyl acetic acid (3F). This product (3F) was applied more for the preparation of derivatives of Gabapentin sulfonamide upon reaction with a series of organic alkyl/aralkyl halides by the application of base LiH and solvent DMF. Synthesized compounds were checked for their antibacterial activity by using various strains of bacteria including *Escherichia Coli, Streptococcus faecalis, S. typhi, Staphylococcus aureus* and *Pseudomonas*

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aeruginosa which showed excellent inhibited activity. Among the bacterial species, the compounds 5Fb and 5Fc have outstanding antibacterial activity for Pseudomomas aeruginosa (-) ATCC 14502 with zone of inhibition comparable with control drug (MIC 12.18). All the compounds were moderately to low active against the S. typhi. Structures of all the derivatives was confirmed by using UV- visible, IR, 1H-NMR and mass spectrometry.

Keywords— (2-(1-((4-methylphenylsulfonamido) methyl) cyclohexyl, Gabapentin, 4-methyl Benzene Sulfonylchloride, antibacterial activity

Development and characterization of dual substituted (K+ AND NO3-) Calcium Phosphate nanofertilzers:

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Abstract—Fertilizers are widely used to supply essential nutrients to crops. These essential nutrients are nitrogen, phosphorus and potassium. However, their excessive use can damage soil health and also environment. Calcium phosphate in the form of hydroxyapatite (CaP- HA) is considered as a promising alternate due to its ability to provide sustained nutrients release. This study aims to develop calcium phosphate urea-based Nano fertilizer, characterized by advanced techniques to enhance plant growth and address nutrient deficiency in soil. Nano-hydroxyapatite was synthesized by co-precipitation using calcium carbonate and orthophosphoric acid with potassium nitrate for ion substitution. The resulting Nano fertilizer was dried, milled and characterized by XRD, XRF, SEM and electron microscopy. X-Ray Fluorescence was used to determine elemental composition by analyzing the atomic energies emitted after heating the sample to 10500C. FTIR identify functional group by observing molecular vibrations in infrared region. Field Emission Scanning Electron Microscopy provides detail about surface morphology after sputtering the sample with Au to enhance conductivity and image quality. The impact of calcium phosphate urea Nano fertilizer NKHA on folia growth of tomato plant and bell pepper was checked for over 28days. The NKHA was synthesized, characterized and tested in soil with 2, 4, and 6g of NKHA. Observations showed no significant growth in the first week. By day 14, plants treated with 6 g NKHA exhibited increased folia growth compared to those treated with 2 and 4 g. Results indicated that 6g of NKHA enhanced folia growth and yield as compared to lower amount. 6 g NKHA demonstrated the most robust growth enhancement, with bell peppers showing more consistent growth compared to tomatoes. So NKHA could be promising alternate to commercial fertilizers for improving plant growth.

Keywords—Nano fertilizer, co-precipitation, morphology

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Performance of polyaniline doping induced active surface area of *Moringa olifera* for heavy metal removal from wastewater

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Abstract—This study explores the synthesis of a polyaniline (PANI) and Moringa oleifera (MO) nanocomposite for enhanced heavy metal removal from wastewater. The PANI/MO composite's adsorption efficiency for Cu^{2+} and Pb^{2+} ions was investigated, showing promising results due to the material's functional groups and surface modifications. The study synthesized a polyaniline-coated Moringa oleifera composite using oxidative polymerization for heavy metal removal from wastewater. Wastewater samples were collected and analyzed using acid digestion, followed by the characterization of the composite through UV-Vis, FTIR, XRD, SEM, and electrical conductivity techniques. The composite demonstrated effective adsorption properties for Cu^{2+} and Pb^{2+} ions. The characterization involved UV-Vis spectroscopy to measure Cu^{2+} and Pb^{2+} concentrations in wastewater and dye stability tests for stability. FTIR was used to identify functional groups in MO, PANI, and PANI/MO, while XRD analyzed the crystalline structure. SEM provided surface morphology details, and electrical conductivity of the composite was measured using a conductometer. The characterization of MO, PANI, and PANI/MO involved SEM to observe surface morphology, FTIR for functional group analysis, and XRD for crystallinity and structure. UV-Vis spectroscopy measured optical properties and band gaps, while electrical conductivity studies confirmed the semiconducting nature of PANI/MO composites. The adsorption of Cu^{2+} and Pb^{2+} on PANI/Moringa oleifera composite is optimized at higher temperatures, pH 4-6, increased adsorbent dose, and lower initial metal concentrations. The process involves chemical coordination, electrostatic interactions, ion exchange, and complexation, enhanced by the composite's porous structure. Kinetics are best described by the pseudo-second-order model, with intraparticle diffusion acting as a rate-limiting step. The PANI/Moringa oleifera composite demonstrated excellent adsorption capacity for Cu^{2+} (10.01 mg/g) and Pb^{2+} (23.01 mg/g), achieving 99% and 97.77% removal efficiency under optimal conditions. The composite's enhanced performance is attributed to its functional groups, electronic interactions, and structural properties, making it a promising material for wastewater treatment.

Keywords—*Polyaniline (PANI) , Moringa oleifera (MO) , Nanocomposite , Heavy metal removal , Wastewater treatment , Adsorption*

Assessment of Antibacterial Spectrum of Female Autoimmune Patients' Serum

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Abstract—Autoimmune diseases, which are defined by the immune system's abnormal attack on its tissues, may significantly impact the natural defense mechanisms of the body, including antibacterial responses. The antibacterial activity of autoimmune patient serum is centered on the presence of anti-microbial antibodies found in individuals with autoimmune conditions, indicating a breakdown in the ability of natural immune system to eliminate microbial threats. The present study was aim to find out the effect of autoimmune disorders on the antimicrobial potential of patients' serum. Serum samples are collected from a wide range of female patients with autoimmune diseases, including Type 1 diabetes, rheumatoid arthritis, and lupus. The serum is evaluated for their antibacterial activity by using the agar well diffusion method against both Gram-positive and Gram-negative pathogenic bacteria. Serum from lupus patients who tested positive for Antinuclear Antibody test showed strong antibacterial effect against Salmonella typhi, with a larger inhibition zone (3.2 mm). Our results showed that the antibacterial activity of autoimmune patients' serum was higher than normal control population.

Keywords—autoimmune disease, antibacterial, serum, Antinuclear Antibody test

A Study on Antibacterial Properties of *Solanum surattense* Fruit Extracts

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Abstract— The objective of the present study was to evaluate the antibacterial potential of fruit extracts of Solanum surattense. Common name of Solanum surattense is Spiny nightshade and Yellow fruited nightshade. In this study, different bacterial strains (n=50) were used i.e. *Staphylococcus aureus, Bacillus subtilis, Escherichia coli, Micrococcus luteus, Klebsiella pneumoniae, Staphylococcus epidermidis, Streptococcus pyogenes* and *Enterococcus faecalis*. Antimicrobial susceptibility of these bacteria was checked against antibiotics and fruit extracts (i.e. Methanolic, Ethanolic, Chloroform, Acetonic, and Aqueous). Most of the bacterial strains were resistant to antibiotics. According to the results the highest resistance was observed against Rifampin (72%) and lowest against Chloramphenicol (20%). It was concluded that the bacterial strains were mostly resistant against antibiotics; however, fruit extracts of *Solanum surattense* exhibited significant antimicrobial activity against the studied bacterial strains. Aqueous fruit extract of *Solanum surattense* showed highest zone of inhibition (25 mm) for Micrococcus luteus while > 20 mm zone of inhibition was observed in case of 18% of bacteria. It is indicated from the results that *Solanum surattense* can be further explored as a potential source of new antibiotics for the treatment of bacterial infections.

Keywords—Solanum surattense, Rifampin, Chloramphenicol, antibiotics, resistant

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Comprehensive Review: Synthesis and Detailed Characterization of Sulfonamide Derivatives with Potent Biological Activities

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Abstract—Sulfonamides, commonly known as sulfa drugs, are compounds derived from sulfonic acid featuring an amide group (-SO2NH2). These substances hold a pivotal place in medical history as the first systematically used drugs for the prevention and treatment of various diseases. The sulfonamide group (-SO2NH2) imparts significant pharmacological value, as these compounds have been utilized in managing conditions such as leprosy, malaria, diabetes, cancer, and tuberculosis. Beyond their clinical applications, sulfonamides serve as indispensable tools in synthetic chemistry, facilitating the synthesis of a wide range of pharmaceutical agents. They act as foundational elements in drug development, impacting both medicinal and non-medical chemistry. Sulfonamides exhibit a diverse array of pharmacological activities, including antimicrobial, antiviral, antidiabetic, and anticancer properties. The characterization techniques UV/VIS, IR, NMR & EIMS techniques assisted to identify the derivatives. Recent advances in sulfonamide synthesis have led to enhanced methods that improve both the efficiency and safety of these compounds. These developments underscore the continuing relevance and potential of sulfonamide-based drugs in modern medicine. This review highlights the ongoing research in the field, emphasizing the innovative approaches in synthesis, characterization and the expanding therapeutic possibilities of sulfonamides.

Keywords— *Pharmaceutical, Therapeutic agent, Sulfonamide, Spectroscopy, Medicinal chemistry.*

Decomposition of Textile Red Dye by Native Soil Bacteria

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Abstract—The toxicity and longevity of textile dyes are both in aquatic and terrestrial ecosystems, synthetic textile dyes— especially bred dyes—have raised serious concerns about their effects on the environment. The breakdown of textile red dye by a group of naturally occurring soil bacteria is the main subject of the investigation. The soil sample was taken from Taxila dye contaminated area and used it to isolate the bacterial strains, which had spontaneously evolved to break down dye related contaminants. The efficacy of the native bacterial consortia in degrading the textile red dye was evaluated in controlled experiments. Spectrophotometric measurement revealed a significant decrease in dye concentration, with over 85% decolorization at 150ppm. Additional test, High-Performance Liquid Chromatography (HPLC), verified the dye's degradation into less hazardous. It was found that optimal degradation occurred at particular pH values and temperatures, indicating that these parameters may be adjusted to improve the bioremediation process. The study also looked at how flexible the consortium was in different environments, showing that it could be used in a range of polluted location. The results highlight the potential of native soil bacteria to function as a safe and efficient natural remedy for textile dye biodegradation. This strategy not only offers a viable substitute for chemical treatments but also presents a promising way to lessen

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the pollution caused by industrial dyes on the environment. To optimize the method for large-scale applications and investigate the efficacy of the consortium against a wider variety of textile dyes, more research is advised.

Keywords—red dye, soil bacteria, high performance liquid chromatography, Toxicity.

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FULL LENGTH PAPERS

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Investigation of O(6) behavior of [188-204]Hg Isotopes within the IBM-1 Model

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Abstract — In this proceeding, the behavior of even-even [188-204]Hg isotopes within interacting boson model-1 (IBM-1). The energy ratios ($R_{4/2}$) of these isotopes in the ground state bands were analyzed along the isotopic chain. The given Hg isotopes close to O(6) limit according to their energy ratio. The Hamiltonian parameters were fitted by comparing the calculated energy ratios with the experimental ones. The band structure were also investigated by analyzing their $R_L = E(L)/E(2)$ values as a function of angular momenta in the ground state band to see their behavior and we obtained that they show the O(6) behavior.

Keywords— Hg isotopes, energy ratios, O(6) symmetry.

INTRODUCTION

Mercury (Hg) isotopes belong to transitional region including the presence of nuclei with different behavior, such as prolate, oblate, triaxial and spherical shapes especially in their ground-states along isotopic chain. Various studies were performed in the neutron-rich even-even isotopes in Hf-Hg region [1-10]. This region was described within interacting boson model (IBM) formalism [1] and the prolate-oblate shapes appear in the neutron-rich Hf-Hg region for some isotopes according to the experimental data [2]. The systematic study was performed for Hg isotopes within IBM based on a Gogny energy density functional [3] and with configuration mixing [4]. The prolate-oblate transition was studied for 200–204Hg [5] and 180–190Hg isotopes [6] within the transitional IBM Hamiltonian. The properties of 190Hg nucleus were studied within four different formalisms for testing its spherical situation [7]. The shape evolution of 190–200Hg isotopes were studied by obtaining the energy spectrum within the covariant density functional framework [8]. The shape-phase transitions in even–even nuclei including 180–190Hg isotopes were studied to find signature shape coexistence of their ground state band [9]. Deformation of 178−208Hg isotopes were investigated by performing the self-consistent calculations of potential surfaces within the approach based on the Fayans energy density functional [10].

In this proceeding, we focused on the O(6) behavior along even-even 188-204Hg isotopes and IBM-1 was applied to this isotopic chain. First, their energy ratios (R4/2) were analyzed to see their behavior along the chain. Then parameters of model Hamiltonian were fitted by comparing the calculated energy ratios with the experimental ones and the energy levels of the given Hg isotopes were calculated within the IBM-1 model. Later, the band structure was investigated by analyzing the RL ratios in the ground state band of the given isotopes. Obtained results within the IBM-1 calculation were compared with experimental values.

INTERACTING BOSON MODEL-I (IBM-1)

IBM-1 is a useful model for studying the nuclear structure properties of even-even nuclei especially in the medium and heavy mass region [11]. In this model, the low-lying collective properties of given nuclei were described in terms of a system of interacting s-bosons and d-bosons for the angular momenta L=0 and L=2, respectively. IBM-1 is an algebraic model and established on U(6) group. This group has three possible

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subgroups U(5), SU(3), O(6) limits which are called as dynamical symmetries corresponding to the spherical, the axially deformed and γ-unstable shapes, respectively. For the present application multipole form of Hamiltonian was used [12]

$$\hat{H} = \varepsilon\hat{n}_d + a_0\hat{P}^\dagger\hat{P} + a_1\hat{L}^2 + a_2\hat{Q}^2 + a_3\hat{T}_3^2 \qquad \qquad \square\square\square$$

Here, the operators are defined in terms of the creation and annihilation operators of the **s** and **d** bosons as following;

The **d**-boson operator $\qquad\qquad \hat{n}_d = d^\dagger \cdot \tilde{d} \qquad\qquad\qquad\qquad$ (2)

The pairing operator $\qquad\qquad \hat{P} = \frac{1}{2}(\tilde{d}^2 - s^2) \qquad\qquad\qquad$ (3)

The angular momentum operator $\qquad \hat{L} = (d^\dagger \cdot \tilde{d})^1 \qquad\qquad\qquad$ (4)

The quadrupole operator $\qquad \hat{Q} = (d^\dagger \cdot s + s^\dagger \cdot \tilde{d}) + \chi(d^\dagger \cdot \tilde{d})^{(2)} \qquad$ (5)

The octupole operator $\qquad \hat{T}_3 = (d^\dagger \cdot \tilde{d})^{(3)} \qquad\qquad\qquad$ (6)

The constants given in Hamiltonian (1) and in the quadrupole operator (6) are called as free parameters and they can be fitted from the experimental data [13].

RESULTS

In this proceeding, we focused on even-even 188-204Hg isotopes. The proton number of Hg nuclei is 80 closed to magic number 82 and their neutron number change from 108 to 124. Their energy ratios (R4/2) in the ground state bands were analyzed to see their behavior along the isotopic chain.
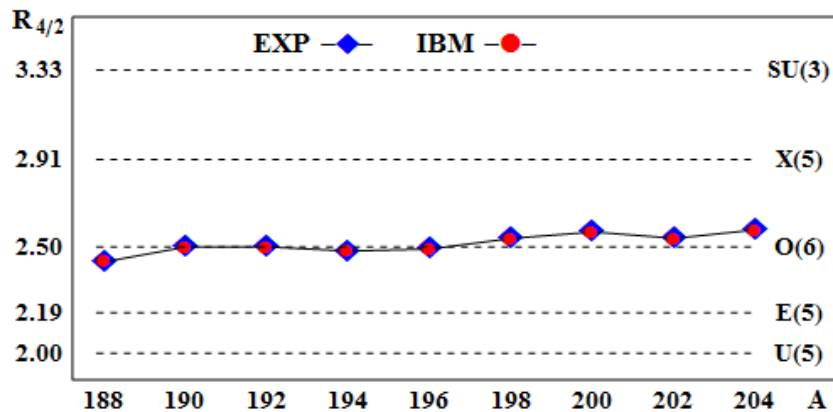
Fig. 1. The experimental (blue) and calculated (red) values of energy ratios for even-even 188-204Hg isotopes.

The values of R4/2 are plotted as function of mass number in Fig. 1 including the typical energy ratios of the U(5), O(6), SU(3) dynamical symmetries and of the E(5), X(5) critical points [14]. As seen Fig. 1, the values of the energy ratios in ground state bands of the given Hg isotopes close to O(6) limit and their shapes tend to be γ-unstable case along isotopic chain. The parameters of the model Hamiltonian (1) were got by fitting from the experimental energy ratios plotted in Fig.1 for even-even 188-204Hg isotopes. As seen this figure, calculated energy levels are almost same with experimental ones. The obtained set of parameters using in PHINT code [15] is listed in Table 1 using to calculate the energy levels each Hg isotope and to analyze their band structure.

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TABLE I. THE PARAMETERS OF MODEL HAMILTONIAN (1). UNITS ARE GIVEN IN MEV. THE NUMBER OF BOSON (N) IS DIMENSIONLESS.

Isotopes	N	EPS (ε)	PAIR (a_0)	ELL (a_1)	QQ (a_2)	OCT (a_3)
^{188}Hg	10	0.0612	-	0.036	-	0.035
^{190}Hg	9	0.00062	-	0.04205	-	0.04134
^{192}Hg	8	0.000572	-	0.0428	-	0.0419
^{194}Hg	7	-	0.00002	0.0411	-	0.0432
^{196}Hg	6	0.0002	-0.001	0.044	-	0.0412
^{198}Hg	5	-0.0071	0.001	0.046	-	0.03946
^{200}Hg	4	-	-0.0009	0.0467	0.0012	0.0315
^{202}Hg	3	-	-	0.0495	0.00046	0.04153
^{204}Hg	2	-	-	0.054	-0.00012	0.0392

Table 1 includes the number of bosons changing from N=10 of ^{188}Hg near to mid-shell region till N=2 of ^{204}Hg closed the doubly-magic ^{208}Pb nucleus. In this table, EPS, PAIR, ELL, QQ, OCT in PHINT refer to ε, a_0, a_1, a_2, a_3 in Hamiltonian (1). The EPS, OCT, ELL parameters were obtained to get better calculated results with experimental data for $^{188-192}$Hg with more bosons while the OCT, ELL, QQ parameters give the better results for light systems with 4, 3, 2 bosons of $^{200-204}$Hg. After fitted parameters, their band structure were investigated by plotting the values of the R_L ratio as function of angular momentum L in the ground state of $^{188-204}$Hg in Fig. 2.

It is really useful to consider the ratios R_L defined by E(L)/E(2) [16] to see the behavior of the nuclei. The experimental and calculated values of R_L ratios are plotted as function of angular momenta for the $^{188-204}$Hg in seen Fig. 2 including the corresponding ratios of the dynamical symmetries; U(5), O(6), SU(3) and of the critical points; E(5), X(5). O(6) limits. As noticed above, the values of $R_{4/2}$ of $^{188-204}$Hg are around 2.5 and closed to the corresponding value of O(6) symmetry. As seen the first panel of Fig. 2, the experimental R_L values of ^{188}Hg isotope follow the E(5) behavior for the angular momenta L=6 and 8 although $R_{L=4}$ is close to value of O(6) symmetry while the all calculated R_L values follow the O(6) behavior. The experimental and calculated R_L values of ^{190}Hg, ^{194}Hg, ^{200}Hg, and ^{202}Hg isotopes follow the O(6) behavior as seen their panels of Fig. 2. The other ^{192}Hg, ^{196}Hg, ^{198}Hg are also follow the same behavior, except that their experimental $R_{L=8}$ values are close to value of E(5) while the calculated ones are exactly same with O(6) symmetry. The last panel of Fig. 2 includes R_L ratios of ^{202}Hg isotope with two bosons and calculated up to 4^+ energy level. This isotope is also show O(6) structure except the experimental $R_{L=4}$ which moves to X(5) critical point. According to the figure, the values of the energy ratios in ground state bands of the given Hg isotopes mostly close to O(6) limit and their shapes tend to be γ-unstable case along isotopic chain.

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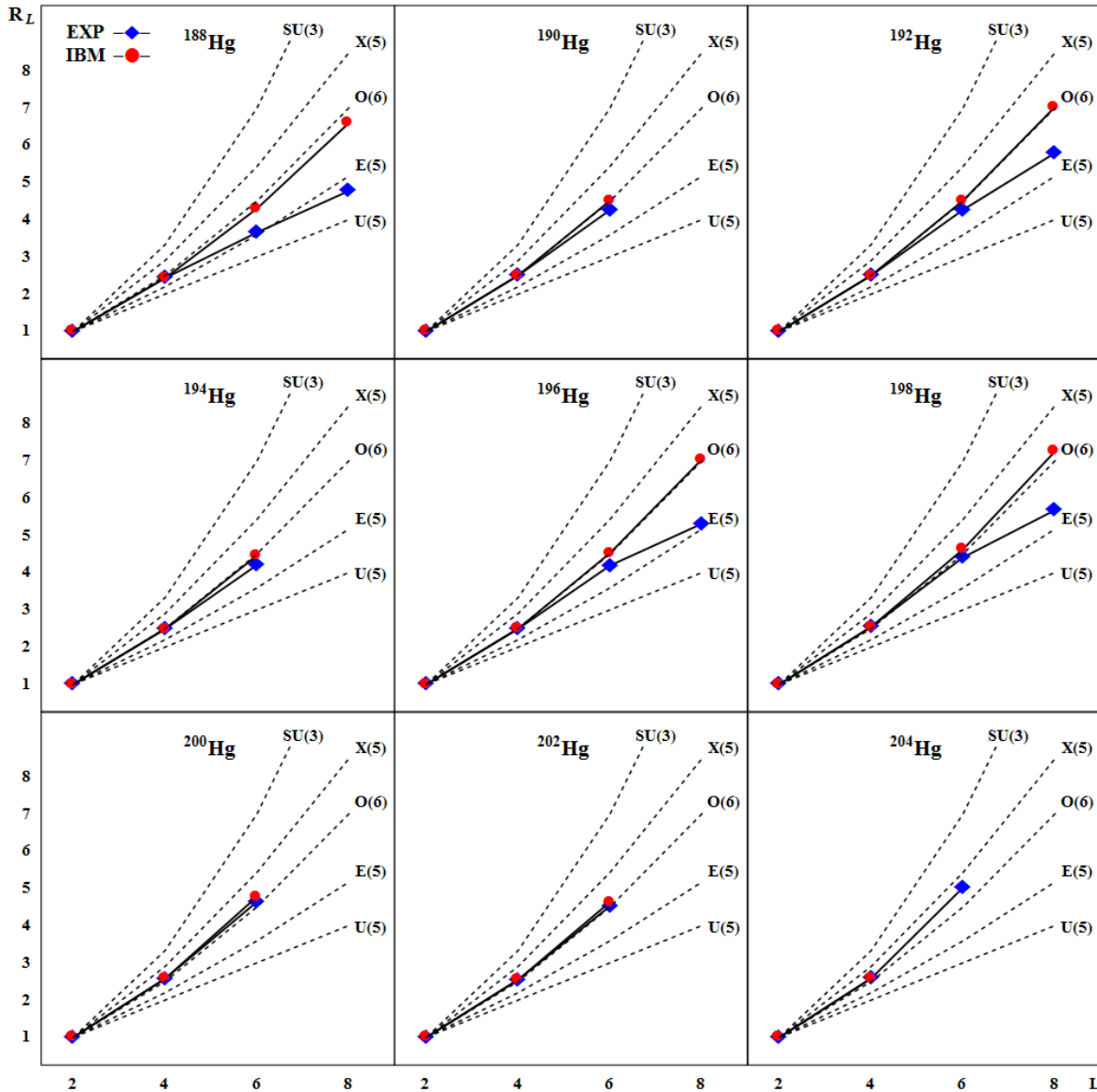

Fig. 2. The R_L ratios of even-even $^{188-204}$Hg isotopes as a function of angular momentum including experimental (blue color) and calculated (red color) values. Each panel includes the corresponding ratios of the dynamical symmetries and the critical points.

CONCLUSION

The O(6) behavior of $^{188-204}$Hg isotopes were investigated in this proceeding. The IBM-1 was applied to along their isotopic chain. The set of Hamiltonian parameters were fitted by comparing the calculated the values of $R_{4/2}$ ratios with the experimental ones. Then the values of the R_L ratios as function of the angular momenta in the ground state band were analyzed to see behavior of the given Hg isotopes. The given even-even Hg isotopes are mostly close to O(6) and they tend to be γ-unstable case according to the values of the energy ratio along

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isotopic chain. The more detail investigation including B(E2) values, the ratios of these values, the energy surfaces are in progress all Hg isotopes along isotopic chain.

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A Comprehensive Review of the Status of Green Construction in Pakistan

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Abstract— Depletion of natural resources is leading to environmental degradation. Furthermore, economic growth is also a growing concern in today's world. The aforementioned concern has forced countries across the globe to pursue sustainable practices such as the Green Building concept and Technologies. Pakistan like every other developing country is facing environmental and economic worries. Despite the increasing trend of following sustainable development across the world, very little effort has been made by Pakistan regarding following sustainable practices such as green building construction. This research study is an effort to review the comprehensive status of Green Construction in Pakistan. The study was divided into four phases i.e., a compilation of the existing practices related to green construction in Pakistan, determining the reason behind the slowly progressing green construction industry in Pakistan, a comparative analysis of the different types of bricks used in green construction, evaluating Telenor headquarter according to Leadership in Energy and Environmental Design (LEED) Rating System as a case study. The methodology used in this research comprised of literature review, field visits, interviews with stakeholders, and the utilization of the LEED tool to evaluate the sustainability of buildings. The research study focuses on the progress and efforts being carried out in Pakistan regarding green construction and the reasons behind the slow progress. Government policies, the involvement of policymakers, professionals, and society at large can help bridge the gap and make the industry more effective and thus contributing towards sustainable development.

Keywords— Sustainable Development, Sustainable Development Goals (SDGs), LEED and Green Construction

INTRODUCTION

The construction industry is a significant contributor to carbon emissions, with buildings accounting for 38% of energy-related emissions, but green buildings can help reduce energy consumption and emissions, creating a healthier and more productive work environment. [1] Green building is a concept that aims to create sustainable buildings that minimizes environmental impact, reduce waste, and promote occupant health and well-being. To achieve this, green buildings incorporate design, construction, and operational strategies that reduce energy consumption, water use, and waste. Some key features of green buildings include using recycled materials, natural light and ventilation, energy-efficient systems, rainwater harvesting, and sustainable transportation options.
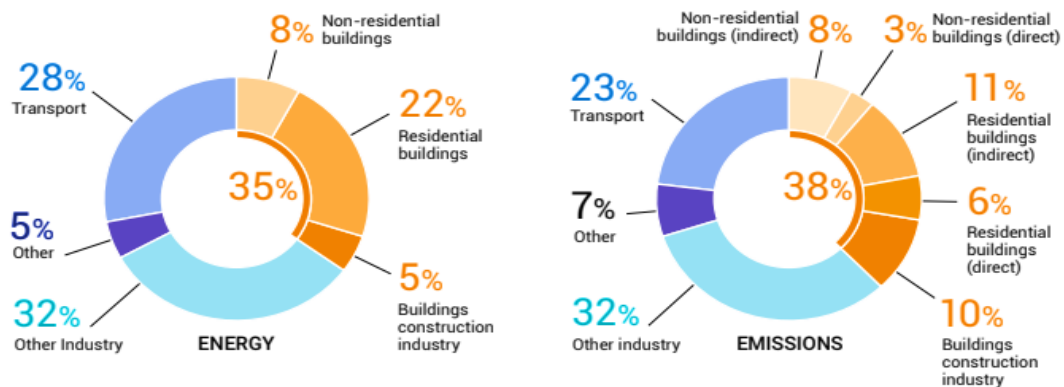

Fig. 1. Global share of building and construction final energy and emission 2019 [1]

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There are several rating systems that evaluate the sustainability of buildings, such as LEED, BREEAM, and Green Star. These provide a framework for design and construction of buildings that meet certain sustainability standards. Pakistan has also started adopting green building practices with the establishment of the Pakistan Green Building Council in 2010. The council promotes sustainable building practices and reduction of environmental impact of construction in Pakistan through training and certification programs, public awareness campaigns, and other initiatives. Overall, green building is an important concept that can help reduce environmental impact, improve occupant health and well-being, and promote sustainability in the construction industry.

LITREATURE REVIEW

Green building is recognized as a crucial aspect of sustainability efforts, addressing environmental, energy, and health concerns. Zuo and Zhao [2] conducted research on defining and scoping green buildings, and exploring approaches to achieve green construction. [3] Several studies have also studied the Environmental Impact of building materials and the importance of sustainable practices. [4][5][6] Rameshravi and Shukla [4] have specifically studied Energy consumption of buildings throughout their life cycle, which includes operational and embodied energy. [3] Green Buildings rely on certified green products with low environmental impact [5] and offer a holistic process that includes interventions across the stages of building construction, from raw material extraction to demolition and waste management. This demonstrates the ability to reduce overall production of emissions from building life cycle, importance of which is highlighted by Rameshravi and Shukla. [4]

Researchers have highlighted the importance of considering regional differences and the need for further research on LEED points' impact. While some countries are making progress in green building guidelines, others are at a developing stage. For instance, India is a notable example, where green buildings have been found to reduce energy consumption by 30-50% compared to traditional buildings. [6] On the other hand, countries like Pakistan are still developing its green building concept. Although some green buildings have been designed as architecture, a focused introduction of green building guidelines for construction in Pakistan can help address energy, water, and waste management problems, making it an important step towards sustainability. [6]

Green Building Certifications offer guidelines for different stages of construction in relation to resource efficiency, environmental impact, and location. [5] Leadership in Energy & Environmental Design (LEED) is one such building certification program developed by the United States of Green Building Council (USGBC) which evaluates buildings and neighbourhoods and has four levels: Certified (40-49 Points); Silver (50-59 points); Gold (60-79 Points); Platinum (80 + Points). [7]

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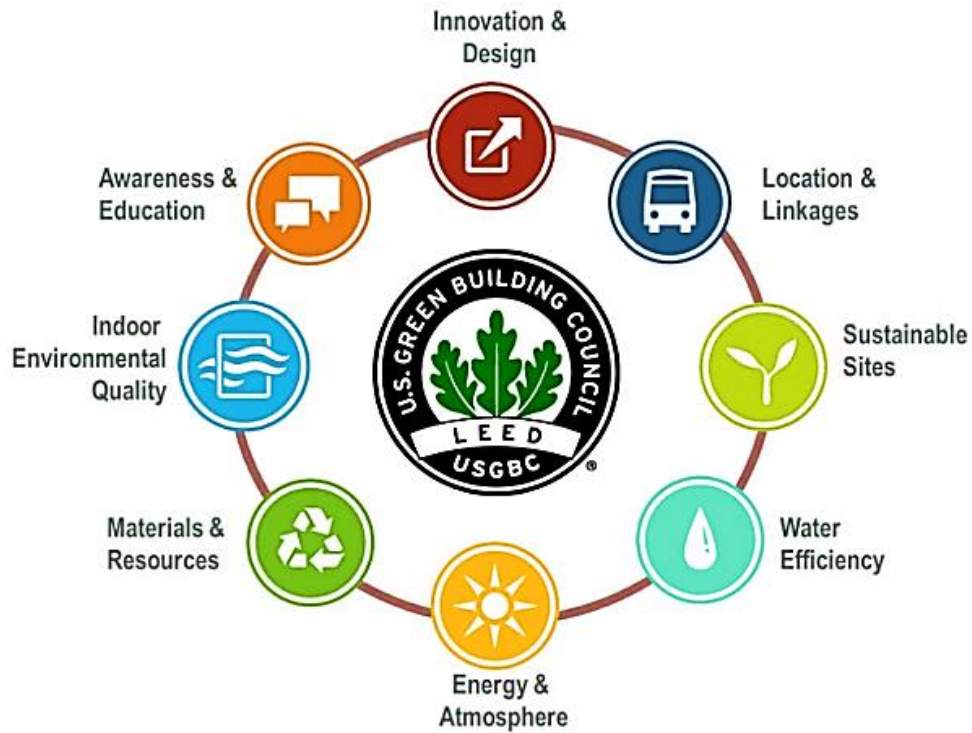**Organized by University of Wah**

Fig. 2.LEED Certification Goals [8]

LEED CERTIFICATION ACTIVITIES IN PAKISTAN

The following table lists some of the LEED certification activities in Pakistan.

TABLE II.   LEED CERTIFICATION ACTIVITIES [9]

Name	Date	Certification Grade
1. Astola Project Getz Pharma Pvt. Ltd. Karachi, Sindh, PK.	2021-04-03	Platinum Certified
2. NKC Agri-Business Building, Mianwali, Punjab, PK.	2021-03-26	Gold Certified
3. Artistic Denim Mill Korangi, Karachi, Sindh, PK.	2021-03-25	Registered
4. Cotton Empire, Karachi, Sindh, PK.	2021-03-25	Registered
5. Style Ralwind 2, Kasur, Punjab, PK.	2021-02-10	Registered
6. Gerrys Dnata Export Warehouse, Lahore, Punjab, PK.	2021-03-05	Registered
7. Mahmood Group Apparel Unit 1, Multan, Punjab, PK.	2021-02-01	Registered
8. MK Sons Pvt. Ltd, Faisalabad, Khurrianwala, Punjab, PK.	2020-08-03	Silver Certified
9. PJ Print Kraft, Faisalabad, Punjab, PK.	2020-08-03	Gold Certified
10. Denim Clothing Unit 12, Karachi, Sindh, PK.	2020-05-18	Gold Certified
11. 11KV MV Switch Rom at Maymaar Grid, Karachi, Sindh, PK.	2020-04-04	Gold Certified
12. Askari Corporate Tower, Lahore, Punjab, PK.	2019-12-19	Gold Certified
13. IFC Office, Islamabad, Islamabad Capital Territory, PK.	2019-12-05	Gold Certified
14. Denim Kind – Scoorty Sustainable Factory, Karachi, Sindh, PK.	2019-10-28	Platinum Certified

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Green Building Certification is gaining popularity globally, with 94% of architects, engineers, and contractors involved in such projects. Client demand and market trends are known to be major drivers, shifting the focus from doing the right thing to a market-driven approach. However, despite the growing demand, only 2% of new buildings have obtained LEED certification. [10]
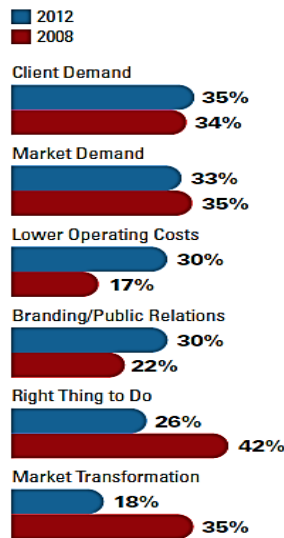
Fig. 3. Top Triggers in Green Building Growth Globally [13]

Status of Green Construction in Pakistan

i.   Recent Progress in the Country

- Green buildings are still in their infancy, but they are gaining popularity. Green buildings covered 5000 square feet in 2014, but currently cover 7 million square feet.
- The household sector consumes 45.9% of annual energy, while the industrial sector consumes 27.5%, primarily for heating, air conditioning, and ventilation.

ii. Sub-Sector Market Growth

- In Pakistan, 79% of the market includes residential structures, while 21% is commercial.
- Warehouses are increasing at a rate of 16.3% faster than the rest of the economy.
- Higher rate of urbanization leading to multi-unit housing is significantly larger than single-family dwellings. Over the next few years, the green market is expected to grow slowly.
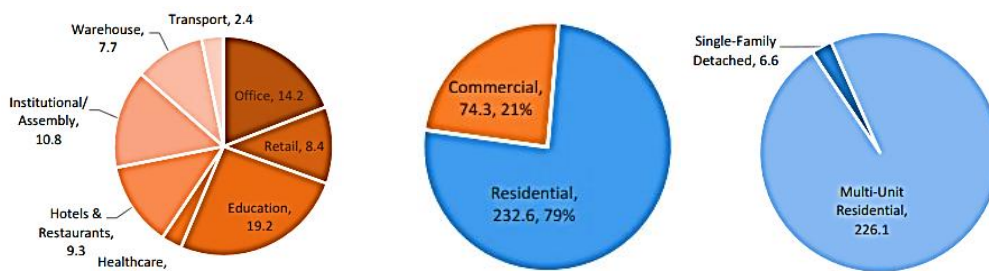
Fig. 4. Total Market Size 2018-25 (USD Billions) [14]

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IMPEDIMENTS IN SUSTAINABLE CONSTRUCTION

Studies have demonstrated the importance of stakeholders in green building adoption. However, in Italy, Umberto Berardi found that stakeholders are hesitant to adopt green technologies due to uncertainty, poor communication, and lack of awareness. [10] To overcome such challenges, a systematic approach is needed to engage stakeholders. Experts have emphasized the importance of understanding stakeholders' agendas and monitoring their performance. To achieve these identifying stakeholders is required to set universal goals, objectives, tasks, priorities.

Research suggests that client and end-users are the most important stakeholders within building projects of Pakistan, and effective communication is key. [13] Conducting stakeholder SWOT analysis can help identify attributes and prevent or mitigate stakeholder conflicts. [14] Other adoption techniques include Unified Theory of Acceptance and Use of Technology (UTAUT) model developed by Venkatesh et. al., 2003 which identifies four (4) motivational elements that affect a person's attitude toward technology adoption. [10]
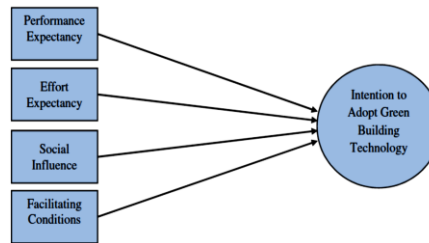
Fig. 5. The Adoption Model of Green Building Technology (AMGBT) [16]

Unfortunately, only 15-20% of urban populations understand the importance of green building, preventing widespread adoption. To address this, governments should invest in infrastructure and regulations, and provide incentives for sustainable construction practices. Additionally, builders must play a key role in reducing energy consumption and promoting renewable energy sources. The following table provides an overview of barriers faced worldwide.
Worldwide Impediments in Sustainable Buildings

TABLE III. WORLDWIDE IMPEDIMENTS IN SUSTAINABLE BUILDINGS [17]

Worldwide Impediments in Sustainable Construction		
Sr.	**Barriers**	**Reference**
1	Lack of credit resources to cover up-front cost; Risk of investment; Lack of training/education in sustainable design/ construction	Miriam L (1999), Milad S (2013)
2	Higher final price; Lack of government support; Lack of professional knowledge	Miriam L (1999), Soheila B (2008), Milad S (2013)
3	Lack of building codes and regulations; Lack of strategy	Milad S (2013), Miriam L (1999)
4	"Green" products not available in my area	Soheila B (2008)
5	Lack of demands; Lack of expertise; Higher investment cost; Lack of incentives; Lack of technology; Lack of database and information	Milad S (2013)
6	Lack of public awareness	Milad S (2013), Soheila B (2008)

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7	Applicability of sustainable design	Hanby (2004)
8	Lack of incentives	Wood (2007)
9	Clerk knowledge of sustainable design; Difficult to obtain financing from banks	Miriam L (1999)

Pakistan is at a developing stage and despite the growing awareness, is currently limited by accessibility to information, technology, funding and knowledge, in addition to lack of communication within project team and commitment from administrative leaders. To overcome challenges, Pakistan needs to identify the top triggers for adoption and develop strategies to overcome obstacles. [10]

METHODOLOGY

The research was conducted across four phases as outlined below.

A. *Phase 01* involved a review of existing status of green buildings worldwide and in Pakistan by compiling the existing efforts present in literature in the form of review paper.

B. *Phase 02* involved determination of obstacles and barriers behind the slowly progressing industry of green construction by using qualitative method of conducting interviews with stakeholders (Plant Owners, etc.) followed by inductive method to analyse interviews to determine obstacles.

C. *Phase 03* involved undertaking a comparative study of the materials used in construction (focused on bricks). This was based on on-campus testing followed by performing economic analysis which was based on information gathered in interviews during site visits.

D. *Phase 04* the final phase involved an attempt to evaluate the Telenor Headquarter 345, Askari Corporate Towers, and University of WAH based on LEED certification standards. This phase was completed by undertaking meeting with the concerned staff, acquiring the desired data through interview and observation, and compiling the score according to LEED rating tool.

GREEN AND CONVENTIONAL BUILDING MATERIALS USED IN PAKISTAN

A. *Green Roof* is a layer of plant materials and waterproofing on top of a building, providing benefits such as absorbing rainwater and reducing heat transfer. It also provides insulation, making it a beneficial feature for the community. [7]

B. *Insulation* can reduce energy costs by lowering the need for heating, ventilation, and air conditioning. In Pakistan, common insulation materials include gypsum board, extruded polystyrene (EPS), polyurethane (PU), low-e windows, and low VOC paint. [7]

C. *Cool Brick* is a new material being experimented within Pakistan, which uses evaporative cooling to lower temperatures. Additionally, a ceramic tile inspired by the "cool brick" concept is being developed to help tiles cool down by using evaporative cooling. [7]

D. *Fly Ash Brick (FAB)* contains fly ash and water, reducing energy needed to produce traditional mud blocks and lowering CO2 emissions. FAB can benefit Pakistan's construction industry, offering more sustainable and energy-efficient alternative. [7]

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TEST RESULTS

A comparative study was conducted on the properties of four types of bricks: (1) Burnt Clay Brick; (2) Calcium Silicate Brick; (3) Fly-Ash Brick; (4) Concrete Brick. The study consisted of on-campus tests and a literature review. Tests performed on-campus are as follows:

Absorption Test (ASTM C 67)

TABLE IV. ABSORPTION TEST

Burnt Clay Brick	Calcium Silicate Brick	Fly-Ash Brick	Concrete Brick
15-25%	5%	10-14%	Value ≤ 10% of its weight
More porous	High apparent porosity	Less porous	Less porous
Soaking in water is very required	Soaking removes dust, sand, and dirt	Only a sprinkling of water is enough.	It is always better to soak them in water

Compressive Strength Test (ASTM C 67M-20)

TABLE V. COMPRESSIVE TEST

Burnt clay Brick	Calcium Silicate Brick	Fly-Ash Brick	Concrete Brick
up to 1600 psi.	3000 psi.	2000 psi.	1500-1900 psi.

Effloresce Test (ASTM C 67-08)

TABLE VI. EFFLORESCENCE TEST

Burnt clay Brick	Calcium Silicate Brick	Fly-Ash Brick	Concrete Brick
Clay brick salt can be used in cement mortars to promote efflorescence.	Excessive lime in brick can cause it to melt..	Coal combustion produces fly ash as molten mineral residue..	Water in concrete causes surface peeling and flaking...

Dimension Tolerance Test

TABLE VII. DIMENSION TOLERANCES TEST

Burnt clay Brick	Calcium Silicate Brick	Fly-Ash Brick	Concrete Brick
Very low tolerances	Very high tolerances	High tolerances	More tolerances than burnt clay brick

Shape Test

TABLE VIII. SHAPE TEST

Burnt clay Brick	Calcium Silicate Brick	Fly-Ash Brick	Concrete Brick
Precise shape with sharp edges due to handcraft.	These bricks are precise in size and shape, with straight edges.	These bricks have a uniform shape and a clear polish.	These bricks are in unique shapes that don't require mortar.

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Economic Analysis

TABLE IX. ECONOMIC ANALYSIS

Burnt clay Brick	Calcium Silicate Brick	Fly-Ash Brick	Concrete Brick
Most costly expansive	Less costly cheap	Less costly cheap	High cost as individual pieces.
11 Rupees per brick	13 Rupees per brick The wholesale rate is 10 Rupees	11-12 Rupees per brick	10 -12 Rupees per brick
The per annum demand for bricks in Pakistan is 112 billion bricks.	Production capacity is 70 K units/day.	The demand for fly ash brick is 1200 to 1400 per ton.	The production of concrete brick is 1150 to 1440 pcs/hr.

CONSLUSION

Pakistan is facing an alarming situation due to its lack of green construction practices, hindering sustainable development by 2030. Rapid urbanization, high population growth, and water scarcity exacerbate environmental and economic worries. The country's lack of knowledge and awareness about sustainable building practices is a major barrier to adoption.

Green building practices are important for energy efficiency and environmental sustainability. The study compared four types of bricks (calcium silicate, fly ash, concrete, and burnt clay) to evaluate their economic performance. Calcium silicate brick was found to have the best overall performance, followed by fly ash brick. While going green may cost more, long-term benefits make it an advantageous choice for adopting sustainable practices.

RECCOMENDATIONS

This study has identified obstacles and potential solutions, emphasizing the benefits of green buildings in mitigating climate change, providing clean air, and addressing energy and water shortages.

Challenge 1
• Efficiency gap due to lack of federal regulation and by laws

Challenge 2
• Slow growth of green industry
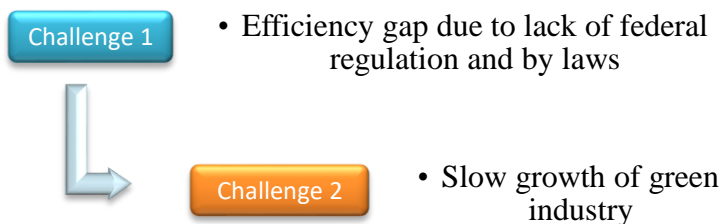
Challenge 1

Pakistan requires government policies that promote green building practices by offering incentives like subsidies, loans, grants, and tax immunities. These could overcome barriers to adopting green building practices, including higher upfront costs and lack of financial motivation. Public-private partnerships should be encouraged which can make green buildings attractive for the public.

Challenge 2

Pakistan also requires collaboration among policymakers, professionals, and society to promote sustainable development. This can be achieved by providing guidelines, increasing awareness of the benefits of green construction, and driving

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individuals towards sustainability through education and training. This study also emphasizes the importance of green building rating systems to improve understanding of sustainable practices. Additionally, architects play a key role in promoting green building practices by interacting with clients and motivating them to adopt sustainable practices.
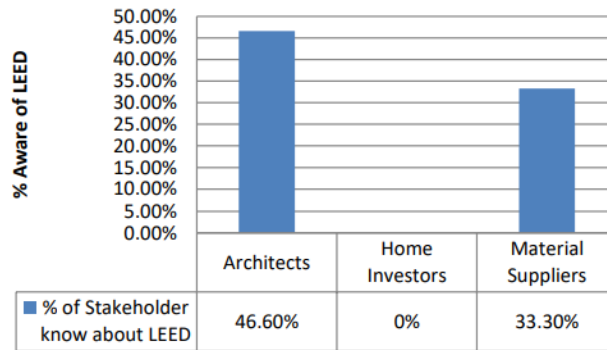

Fig. 6.LEED Awareness Chart [18]

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Nearly Zero Energy Buildings – A Case Study in Pakistan

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Abstract—Nearly Zero Energy Buildings (nZEB) are critical to sustainable development, significantly reducing dependency on nonrenewable energy sources and minimizing environmental impact. This study aims to provide essential guidelines for developing nZEB through a case study of a residential project in Islamabad, Pakistan. The focus on this project is particularly urgent given Pakistan's severe energy crisis and public backlash due to heavy bills. The methodology includes passive design tactics such as optimal orientation, natural ventilation, and effective insulation, supplemented with on-site solar energy generation. Initial calculations show that combining these measures can reduce energy use by up to 70%, significantly improving the building's overall energy performance. The paper concludes with practical recommendations for applying nZEB principles, emphasizing their potential to yield major environmental, social, and economic benefits. The findings of this study will assist developing countries like Pakistan in addressing the energy concerns and also ensuring sustainable development.

Keywords—nZEB (Nearly Zero Energy Building)

INTRODUCTION:

Nearly Zero-Energy Buildings (NZEBs) achieve low operational energy needs by combining efficient building envelopes with on-site renewable energy. Zero-Energy Buildings (ZEBs) aim for complete energy neutrality, fully offsetting any surplus energy usage with renewables. Popularized since the 1970s oil crisis, ZEBs highlight the vulnerability of fossil fuel reliance and promote energy independence through advanced technologies. [1].

Pakistan's electrical generation relies mainly on fossil fuels, specifically natural gas, and imported oil, causing severe environmental and financial impacts. Because of this reliance, electricity rates have increased, which has led to a recent backlash from the public and protests that have broken out around the nation in response to rising electricity prices. High operational inefficiencies in the power sector and IMF-mandated economic reforms have contributed to these hikes.

However, renewable energy sources like solar and wind present a viable alternative. Using just 0.071% of Pakistan's land for solar photovoltaic (PV) power could meet the country's energy needs [2]. Pakistan's wind corridors also have high potential, with average speeds of 7.87 m/s in the windiest areas. Despite this, the current operational capacity of solar and wind energy is limited to around 1,500 megawatts, contributing to only 2% of total power generation [3].

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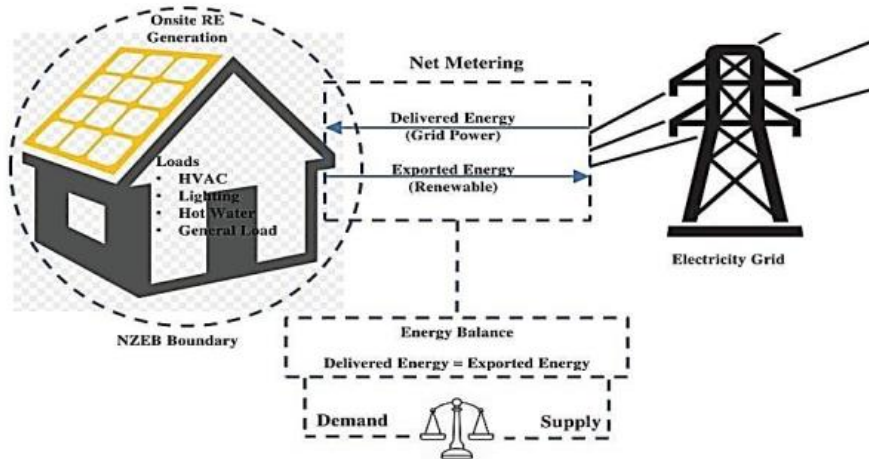**Organized by University of Wah**

Figure 1: Energy Balance of a Net Zero Energy Building

Energy is a fundamental necessity for daily life and a critical component of economic progress. Despite Pakistan's abundant renewable energy resources, the country faces a severe energy crisis and heavily relies on imported electricity to meet its needs. Renewable energy presents a long-term solution to this challenge, with solar photovoltaic energy holding the potential to significantly transform Pakistan's future energy landscape.[4]

Pakistan's reliance on imported electricity, despite its renewable energy resources, hampers both living standards and economic development. The country's energy crisis underscores the need for sustainable energy solutions. [5]

Pakistan's electrical generating mix decreased between 2009 and 2021 as a result of the disdain for renewable energy. The development of thermal generating was the main driver of the rise, even if the overall capacity to generate power increased. Consequently, the percentage of thermal generating increased from 65.8% in 2009 to 67.6% in 2013, with some fluctuations. Due to its reliance on imported fuel oil, gas, and coal, the current energy generation mix is unsustainable. In recent years, the share of imported energy in the overall energy mix has remained approximately 50%.[6]
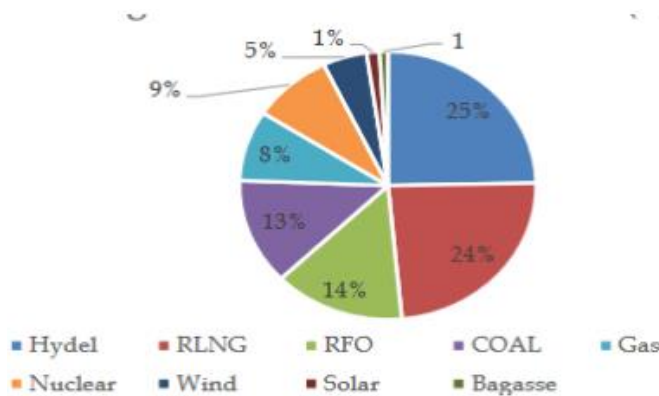

Figure 2: Pakistan's Power Mix in Percentages

A nation's practical evidence is its per capita power consumption, which provides insight into its citizens' living levels. Residential and commercial buildings consume a substantial amount of energy in terms of overall energy consumption.

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As a consequence, energy consumption has a significant impact on climate change, which cannot be mitigated via energy conservation. Nonetheless, the NZEB approach should be used to this situation.[7]

The concept of net-zero energy buildings, though not new, is increasingly gaining traction as construction techniques advance. These advancements, supported by ongoing scholarly research, make renewable energy systems more feasible and encourage a shift from traditional buildings to net-zero energy structures. Such developments are crucial for promoting sustainability in the built environment.[8].

Pless and Torcellini, prominent researchers who are affiliated with the National Renewable Energy Laboratory (NREL), categorize NZEBs based on the site of renewable energy production, which provides a structured approach to understanding the different methods of achieving net-zero energy status:

1. **Type A:** These buildings create and consume energy through a combination of fuel efficiency and renewable energy gathered inside the building footprint [9]
2. **Type B:** These buildings utilize a variety of methods, including energy conservation, renewable energy generated by the footprint, and on-site generation of renewable energy [9]
3. **Type C:** These buildings extensively use renewable energy solutions, including off-site renewable resources that are transported on-site, in addition to the strategies employed by Type A and B structures [9]
4. **Type D:** These structures adopt the approaches of NZEBs A, B, and C, and further explore renewable energy by purchasing it from a generating site, ensuring the fullest degree of feasible on-site renewable energy use [9]

Renewable energy production stands out as the most environmentally appropriate option to meet electrical energy demands while protecting the environment. Solar photovoltaic energy, in particular, could substantially impact electrical energy production in the coming years [5]

Making the shift to net-zero energy buildings is essential to solving Pakistan's energy issue and advancing environmentally friendly building practices. Following design guidelines is the first step in determining the energy inputs required to reach equilibrium. Next, a variety of technologies are used to predict energy use, maximizing elements such as heat island reduction, glass, shading, building alignment, and lighting. Energy efficiency is further improved by utilizing natural landscaping and resource conservation. This calculated move establishes a long-term standard for Pakistani construction methods going forward.

All factors must be considered concurrently, including the use of passive heating or cooling strategies such as solar chimneys and direct heat gain through south-facing glazing and/or isolated gain or sunspace, avoiding thermal bridging in all external wall construction, increasing the R-value of all roof construction, utilizing efficient lighting, daylighting sensors, and occupancy sensors, and finally, utilizing energy-efficient office equipment.[10]

NZEB is guided by four fundamental concepts. These ideas may be used on a variety of levels, with particular measurements such as absorbed energy and environmental effect being utilized. Design teams must use these four concepts to the building typology and weather patterns setting in order to generate the most fit-for-purpose measures that correspond to the phases or principles indicated below: [11]

- To begin, the energy usage of newly constructed buildings should be reduced. The energy demand value is the sum of the heating, cooling, DHW, supplemental energy, circulation, lighting, and appliance requirements for the facility.
- Second, to achieve optimum thermal comfort while preventing overheating, improve indoor environmental quality (IEQ).
- Finally, the annual renewable energy equilibrium must cover a specified percentage of renewable energy needs. Additional solutions for addressing energy alignment and storage issues must also be addressed.

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- Fourth, decreasing the overall cost of primary energy and carbon emissions on an annual basis. Additional tactics for mitigating concerns about material mobility and embodied energy must also be changed.

A few simple procedures may have a significant impact on the building's condition in climates where solar radiation is strong and heavy rainfall and humidity contribute to mold growth. The most critical are cooling and ventilation, since they use the greatest amount of energy. NZEB (net zero energy building) performance is achieved by a combination of passive and active actions. Prior to implementing strong energy-saving measures, it is critical to exhaust all potential passive energy-saving measures.
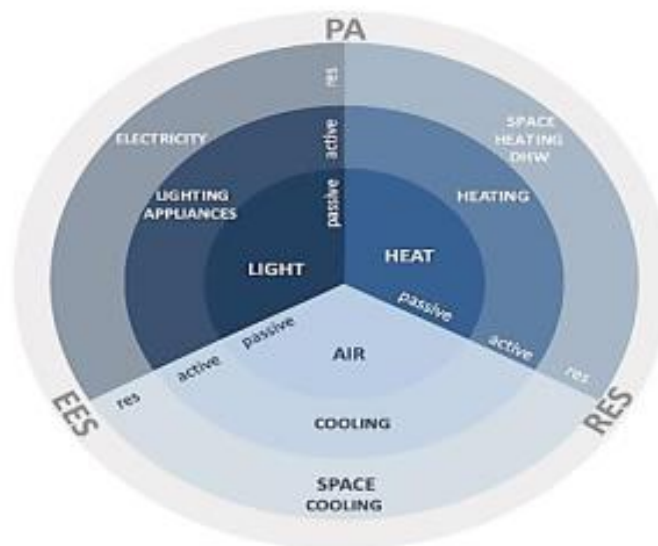
Figure 4: NZEB design principles include the following: PA (passive technique), EES (energy efficient system), and RES (Renewable energy systems) [21]

Following are the steps one need to keep in mind to create an efficient Nearly Zero Energy Building (NZEB):

- **Natural Ventilation:**
  A natural ventilation system can aid in the reduction of excess moisture and is particularly beneficial in NZEBs. Due to the moisture, high air velocity is required to provide a suitable living environment in hot and humid climates. Additionally, sufficient outdoor air quality is essential to guarantee that the interior air fulfils comfort standards.[12]

- **Windows:**
  Temperature fluctuations and the direction of the wind must affect the size and location of the windows. In hot and humid climates, a window-to-floor ratio of 15-20% is optimal. The primary source of heat is via windows, which must be appropriately protected and covered in order to minimize the U-value (the lower the better) and block out sunlight.[13]

- **Orientation:**
  The demand for supplemental heating and cooling is minimized with good orientation, resulting in lower energy expenditures and decreased greenhouse gas emissions. The fundamental concepts of proper orientation are as follows:

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- When combined with other energy-efficient measures, appropriate orientation may significantly decrease or even eradicate necessity extra heating and cooling, leading in reduced greenhouse gas emissions and increased comfort.
- Select a site or property that is well-suited to your environmental and regional circumstances, and construct or remodel to optimize the site's passive heating and cooling capabilities, adjusting the focus accordingly.[14]

Due to the fact that the sun is lower in the sky during the winter than it is during the summer, we may design and construct buildings that capture free heat in the winter and reject it during the summer. To guarantee the success of a 'passive' approach, the whole system must be led.[15]
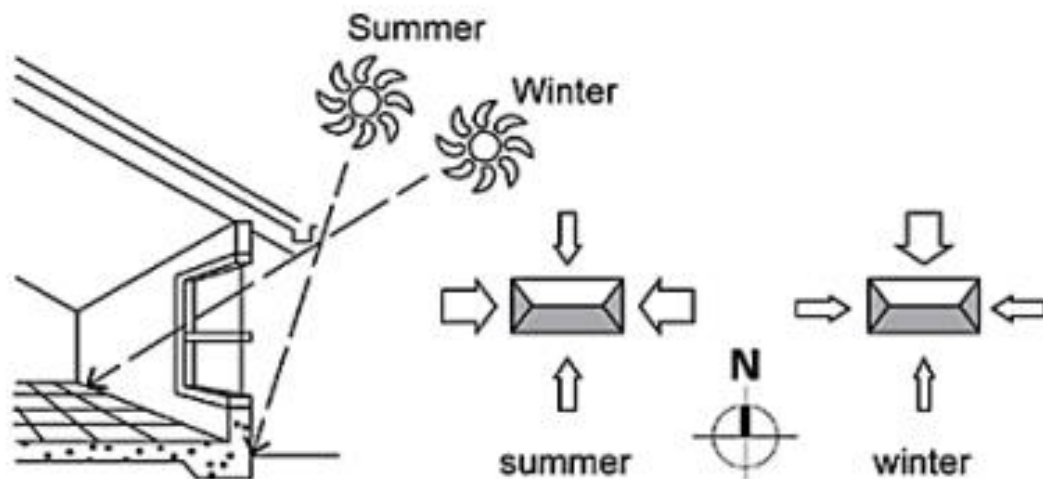
Figure 5: Direction of walls and windows according to sun [15]

- **Solar Energy:**
  Solar energy, more often referred to as photovoltaic systems, is gaining popularity as a holistic strategy for generating sustainable energy, with a focus on carbon-neutral energy production.[16]
  Solar cells convert the energy stored in photons of sunlight to electricity using photoelectric processes inherent in semiconductor materials such as silicon and selenium. Temperature, insolation, sunshine spectrum, and a range of other parameters all have an impact on solar cell efficiency. Under optimal circumstances, solar cell efficiency now varies between 11 and 18 percent.[17]
  Solar (PV) considered to be a promising kind of energy since it is pollution-free and abundantly accessible around the globe. PV energy is particularly beneficial in remote places such as deserts or country regions where transportation constraints and a lack of electrical grid connections make conventional options impractical.[18]

- **Insulation:**
  Thermal behavior optimization of the components that comprise the building envelope is one of the actions that must be included into the design process of every new system in order to meet the expanding energy efficiency standards.[19]

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Depending on the energy consumption structure of the building, the thermal performance of the building envelope is a critical component in determining energy utilization; as a consequence, thermally insulated walls may reduce air conditioning and heating system resource use.[20]

Converting a low-energy-efficiency building to a NZEB via the use of a well-insulated thermal envelope resulted in increased thermal comfort and a reduction in energy use for space heating. [21]. Insulation thickness, for example, could be increased to enhance thermal resistance of the envelopes, or better coefficient windows should be used.[22]

METHODOLOGY

This section presents a methodical way to apply targeted energy-efficiency improvements to convert a traditional structure into a Nearly Zero Energy structure (NZEB). Optimizing building orientation, adding solar energy systems, improving thermal insulation, and integrating passive design techniques are the four main components of the methodology. In order to facilitate the transition to net-zero energy usage, every component was meticulously evaluated, designed, and implemented to attain a balance between energy demand and renewable energy supply. This section describes the particular changes, the reasoning behind their choice, and how they should affect the building's overall energy efficiency.

- **Ventilation**

    Natural ventilation is an appealing management strategy since it eliminates the need for fans and fan maintenance. Natural ventilation, as opposed to fan-forced ventilation, uses the natural forces of wind and buoyancy to bring fresh air into buildings. Cross ventilation is a natural cooling method. Wind is used to push warm internal air outside through an inlet (such as a wall louvre, a gable, or an open window), while cold exterior air is drawn into the structure via an inlet (such as a wall louvre, a gable, or an open window) (through a roof vent or higher window opening).

    Now we must include openings into the structure to facilitate Cross-Ventilation. Providing an adequate number of apertures throughout the building can help reduce ceiling fan use and any cooling burden.

    In this calculation we will find out how providing cross ventilation affect the power consumption of a 75-Watt ceiling fan.

    The Dimensions of the Room for the Residential Building are as follows:

    o **Average Room dimensions:**
    - Length: 3.65m
    - Width: 4.26m
    - Height: 3.04m

    o **Average Window dimensions:**
    - Length: 0.609m
    - Height: 1.21m

    o **Average Door Dimensions:**
    - Length: 0.9144m
    - Width: 2.13m

    A term called **Ventilation Rate** that is used in this calculation is described as follows:

    "A building's Ventilation Rate is often described as the rate at which exterior air (fresh air) flows into the building.[23]"

    The Ventilation rate is given by the formula:

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Ventilation rate = 0.65 x wind speed (m/s) x smallest opening area (m^2) x 1000 (l/m^3) [24]

We found out from the past 5-year data that the wind flows at average speed of 3.16 m/s speed from the direction of North East.

Now, Using:

- ° Average Wind speed = 3.16 m/s
- ° Smallest opening area (Window) = 0.609m x 1.22m = 0.736 m^2

We calculated the Ventilation rate as:

- Ventilation Rate = 0.65 x 3.16 x 0.736 x 1000 => **1509.28 L/s**
- Converting to CFM = **3197.98 CFM**

This value is when the door and the window of the room is open at the same time. If one of the doors or one of the windows is closed the ventilation rate will decrease.

Mechanical Ventilation (Ceiling Fan)

If we refer to previous research on ceiling fans flow rate in a standard ceiling available in Pakistan, we can see that a 75 W fan with diameter of 46 inches has a minimum flow rate of 5000 CFM running at high speed. [25] The ceiling fan provides more airflow (5000 cfm) than natural ventilation (3194.29 cfm) at maximum power, but this increases energy consumption. ASHRAE recommends a minimum ventilation rate of 0.35 L/s per person and an average of 15 L/s. As the speed of the fan increases the power utilized by the fan also increases and thus increases the cost. [26]

This tells us that our ventilation rate calculated through natural ventilation from adequate data from last 5 years, is more than enough to ventilate the room and provide ample thermal comfort to the residents, until the number of people exceed the threshold.
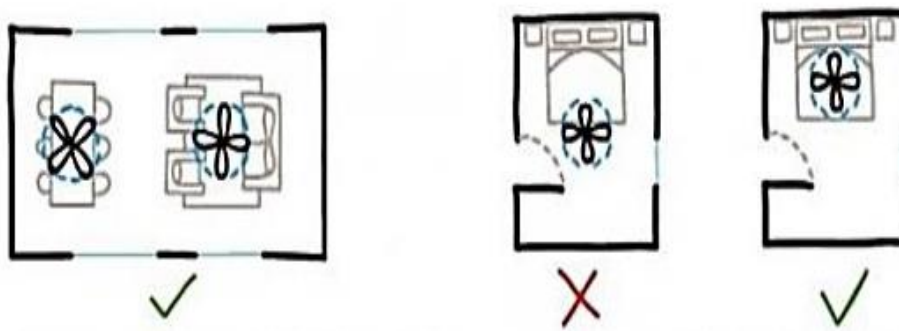

Figure 6: Correct and incorrect placement of fans in a room [15]

Properly positioned ceiling fans give the greatest level of comfort, cooling, and energy efficiency. Generally, fans should be placed directly over each activity area rather than in the room's center. Two fans should be installed in a big living room with a sitting and eating space. In a bedroom, hang a single fan above the head of the bed.

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- **Insulation:**

Insulating a building has its perks and that includes a good enough drop in room temperature as compared to the outdoor temperature. Insulation works both ways, as it keeps the outdoor temperature from infiltrating indoor in summers and keeps the indoor temperature from going outdoor in winters.

Thermal resistance, or resistance to heat transmission, is used to pick an insulator.

In simple terms, the R-value of a substance refers to its resistance to heat flow. An appropriate insulating material will have a high R-value. Most of the insulation materials are selected on the basis of their R value.

the rate of heat transfer is inversely proportional to the thermal resistance of the material.

Another way is to ask for the heat conduction of the insulation as heat conduction is the inverse of heat resistance of the material as:

$$K\text{-value} \propto 1/R\text{-value}$$

Through market survey we found out that there are two types of insulations that can be used based on their R-value:

Table 1: Insulation Materials available in market and their respective R value and Thermal Conductivity

Sr No.	Insulation Material	R-value (K/W)	Thermal Conductivity (W/Km)
1	Fiberglass	23.8	0.42
2	Poly-Styrene (XPS)	31.8	0.0314
3	Ceramic Thermal Insulation Coating	-	-

We did an experiment in our university lab using polystyrene insulation. We put it on a hot plate and kept the temperature at 50 degrees Celsius. The results of the experiment are as follows:

Table 2 Experiment conducted on poly-styrene insulation

Number of Trials	Insulation surface temperature (°C)
1	40.1
2	39.1
3	38
4	39.2
5	38.9

By conducting this experiment, we found out that the average drop in temperature is of **11.08□C.**

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Unlike fiberglass insulation, ceramic coatings don't even have an R-value rating that estimates a building's heat load and just measures the pace at which that heat is conveyed. Instead, they are graded based on their "emissivity," which is a measure of both their ability to reflect heat and the amount of heat that is applied to a surface.

The commercially available ceramic insulation is known as Isothane insulation. This insulation may be used on both the roof and the walls. This kind of insulation keeps heat-carrying radiations out, especially infrared radiations. Unlike many other insulations that reduce conduction of heat via the medium, ceramic coating insulation limits heat transfer since the substance absorbs no heat.

It was decided that ceramic thermal coating would be an ideal thermal coating for the building due to the following factors:

- **Corrosion-resistant and versatile:** Suitable for various materials and tight spaces.
- **Excellent insulator:** Provides thermal and waterproofing.
- **Strengthens structures:** Improves resistance to deformation and temperature changes.
- **Easy application:** Requires no additional wall unlike other insulations.

- **Orientation**
  The location of a structure in relation to seasonal variations in the sun's path and prevailing wind patterns is referred to as orientation. The proper orientation may enhance the energy efficiency of your house, making it more comfortable to live in and less costly to maintain. Passive solar energy is a significant source of low-cost energy that may be used by a properly oriented new home. It is not a novel idea to position a building to benefit from the sun's heat in the winter while avoiding unnecessary solar heat in the summer.

  We conducted an investigation on the orientation of our case study site and determined that it was east- west orientated. While this allows for more sunlight to enter the residence, it also allows for increased heat to enter the building. Locals may struggle to deal with the severe heat throughout the summer. It is feasible to mitigate the downsides of this orientation by installing glazed windows, but this would greatly increase the structure's total cost. So, making maximum use of the wind conditions is a more feasible option.
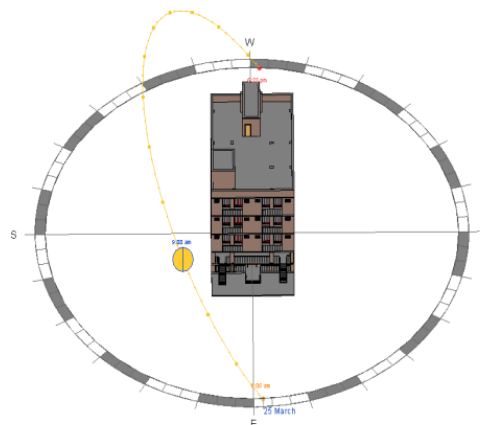

Figure 7: Revit Image showing the path of sun during different hours of the day.

As shown in the figure above, when we modelled the building in Revit according to the site data and orientation, the location was designed with the majority of the windows facing the sun. This permits heat to

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enter the building continually and heat it to its maximum capacity throughout the day. We must work hard not to be oriented in this manner.

The ideal orientation of the building depends on the region. If the region under consideration is of harsh climate, we can resort to orienting our building in a way that we can make better use of the winds moving from north to south direction. This will increase ventilation in the building as well as lower the cooling load of the building. This will also prevent excessive sunlight from entering the building, thus reducing the temperature inside the building to a comfortable level.

When deciding on the optimum orientation for your property, take in mind that the climate is always changing. Summers are getting hotter, and more destructive heat waves are occurring more often. While passive heating is still preferred in the majority of temperate zones, passive cooling is gaining popularity. It is advised that more attention be paid to shading windows and walls (especially those facing west), as well as to the building's sensitivity to cold breezes and other natural cooling.

- **Solar Panel**

540W solar panels offer a compelling advantage for buildings. Their high efficiency thanks to modern technologies translates to greater power generation. This means needing fewer panels, saving space on rooftops and potentially reducing installation costs since less mounting structure, wiring, and labor are required. Additionally, these panels boast better performance in low-light conditions, enhancing overall reliability.

Solar Panels Specifications and Market Survey

For this project, after visiting 10 different vendors and collecting their quotations, 540-watt solar panels are chosen based on the following characteristics:

1. Efficiency: 18% to 21% [27]
2. Optimal performance from 10:00 AM to 05:00 PM
3. Peak performance time: 10:00 AM to 02:00 PM, producing 2700 watts (540 watts * 5 hours), with a current output of 13.5 amperes per hour

Load Estimations

Table 3: Load Estimation for Commercial Shops Showing the Energy Consumption of Various Appliances

Appliance	Quantity	Used Hours	Load (Wh)
Fan	1	6	360 (60W * 6h)
LED Bulb	4	10	400 (10W * 4 * 10h)
Fridge	1	6	540 (90W * 6h)
AC (1 Ton)	1	5	4500 (900W * 5h)
Exhaust	1	2	100 (50W * 2h)
Total			**5900 Wh**

- Total Number of Shops: 6
- Daily Load per Shop: 900 Wh

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Table 4: Load Estimation for Apartments Showing the Energy Consumption of Various Appliances

Appliance	Quantity	Watts	Used Hours	Load (Wh)
AC (1 Ton)	1	900	7	6300
Fan	2	75	6	900
LED Bulb	12	10	10	1200
Fridge	1	90	8	720
Iron	1	900	1	900
LED TV	1	100	6	600
Exhaust	2	100	2	200
Total				**10820 Wh**

- Total Load for All Apartments: 13 apartments * 10820 Wh = 140,660 Wh or 140.66 kWh

Estimation of Number of Solar Panels

To calculate the number of solar panels required, use the following formula:

$$\text{Number of Panels} = \text{Total Watt Hours} \times 1.3 \, / \, \text{Peak Sun Hours}$$

Where:

- Total Watt Hours = Load of Apartments + Load of Shops
- Peak Sun Hours = 5 hours (typical value for many locations)

Total Watt Hours=140,660 Wh (apartments) + 35,400 Wh (shops) =176,060 Wh

$$\text{Number of Panels} = [(176060\text{Wh} \times 1.3) / 5\text{h}] / 540\text{W}$$

Which approximately equals to **85 panels**

The use of 540-watt solar panels for the proposed building is justified due to their high efficiency, optimal space utilization, and cost-effectiveness. Future advancements in photovoltaic technology could further enhance system performance and feasibility.

RESULTS AND CONCLUSION

Through comprehensive market analysis and a review of recent research, we identified key strategies for transforming conventional buildings into Nearly Zero Energy Buildings (NZEBs). Among the various factors considered, building orientation emerged as the most significant in optimizing overall energy performance.

In our case study, we found that orienting the building along a northeast-to-southwest axis maximized natural sunlight exposure while minimizing unwanted heat gain. This orientation also enhanced natural ventilation by aligning with prevailing wind patterns, thereby promoting effective airflow. While ventilation, solar energy generation, and insulation

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each contributed to improved energy efficiency, cross-ventilation design proved the most effective in maintaining thermal comfort and reducing reliance on mechanical cooling systems.

To further enhance thermal resistance, we selected nano-ceramic insulation, which offers superior heat transfer minimization and promotes long-term sustainability by decreasing the need for extensive heating and cooling. This material's properties provide a durable solution for maintaining energy efficiency over the building's lifespan.

Regarding renewable energy integration, our analysis determined that installing 85 solar panels, each with a 540W capacity, would adequately meet the building's energy demands. This solar setup significantly offsets traditional electricity consumption, leading to substantial reductions in operational costs.

By implementing these strategies, both new and existing buildings can transition to NZEB standards, achieving significant reductions in energy consumption and operational expenses. These modifications not only conserve energy but also foster a more sustainable built environment, yielding long-term financial and environmental benefits.

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Status of Occupational Health & Safety Culture in the Construction Industry of Pakistan

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Abstract: The construction industry significantly contributes to Pakistan's GDP, employing over 30% of the population; however, it is also the second most injury-prone industry, with workers suffering disproportionately high injuries. This research study examines the Occupational Health and Safety (OHS) culture on construction sites in Pakistan. The construction sites in different cities of Pakistan are analyzed against a checklist provided by the International Labor Organization, and the actual on-ground situation is reported. Moreover, qualitative research techniques, including stakeholder interviews and questionnaire surveys, are used for this research study. Results show that the OHS culture on construction sites is unsatisfactory in small construction companies, while larger companies have better safety cultures. Moreover used their perceptions and assessments to assess safety on work sites. The study identifies physical and ergonomic ha, stakeholders zards as the top two categories among occupational hazards. These findings will aid stakeholders in enhancing OHS culture on construction sites, resulting in improved productivity and outputs.

Keywords: Construction Industry, Occupation Health and Safety, RII, Stakeholders, ILO.

INTRODUCTION

Occupational Health & Safety (OHS) is the anticipation, recognition, evaluation, and control of occupational hazards that can harm workers during work. OHS is integral to Safety Management and significantly affects the company's benefits, productivity, and social reputation. Due to the development of industries and the increasing diversity of hazards, the need for identifying and assessing the OHS risks has dramatically augmented, too [1], [2].

The construction Industry plays a vital role in the economy of developed and developing countries [3]. Also, the construction industry is one of the most critical industries for any country [4]. The importance of the construction industry is widely acknowledged by its participation in economic growth and national development [5], [6]. Table. I show the construction industry's contribution to different developed and developing countries' gross domestic product (GDP).

TABLE I: GDP FROM THE CONSTRUCTION OF DIFFERENT DEVELOPED AND DEVELOPING COUNTRIES (KHAN ET AL., 2019).

Country	GDP (2018) (USD)
Pakistan	2304.89 million
Turkey	6810161.40 million
Mexico	70280.63 million
Indonesia	18.78 billion
Canada	98888.63 million
South Africa	7938.30 million
Australia	24705.07 million
Japan	381.32 billion
United Kingdom	37342.66 million

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Country	GDP (2018) (USD)
France	38213.53 million
Saudi Arabia	8525.87 million
China	8321.41 million
Argentina	615.084 million
South Korea	15.91 billion
Italy	27849.89 million
Spain	32865.62 million
Brazil	5387.10 million
Netherland	10065.81 million
Singapore	3598.11 million
India	35.08 billion
Russia	26.34 billion
United States	783 billion
Germany	45.99 billion

Construction is one of the largest industrial sectors in the South Asian region. Many young, female, and migrant workers are employed in this sector [7]. The Indian construction industry employs over 30 million people, almost 16 percent of the population, creating about 200 billion Indian rupees [8]. It is Pakistan's 2nd largest industrial sector after Agriculture and contributes 2.39% to Pakistan's GDP. It employs 30-35% of the population directly or indirectly [9], [10].

Work-related accidents generally pose tangible and intangible threats to all industries worldwide [11]. The construction industry is designated as a priority industry due to the high number of work-related injuries and inherent risks linked with working in this industry [12]. Compared to all other industries combined, workers in the construction industry suffer from a significantly higher number of injuries (making it the second most injury-prone industry) and musculoskeletal disorders, with a rate that is 11% higher (Kim et al. 2019; Zahoor et al. 2015; BLS, 2016). According to the International Labor Organization (ILO), in developing countries, the accident rate in the construction industry increased by 17.3% in 2017 [13]. The significant challenges faced by workers in the construction industry include high production expectations, repetitive manual handling of heavy materials and that too in improper positions, dependence on seasonal labor, and working in a dynamic, fast-paced, and unpredictable environment [14], [15], [16]. The workers in the construction industry face multiple hazards [7], [12] characterized falling from heights as the top hazard.

Moreover, ignoring the use of PPEs, injuries from falling objects, lifting hazards, lack of safety training, lack of activity planning, lack of technical support, exposure to extreme weather, and electrocution are the other leading causes of work-related accidents [17], [18]. Additionally, the management and employees have little knowledge about safety laws and standards in Pakistan [19]. Also, they ignore the accidents and injuries at the site. The incident reporting system in Pakistan's construction industry is poor. In the Pakistan construction industry, workers' safety depends on their risk perception, management, risk reporting, and understanding of safety rules and procedures [20]. Because of the poor safety regulatory system of Pakistan, safety is not the main focus of the construction industry of Pakistan [21].

These hazards lead to multiple accidents and consequently cause work stoppages, project delays, a decline in workers' morale, increased construction costs, and affect the productivity & morale of workers [22]. The universality of work-related accidents has increased the importance of implementing Safety and Health Management Systems in companies. The need for developing techniques and assessing options to reduce the risk of work-related hazards has been recognized by multiple researchers [23]. According to [24], [25], management dedication and employee involvement are essential to implementing a safe construction environment. Site Managers are mainly responsible for providing a safe working environment [26].

Developed countries spend many resources on including Safety and Health services in construction plans. The developing countries, on the other hand, do not account for health and safety services on sites. Most South Asian countries do not

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have any legislation for Health and Safety in the Construction Industry. Pakistan is a developing South Asian country facing similar problems of work-related hazards in the construction sector and possesses no specific law for Health & Safety in the Construction Industry [12], [27].

Given the significance of the construction industry's economic contribution and the adverse impact of poor health and safety practices on its potential, it is crucial to examine the issue of safety culture in the construction industry. As highlighted earlier, Pakistan's construction industry lacks a safety culture and has inadequate legislation to regulate safety practices. With this context in mind, this research study focuses on providing a direct and pictorial status of the Occupational Health and Safety situation on construction sites in Pakistan, thereby offering a unique perspective on the actual on-ground situation in the country. The situation on the construction sites has been compared to an ILO checklist which contains the main precautions to ensure a safe working environment. Moreover, stakeholders, including the managers and laborers, were interviewed to assess their awareness of the importance of Occupational Health and Safety. The site managers were also asked to rate the importance of the main occupational hazards, including physical, chemical, biological, psychosocial, and ergonomic hazards.

The methodology adopted for this research study included site visits, and stakeholders' interviews which were recorded and later transcribed for analysis. RII was used to rank the responses to analyze the relative importance of main occupational hazards. The study's main findings showed that the large companies were maintaining health and safety services on-site due to contractual obligations. However, the situation in small construction companies in general, and the informal construction sector, in particular, was unsatisfactory. Federation Internationale des Inginieurs Conseils (FIDIC) was being followed in mega construction companies to fulfill contract conditions in general and OHS in particular. The NEBOSH standards were being followed in preparing Health and Safety plans. Socioeconomic characteristics were identified as the primary reason behind the poor occupational health and safety culture in the construction sector of Pakistan.

METHODOLOGY:

A combination of qualitative and quantitative research techniques was utilized for this research study. The methodology consisted mainly of site visits and interviews, detail of which is elaborated on in the subsequent paragraphs:

Site Visits: Multiple sites in Haripur, Mansehra, Rawalpindi and DI Khan were visited and observations were made based on a checklist prepared by [7] specifically for the construction works. The detailed breakdown of the site visits and relevant details are provided in Table. II.

Table II: DETAIL OF SITE VISITS

Type of Contractor	Bidding Capacity	Responses Collected	Managers	Laborers	Responses Collected from Areas
CA	No Limit	30	2	28	Diamer, Gilgit
CB	Upto 4000 Million PKR	30	3	27	DI Khan
C1	Upto 2500 Million PKR	30	15	15	Haripur and Peshawar
C2	Upto 1000 Million PKR	30	15	15	Islamabad and Rawalpindi

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Type of Contractor	Bidding Capacity	Responses Collected	Managers	Laborers	Responses Collected from Areas
C3	Upto 500 Million PKR	35	15	20	Rawalpindi
C4	Upto 200 Million PKR	40	18	22	Rawalpindi
C5	Upto 65 Million PKR	44	20	24	Rawalpindi
C6	Upto 25 Million PKR	55	30	25	Rawalpindi
Informal Contractors	-	61	35	26	Rawalpindi

1. ***Stakeholders' Interviews***: For this phase, the qualitative research technique was adopted, and stakeholders, including the site managers and laborers, were interviewed. Open-ended questions were asked to encourage the stakeholders to share their opinions and experiences. The interviews were recorded and later transcribed for analysis using a thematic approach. The details of the stakeholders are provided in Table 2.

2. ***Questionnaire Survey:*** Site managers were additionally asked to provide their input regarding the importance of the main categories of occupational hazards. Five categories were identified, and the details and descriptions of each category are provided in Table 3. The responses were later analyzed using Relative Importance Index (RII) analysis.

TABLE III: DESCRIPTION OF OCCUPATIONAL HAZARDS CATEGORIES

Occupational Hazard Category	Description
Physical Hazards	Physical Hazards that can cause harm to the worker due to physical contact, e.g., Noise, Vibration, Working at heights, Slips, Trips, Falls, and Temperature extremes.
Chemical Hazards	Chemical hazards can harm a worker due to exposure to harmful chemicals, e.g., toxic substances, corrosive substances, hazardous substances, flammable substances, and explosive chemicals.
Biological Hazards	Biological hazards that can hurt a work due to exposure to living organisms or their byproduct, e.g., Fungi, Animal bites, Parasites, Bacteria, and Viruses.
Ergonomic Hazards	Ergonomic hazards can cause harm to the worker due to poor posture, e.g., Repetitive motions, Awkward postures, Poor lighting, Inadequate rest periods, Lifting heavy objects, and Poor workstation setup.
Psychosocial Hazards	Psychosocial hazards can hurt the worker's mental well-being, e.g., Stress and burnout, Job insecurity, Poor management, Work-family conflict, long work hours, and Workplace violence/harassment.

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ANALYSIS & RESULTS:

The results section comprises three sections, each relating to each research question. This research study focuses on answering the following three research questions. 1) What is the on-ground situation of OHS in construction sites in Pakistan; to what extent it follows the guidelines of ILO? 2) What is the stakeholders' perspective, including site managers and laborers, regarding their general understanding and importance of OHS in construction? 3) How are the main categories of occupational hazards ranked per the managers' perspective? The subsequent sections present the result analysis of each research question in detail.

1. Health and Safety Situation on Construction Sites:

The checklist was prepared in the light of [7] mainly covers the following aspects of the site:

  i. Site Layout
 ii. Work at Height
iii. Safe Use of Machinery and Electricity
 iv. Materials Handling and Storage
  v. Physical Environment
 vi. Work Organization & Training
vii. Safe work in excavations

The lack of organization was evident on the construction sites, with wooden planks and other materials scattered haphazardly throughout the site, as depicted in Figure. 1(a). ILO checklist states that it is imperative to establish an organized site layout from a safety standpoint to facilitate safe and efficient work

There were no escape routes available on site in case of emergencies and for emergency vehicles. In addition, the passageways and walkways were not appropriately marked. To accommodate the wheelbarrows and workers, temporary arrangements, as depicted in Figure. 1(b), were made.

Figure. 1(c) shows that the scaffolding lacked safe platforms, and no guard rails, safety harnesses, The workers seen in Figure. 1(d) who were working at heights did not appear to be taking any safety precautions or safety nets were present, contrary to what is mandated by ILO guidelines.

On site, another unsafe observation was the under-construction lifts and stairs, which were not cordoned off, and workers and site staff were working nearby, as depicted in Figures 1(e) and 1(f).

Figure. 1(g) shows that the ladders used on the site were not appropriate and were used without being secured. It is important to note that safety manuals require ladders to be secured even for small heights.

The workers were observed working near heavy machinery, as depicted in Figure. 1(h). This is a serious safety hazard, as accidental contact with moving machinery can lead to severe injuries or fatalities. It is crucial for the workers to maintain a safe distance from the machines at all times and for the site management to implement strict safety protocols for working with machinery. Such protocols may include providing workers with personal protective equipment (PPE), marking off designated work areas, and implementing lockout/tagout procedures to prevent accidental machine start-up.

The workers shown in Figure. 2(a) were handling equipment for cutting steel bars. However, it was observed that they were not following any safety precautions. This is a serious concern as it poses a risk of injury to the workers operating the equipment and those working in the vicinity of the equipment. The workers should have received appropriate personal protective equipment (PPE), such as gloves and goggles, to ensure their safety while handling the equipment. Moreover, proper training should have been provided to the workers to ensure they were aware of the potential hazards associated with the equipment and the appropriate safety measures to follow while operating it.

The electrical connections observed on site were found to be unsafe, as depicted in Figure. 2(b). The power cords were frayed and exposed, increasing the risk of electrocution and fire hazards. Similarly, the extension cords used on site were

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also in poor condition, with exposed wiring and broken insulation, as shown in Figure. 2(c). This situation poses a danger to workers and increases the likelihood of power outages and equipment failures.

Figure 1: Safety violations observed at various construction sites including Poor Site Layout (a), Poor site layout (b),

logos

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Scaffolding not equipped with safe platforms (c), Unsafe work at heights (d), Under construction stairs (e), Under construction lift (f), Unsafe use of ladders (g), and Labor working near the machine (h)

On the construction site, workers were observed manually lifting heavy loads, which can lead to serious musculoskeletal injuries. The loads were not being lifted using proper lifting techniques and equipment, as shown in Figure 2(d).

Figure 2: The unsafe work environment that can lead to major accidents or injuries at work sites including Unsafe steel bar cutting (a), Unsafe electricity connection (b), Unsafe extension cords (c), Unsafe manual lifting (d), Poor lighting (e), No PPEs (f), Non-Compliance of Covid SOPs (g), Unhygienic water coolers (h), and Unsafe Excavation work (i)

The worksite operated during the night lacked sufficient lighting, making it difficult for workers to see clearly and navigate safely, as seen in Figure. 2(e). Moreover, the majority of workers on the site were not provided with Personal Protective Equipment (PPE), as shown in Figure. 2(f), putting them at risk of injury or illness.

Despite the ongoing COVID-19 pandemic, it was observed that the recommended standard operating procedures (SOPs) to prevent the spread of the virus were not being followed on the site, as illustrated in Figure. 2(g).

Most construction sites lacked a safe drinking water facility, and the available water coolers, as shown in Figure. 2(h), were often unhygienic. Moreover, the coolers were not easily accessible to the laborers working at heights, posing a risk to their health and safety.

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According to [7], [28], providing suitable accommodation and amenities for workers on construction sites are recommended. These documents also recommend having clean and accessible toilets, washing facilities, meal areas, and rest areas for workers. However, none of these facilities were found on the site. In addition, no first aid facility was available on site for workers in small construction companies, however, the situation was relatively better in mega construction companies.

The workers working in trenches or excavated areas were observed not to be following the safety precautions recommended by the (International Labor Organization, 2021), as depicted in Figure. 2(i). The organization recommends using the shoring technique, which involves supporting trench walls with shores to prevent collapse and protect workers from cave-ins.

2. Interview Analysis

As per the details in Table. 2, site managers and workers were contacted upon site visits and interviewed using qualitative research techniques. Open-ended questions were asked about stakeholders' opinions on the role and importance of Occupational Health and Safety in construction sites. Managers were also asked which regulations about OHS are followed on their construction site. The interviews were later transcribed, and thematic analysis was undertaken to observe the common patterns mentioned in the subsequent section. Workers said they care little about Occupational Health and Safety (OHS) procedures and regulations. They mentioned that they rely on their experience and convenience to ensure their safety.

i.   Workers trust their perceptions and intuition to avoid accidents and hazards. They also mentioned that OHS procedures are often tedious and time-consuming, which can be inconvenient for them.

ii.   Workers acknowledged that ignoring OHS regulations can be risky but preferred to take their chances.

iii.   They also stated that OHS procedures may not always be practical or relevant to their work, which can lead to non-compliance.

iv.   The workers were ignoring the safety signs available on construction sites. The low literacy level of labor and no safety training on-site were the contributing factors to that.

v.   The workers said they do not have any insurance/support from their companies in case of injuries or illnesses. They did not even have any leave entitled to them. They were replaced in case of accidents or illnesses. The situation in mega construction companies was comparatively better.

vi.   Although FIDIC suggests in general conditions of the contract that insurance may be obtained for all the workers on site, the ground situation was contrary to the FIDIC requirements.

vii.   Some workers expressed dissatisfaction with the OHS culture in their workplace, stating that it is not taken seriously and is often neglected. They also mentioned that some workers are not adequately trained in OHS procedures, which can contribute to non-compliance and accidents.

viii.   There is no specific safety manual for the construction industry in Pakistan. There is a lack of general safety regulations in Pakistan. The only relevant Act is the Pakistan Factory Act 1934.

ix.   As per the managers' perspective working in the formal construction industry, the standard bidding documents on the PEC website use vague safety language.

x.   The FIDIC is commonly referred to in fulfilling the contract requirements. The FIDIC document specifies the mandatory safety considerations for the contractor to fulfill. Safety considerations such as worker insurance, provision of accommodation, and ensuring a safe working environment, are a part of the FIDIC document. There are multiple editions of FIDIC, and the edition used mainly depends on the project's nature and terms between the Client and Employer.

xi.   For the preparation of the Health and Safety plan, which is an integral part of the contracts made considering the FIDIC, National Examination Board in Occupational Safety and Health (NEBOSH) standards are used.

xii.   The role of Client is significant in the case of OHS on construction sites. For instance, per the [28] the contractor needs to present the insurance evidence to the employer at the start of the project and complete all the insurance

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formalities within the 84 days from the start of the project. Suppose the Client is strict about the implementation of FIDIC requirements, which was observed on one of the mega projects during the interviews. In that case, the overall safety culture is satisfactory and vice versa. The FIDIC requires contractors to appoint accident control officers, Safety experts on projects. The Client can ensure that the contractor appoints the necessary staff as suggested by FIDIC on projects.

xiii. The mega construction companies, i.e., C-3 and above, are implementing safety rules on their projects. These companies have appointed qualified safety staff on their projects. The implementation in the case of international joint ventures is better than that in the case of local projects. Another reason for implementing safety regulations is the penalties enforced in case of an accident reported.

xiv. The situation in small construction companies regarding OHS is not satisfactory. According to the interviews conducted with site managers of small construction companies, the PPEs are only provided during the visits of senior officers. There was no safety officer on any projects that small construction companies constructed.

xv. The site managers/engineers acknowledged the importance of OHS during the interviews. They recognized its importance in improving the overall efficiency of the project. However, the situation on the ground was contrary to what they said.

xvi. When asked about the absence or lack of safety culture on construction sites, the managers mentioned several primary reasons. These included the lack of incentives or implementation from regulatory authorities, the high costs associated with ensuring safety, such as hiring additional safety staff and purchasing expensive personal protective equipment (PPE), and the pressure to follow strict schedules. These factors all contribute to the challenges of implementing and maintaining a strong safety culture on construction sites.

xvii. There was no mechanism to record accidents, injuries & fatalities. This can be attributed to the vague & weak safety culture of Pakistan.

3. Questionnaire Survey:

As Per the detail in Table II, the managers were additionally asked to rank the main occupational hazards mentioned in Table III through a questionnaire survey. The responses were analyzed via the Relative Importance Index (RII); the results are in Table IV.

Physical hazards include risks related to the physical environment, such as machinery, equipment, noise, temperature, and manual handling, and they have the highest RII score which shows that it is more important to consider than others. An RII score of 0.69 indicates that ergonomic hazards, which are connected to workplace design, duties, and equipment and may cause musculoskeletal problems, are somewhat important, but less critical than physical hazards. With an RII score of 0.63, psychological hazards, which include work-related stress, interpersonal conflicts, workload, and mental health problems are moderately important. Chemical hazards have an RII score of 0.47, which indicates its modest relevance when compared to physical and ergonomic hazards. These hazards are connected to exposure to dangerous substances, such as chemicals, poisons, and fumes. The lowest RII value of 0.27 is assigned to biological hazards, which are risks related to exposure to biological agents including bacteria, viruses, and fungi. This indicates that these risks are less significant in this specific context.

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Table IV: RANKING OF HAZARDS

Factors	RII Value
Physical Hazard	0.89
Ergonomic Hazard	0.69
Psychosocial Hazard	0.63
Chemical Hazard	0.47
Biological Hazard	0.27

CONCLUSION:

According to this survey, construction sites in Pakistan are plagued by numerous hazards. The construction sites were disorganized, with no adequate safety plan, PPEs for the staff working. The situation in the informal construction industry was even worse and the workers were suffering extreme exploitation at the hands of their employers. Although large construction companies offered health and safety services, the Client's involvement was crucial to successfully implementing on-site occupational health and safety (OHS) measures. The absence of binding mechanisms was the main reason for the generally weak safety culture in the construction industry. In addition, the lack of specific regulations for the construction industry also contributed to the weak safety culture. FIDIC clauses were primarily used in contracts for health and safety services, and their implementation largely depended on the nature of the Client involved in construction projects. Due to the lack of safety regulations, no record-keeping was practiced for construction site accidents, injuries, and fatalities. Workers were unaware of the importance of OHS services and were not provided with any safety training. Workers used their perceptions, experiences, and intuition to negotiate on-site activities. Workers, as well as the managers on most sites, considered safety precautions hindrances to efficient working and wasting money & time. Socioeconomic and sociocultural factors were found to be significantly influencing safety culture on construction sites. Moreover, managers considered physical and ergonomic hazards as the top categories of occupational hazards. The study's findings can help the policymakers and other stakeholders better adopt and implement OHS on construction sites. Other countries with similar socioeconomic characteristics as of Pakistan can also benefit from the findings of this research study; therefore, this research can have broader applicability.

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Synergistic Effect of Waste Foundry Sand and Lime as Partial Replacement of Cement-Bentonite Slurry

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Abstract—Slurry walls are widely used as vertical barriers to contain the lateral flow of groundwater and contaminants. This research presents an experimental investigation into the utilization of waste foundry sand (WFS) and lime as partial replacements for cement in cement-bentonite (CB) slurry. The primary objective was to develop a synergistic mix capable of reducing permeability while enhancing the strength of CB slurry walls. Various slurry mixtures with different proportions of cement, bentonite, WFS, and lime were prepared and tested for permeability and unconfined compressive strength (UCS). The influence of curing time on both permeability and UCS was also examined. The test results indicated that the incorporation of WFS and lime into CB slurry significantly reduced permeability and increased the strength of the mixtures. It was observed that a minimum threshold of WFS and lime was necessary to achieve notable strength improvements, although the rate of strength gain diminished beyond a certain limit. A one-way analysis of variance (ANOVA) confirmed that the partial replacement with WFS and lime had a statistically significant positive effect on the compressive strength and permeability of CB-WFS-lime mixtures across all curing periods. The study concludes that incorporating WFS and lime is a practical and environmentally sustainable approach for CB slurry wall construction.

Keywords—Cement-Bentonite Slurry, Waste Foundry Sand, Lime, Permeability, Unconfined Compressive Strength, ANOVA

INTRODUCTION

The rapid pace of urbanization and industrialization worldwide has led to significant environmental challenges, one of which is the disposal of industrial and municipal waste [1]. Landfilling remains one of the most adopted methods for waste disposal, despite its potential to cause severe environmental degradation. As societies develop, the need to manage waste responsibly becomes increasingly urgent, posing a significant challenge for governments globally [2]. Groundwater is an essential resource, utilized extensively for domestic, industrial, commercial, and agricultural purposes. In regions like Pakistan, groundwater accounts for 70% of the domestic water supply and 50% of the agricultural water supply [3]. However, the contamination of groundwater presents a serious threat to nations that depend heavily on this resource. As such, effective measures to protect and preserve groundwater quality are critical [4].

One widely employed method to prevent groundwater contamination is the use of slurry walls [5]. These underground vertical barriers are designed to prevent the lateral flow of contaminated groundwater, control saltwater migration, protect deep excavations from flooding, and retard the lateral migration of leachate in geo-environmental applications [6], [7]. Slurry walls are particularly useful in areas where residual contamination or waste needs to be isolated at the source to mitigate potential harm to public health and the environment [1].

The construction of slurry walls typically involves using soil-bentonite or cement-bentonite mixtures, with the latter being more common due to its superior structural properties. Cement-bentonite slurries can be used in slurry trenches either as pure slurries or combined with soil, sand, or gravel to create soil-cement-bentonite mixes or plastic concrete, respectively [8], [9]. The slurry trench method is frequently employed to create cutoff walls in the cores or foundation soils beneath dams and embankments [10]. This construction process generally involves the excavation of a trench around the contaminated zone, filling the trench with a pre-prepared bentonite-water slurry, allowing it to hydrate for 24 hours, mixing soil-bentonite with the slurry, backfilling the trench, and finally, pumping out any excess slurry [11]. Vertical cutoff walls are preferred due to their cost-effectiveness and ability to achieve low hydraulic conductivity,

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typically in the range of 10^{-7} to 10^{-11} m/s [12]. However, achieving these low permeability values can be challenging, particularly for certain sites, highlighting the importance of quality control during the installation process.

Plain cement-bentonite slurry, while effective in many cases, may not always achieve the desired permeability. To address this, various additives have been explored to enhance the performance of bentonite slurry walls, particularly by lowering permeability and reducing contaminant transport [13], [14]. The use of waste products and low-cost natural materials, such as fly ash, cocoa shell, limestone, recycled concrete, ground granulated blast furnace slag, iron slag, cement-kiln dust, and sewage sludge, has been studied extensively for their potential in groundwater contamination remediation [15], [16], [17].

One promising material that has garnered attention in recent years is Waste Foundry Sand (WFS). Annually, 6 to 10 million tons of WFS are generated in the USA alone, with only 15% being recycled, while the rest is disposed of in landfills [18]. The disposal of WFS in landfills poses significant environmental risks, including potential soil and water contamination [19], [20]. Consequently, there is a growing interest in finding sustainable uses for WFS in various civil engineering applications. Studies have shown that WFS has potential uses in highway construction, berms, hydraulic barriers, and ground improvement, among others [21], [22]. The physical and chemical properties of WFS, which vary depending on the industrial sector and foundry process, make it a feasible material for constructing low hydraulic conductivity barriers.

In this paper, we present the results of an experimental study that investigates the partial replacement of cement with a synergistic mixture of WFS and lime in cement-bentonite slurry. The study focuses on evaluating the hydraulic conductivity and unconfined compressive strength (UCS) of the modified slurry. The experimental results provide insights into the potential use of this synergistic mix in the construction of slurry walls, offering a promising solution to improve the performance of these structures while also addressing the environmental concerns associated with WFS disposal.

MOTIVATION OF THE STUDY

It is evident from past research that CB-slurry's performance can be improved through various modifications, with or without inclusion of additives. Furthermore, researchers have emphasized the use of local ingredients and field conditions to perform such modifications. This research aims to utilize locally available by-products to improve CB-slurry performance, potentially lowering logistic costs, resulting in a cost-effective and environmentally friendly mitigative measure. Furthermore, to the authors' knowledge, no research has been conducted on these local by-products, which is a significant gap of research. This research could be useful for the practitioners and researchers dealing with the subjected alternative materials and screening protocols/techniques to form relatively impermeable synergistic grouts in strengthening landfill walls in Pakistan.

MATERIALS AND METHODOLOGY

This study investigated the effects of partially replacing cement with WFS and lime in cement-bentonite slurry. Ordinary Portland Cement (OPC, Type I), Sodium Bentonite (SB), WFS, and lime were used in predefined proportions to prepare the slurry mixes. All materials were sourced from local vendors in the Punjab province of Pakistan. The chemical compositions of SB, WFS, and OPC are presented in Table 1.

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Table 1. Chemical Composition of SB *[23]*, WFS *[24]*, and OPC *[25]*

Compound	Values by Percentage		
	SB	**WFS**	**OPC**
SiO_2	50.0 – 65.0	87.91	21.74
Al_2O_3	15.0 – 25.0	4.70	5.0
Fe_3O_3	2.0 – 4.0	0.94	3.17
MgO	3.0 – 6.0	0.30	2.97
CaO	0.50 – 2.0	0.14	62.79
Na_2O	0.50 – 5.0	0.19	0.11
K_2O	0.20 – 1.0	0.25	1.36
TiO_2	0.20 – 0.50	0.15	-
SO_3	-	0.09	1.67

Slurry Mixes

For the current study, control mix (designated as Mix 0) was prepared with 10% bentonite, 20% cement, and 70% water by weight. In all slurry mixes, the proportions of bentonite and water were kept constant at 10% and 70%, respectively. The remaining 20% of cement was systematically replaced with varying proportions of WFS (0, 10, 20, 30, 40%) and lime (0, 2.5, 5, 7.5, 10%) by weight, maintaining the overall cementitious material content at 20%. Table 2 outlines the composition of each slurry mix. Calculations for the slurry mixtures were standardized based on 1000 kg of water.

Table 2. Detail of Slurry Mixes

Slurry Mix	Water (%)	Bentonite (%)	Cement (%)	Proportion of WFS in Slurry (%)	Proportion of WFS as Cement replacement (%)	Proportion of Lime in Slurry (%)	Proportion of Lime as Cement replacement (%)
Mix 0	70	10	20	0	0	0	0
Mix 1	70	10	17.5	2	10	0.5	2.5
Mix 2	70	10	15	4	20	1	5
Mix 3	70	10	12.5	6	30	1.5	7.5
Mix 4	70	10	10	8	40	2	10

Sample Preparation

- The preparation of CB slurry followed the recommendations from the established literature [10], [26]. Initially, a predetermined amount of bentonite was mixed with distilled water in a pan. The mixture was hand-mixed using a steel spatula for 5 minutes to ensure homogeneity, and then allowed to hydrate for 24 hours. After hydration, the specified amounts of cement, WFS, and lime were added in their dry

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powder form, as detailed in Table 2, to prepare various slurry blends. The prepared slurry was then poured into cylindrical plastic molds with a diameter of 50 mm and a height of 150 mm. Each sample was carefully sealed with plastic wrap to prevent moisture loss and then allowed to be cured under controlled conditions.

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Testing

The prepared specimens were evaluated for their UCS and permeability. To evaluate the mechanical and hydraulic properties of the CB slurry, UCS and permeability tests were performed on samples cured for 7, 14, and 28 days. These curing periods were selected to assess the development of strength and permeability characteristics over time. The UCS test was conducted using a strain-controlled compression testing machine at a constant displacement rate of 1.2 mm per minute. Specimens were prepared with a height-to-diameter ratio of 2:1, adhering to standard practices to ensure consistent and comparable results. The maximum compressive stress sustained by the sample before failure was recorded as the UCS value. The permeability of the slurry samples was determined using a falling head permeameter. Prior to testing, the specimens were fully saturated by immersing them in water for 24 hours to ensure consistent saturation levels. The permeability test involved filling the standpipes with water to a predetermined level. The space between the porous disc and the specimen was sealed with paraffin wax to ensure a watertight environment. The test was initiated by allowing water to flow through the specimen, with the time taken for the water level in the standpipe to drop from the upper to the lower limit being recorded. This data was used to calculate the permeability coefficient of the slurry samples.

RESULTS AND DISCUSSION
The main purpose of this research study was to investigate the synergistic effects WFS and lime as partial replacements for cement in CB slurry. The performance of various blended mixes was evaluated against control mixes of the same age, focusing on critical parameters such as permeability and unconfined compressive strength.

Permeability

Permeability is a critical factor in determining the effectiveness of slurry walls, particularly in containment and barrier applications. Research indicates that permeability tends to decrease with increased curing time and confining pressure [27], attributed to ongoing hydration and pozzolanic reactions within the slurry matrix. As illustrated in Figure 1, the coefficient of hydraulic conductivity (k) of the CB slurry modified with WFS and lime shows a consistent decrease over the curing periods. This trend highlights the effectiveness of the synergistic mix in reducing permeability, a key performance indicator for slurry walls.

The observed reduction in permeability can be primarily attributed to the hydration and pozzolanic reactions occurring within the cementitious matrix. These reactions progress over time, leading to the formation of additional cementitious compounds that fill the void spaces, thereby reducing the permeability of the mix. Additionally, the increase in the overall solids content of the slurry due to the inclusion of WFS and lime further contributes to this reduction. The bentonite component, known for its expansive properties when in contact with water, also plays a crucial role in reducing permeability by swelling and occupying the available pore spaces.

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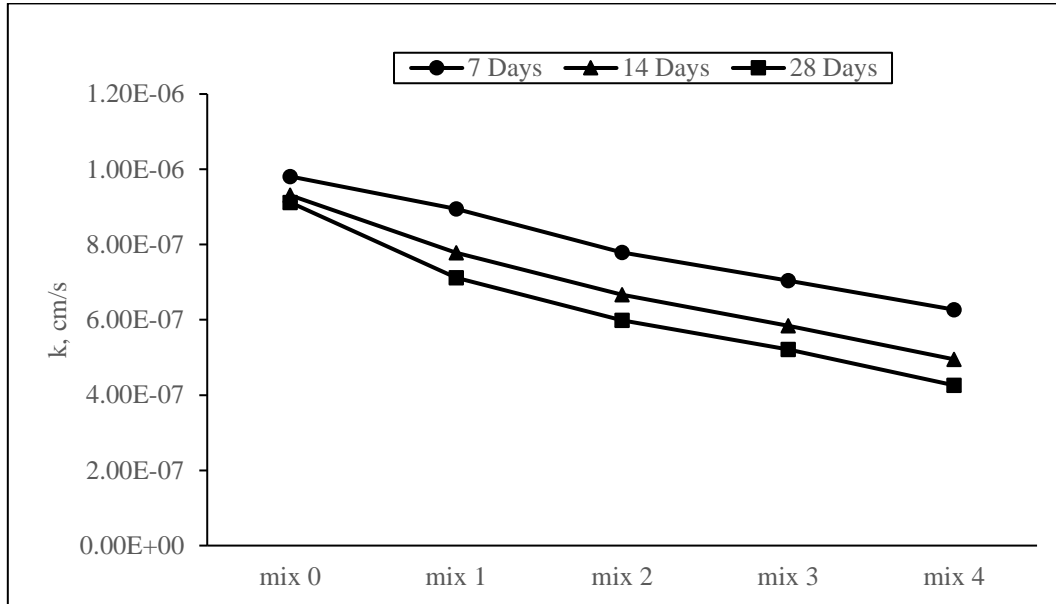**Organized by University of Wah**

Figure 1. Comparison of Permeability values for Slurry Mixes at different curing periods

Unconfined Compressive Strength

   The laboratory investigations revealed a significant relationship between UCS and the content of WFS and lime in the cement-bentonite slurry. As illustrated in Figure 2, the UCS values increased progressively with the extension of curing time, with the highest strengths recorded after 28 days of curing across all tested mixes. The increase in UCS with time is primarily attributed to the chemical interactions facilitated by the lime addition. Lime introduces various reactions, including cation exchange, pozzolanic reactions, and cementation, which result in the transformation of small particles into larger, more stable agglomerates [28], [29], [30]. This transition enhances the overall structural integrity of the slurry, allowing it to resist higher compressive loads and thereby increasing its UCS.

Furthermore, the inclusion of WFS plays a crucial role in enhancing the mechanical properties of the slurry. WFS contributes to the structural compactness and densification of the material [31], [32]. Its fine particles effectively fill the voids within the slurry matrix, leading to a denser and more cohesive structure. This densification not only enhances the UCS but also improves the stiffness of the specimens, making the modified slurry mixes more robust and resilient.

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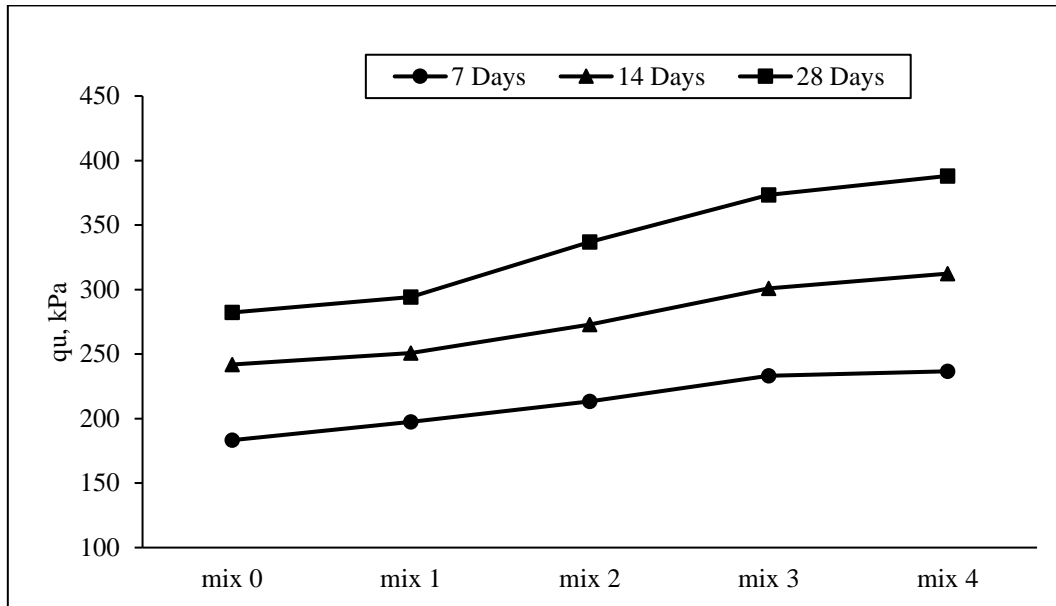
Figure 2. *Comparison of UCS values for Slurry Mixes at different curing periods*

The observed results clearly indicate that the synergistic addition of WFS and lime significantly improves the UCS of the cement-bentonite slurry. This improvement in mechanical performance is crucial for applications that require enhanced structural integrity and durability, such as in the construction of slurry walls where higher compressive strength is essential.

Relationship between UCS and Permeability

Figure 3 presents the relationship between UCS and permeability (k) of the CB slurry specimens at different curing times (7, 14, and 28 days). The data reveals that as the curing time increases, the UCS of the specimens increases, while the permeability decreases, indicating a strong inverse relationship between these two properties. The correlation between UCS and permeability is quite robust across all curing periods, as demonstrated by the high R^2 values (0.9768 @ 7 days, 0.9309 @ 14 days, and 0.9016 @ 28 days). This trend confirms that the structural integrity and densification of the CB slurry are enhanced with the synergistic addition of WFS and lime, leading to a significant reduction in permeability as the compressive strength increases.

However, an interesting observation can be made when analysing the correlation trends across different curing times. As the curing period extends from 7 to 28 days, the strength gain properties of the CB slurry tend to flatten out. This is evident from the decreasing R^2 values with longer curing periods, suggesting that the rate of UCS increase slows down over time while permeability continues to decrease. This phenomenon could be attributed to the diminishing reactivity of the cementitious components with prolonged curing, which might limit further strength development after a certain point.

This data implies that while the initial gains in UCS are substantial, particularly in the first 14 days, the incremental benefits in strength from extended curing (up to 28 days) become less pronounced. Consequently, this could indicate a point of diminishing returns, where the focus might shift from merely increasing curing time to optimizing the mix proportions to achieve the desired balance between strength and permeability.

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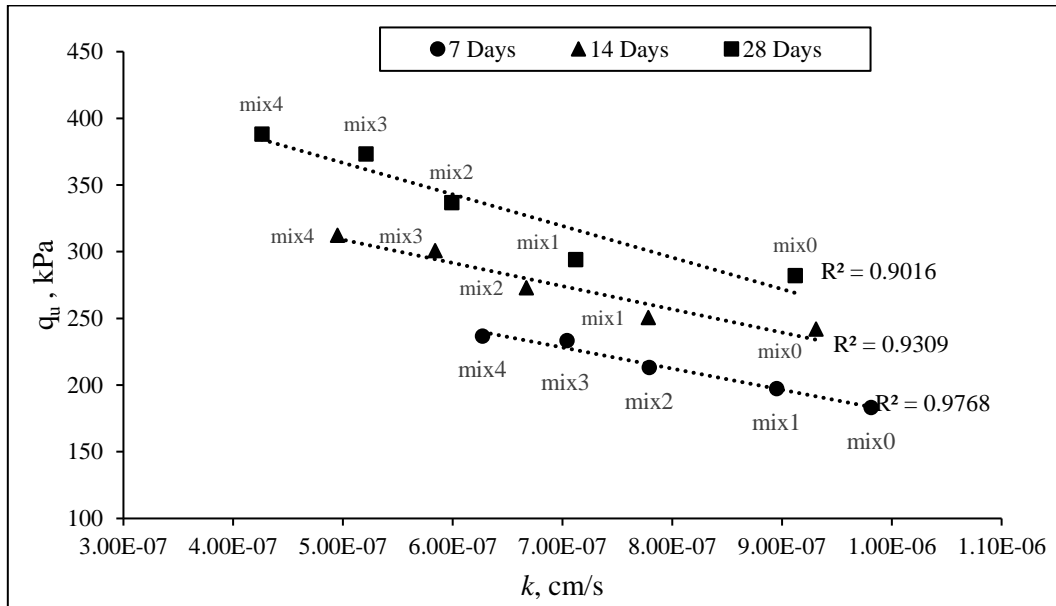
Figure 3. *Comparison of Permeability and UCS values at different curing periods*
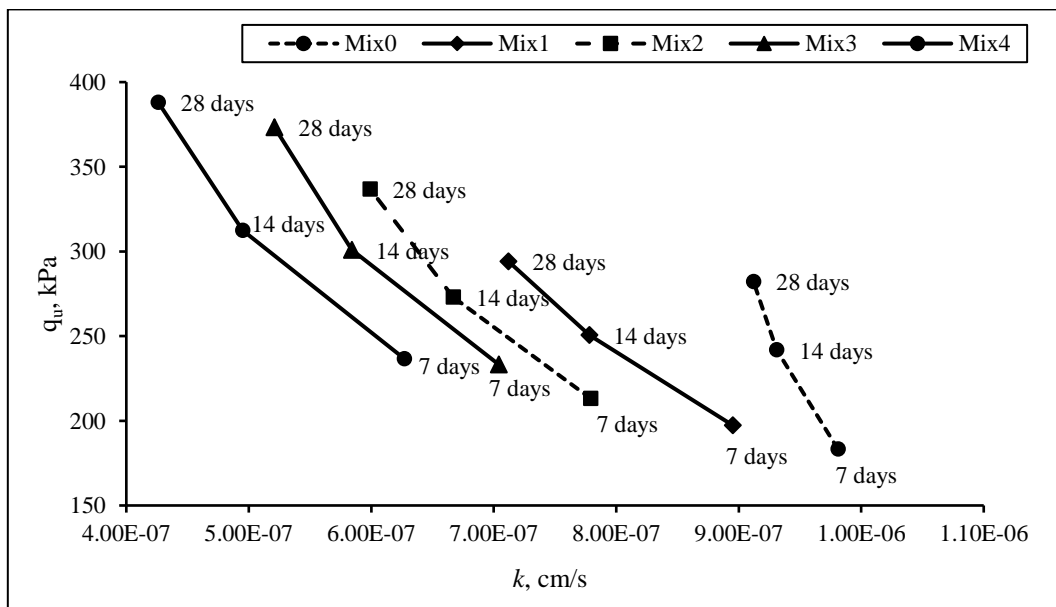
Figure 4. Comparison of Permeability and UCS values for different synergistic mixes

Figure 4 illustrates the relationship between UCS and permeability (k) for CB-slurry specimens prepared with different proportions of blending mixtures. The figure compares the performance of five different mixes, with varying degrees of cement replacement by WFS and lime, over three curing periods (7, 14, and 28 days). The data reveal that Mix-4, which features the highest level of cement replacement (50% by WFS and lime), yields the most favorable results among all mixes. Specifically, Mix-4 consistently demonstrates the highest UCS values coupled with the lowest permeability across all curing times. This suggests that the inclusion of 50% WFS and lime not only enhances the

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compressive strength of the CB-slurry specimens but also significantly reduces their permeability, making Mix-4 the optimal blend in terms of both strength and durability.

The performance of the other mixes, which contain progressively lower amounts of WFS and lime as replacements for cement, also follows a similar trend. However, the degree of improvement in UCS and reduction in permeability is less pronounced as the proportion of WFS and lime decreases. This indicates that the synergistic effect of WFS and lime in enhancing the mechanical properties of the CB slurry is most effective at higher replacement levels.

To further understand the impact of different mix parameters on the performance of CB slurry walls, a Single-Factor ANOVA test was performed with a significance level (α) of 0.05. The test was conducted to evaluate the statistical significance of the variation in percentage increase in UCS and percentage decrease in permeability among the different mixes. The results of the ANOVA test are presented in Table 3. The significant "F-values" and low "Significance" values from the ANOVA test confirm that the variations in UCS and permeability among the different mixes are not due to random variability but rather are influenced by the specific proportions of WFS, lime, and other additives. This suggests that the proposed model is a robust predictor of the relationship between the independent variables (mix composition) and the dependent variables (UCS and permeability).

These findings highlight the importance of optimizing mix proportions in the design of CB slurry walls. The statistical significance of the results provides confidence in the reliability of the experimental data and supports the conclusion that the synergistic use of WFS and lime in the mix formulation is effective in enhancing both the strength and impermeability of the slurry walls. Therefore, further refinement and application of these mix designs could lead to more durable and efficient CB slurry wall structures in practice.

Table 3. Single- Factor ANOVA test

Source of variation	Sum of Squares	df	Mean Square	F	Sig.
(i) **For percentage increase in UCS**					
Between Mixes	2309.671	4	577.418	52.195	1.0E-06
Within Mixes	110.627	10	11.063		
Total	2420.297	14			
(ii) **For percentage decrease in permeability**					
Between Mixes	3777.767	4	944.442	21.371	6.90E-05
Within Mixes	441.933	10	44.193		
Total	4219.700	14			

CONCLUSION

This research study investigates the use of WFS and lime as partial replacement of cement in CB-slurry in order to prepare a blended material for the construction of slurry walls having enhanced compressive strength and lower permeability. The following conclusions were drawn from this experimental study:

(1) The unconfined compressive strength of WFS-lime-CB slurry specimen increased with curing period as compared to the control CB slurry specimen. For 28 days of curing, the maximum strength achieved for Mix-4 was 34.6% greater than the control mix of same age.

(2) Permeability of WFS-lime-CB slurry specimen reduced significantly as compared to control CB slurry specimen after 28 days of curing. The lowest value of permeability was 4.27×10^{-7} cm/s (4.27×10^{-9} m/s), achieved after 28 days of curing for Mix-4, which is 114% improved from the control mix of same age.

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(3) The relation between UCS and permeability exhibits that as the UCS of specimen increases, the permeability decreases, regardless of the proportion of WFS and lime in WFS-lime-CB slurry.

(4) Comparison revealed that a correlation exists between percentage reduction in permeability and percentage increase in UCS (R^2=0.7959). However, a logical trend was observed, indicating that an increase in UCS decreases the permeability, suggesting that synergistic samples with increase in UCS values may produce mixes more impervious.

The laboratory investigations indicate a significant improvement in the properties of CB slurry by the addition of WFS and lime. Therefore, the authors have established that WFS-lime-cement-bentonite grout is stronger and more impermeable than cement-bentonite grout.

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Enhancing OSPF Authentication Using Quantum Key Distribution and Software- Defined Networking

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*Abstract— —*OSPF is a widely used routing protocol. Many researchers have studied it to address the everyday challenges faced in its deployment as technology continues to advance. This paper presents a new method for enhancing OSPF authentication security by integrating Quantum Key Distribution (QKD) with Software-Defined Networking (SDN). Traditional OSPF authentication methods are increasingly vulnerable to advanced and quantum-based attacks. By leveraging QKD, we can generate and distribute secure keys, while SDN provides centralized control and dynamic configuration capabilities. Our approach improves key management, detects eavesdropping, and enhances overall network security. Experimental results demonstrate that our method not only bolsters security but also improves network performance, providing a reliable solution for future OSPF authentication needs. Additionally, the integration reduces latency and increases the efficiency of network resource allocation, making it an optimal choice for modern networks. Our results show significant improvements in key performance metrics: convergence time decreased from 15s to 10s, packet loss reduced from 1.2% to 0.8%, average latency dropped from 20ms to 15ms, and throughput increased from 100Mbps to 120Mbps.

Keywords— OSPF, QKD, SDN, network security, quantum computing, cryptography

INTRODUCTION

The rapid development of networking technologies and the growing complexities of network infrastructures call for routing protocols that are quite robust to ensure the accuracy and reliability of the transmitted data. Open Shortest Path First (OSPF) is one of the most common interior gateway protocols, mainly because of its effectiveness in calculating the best path for data packets among huge and dynamic networks. And despite the widespread popularity of OSPF, its security mechanisms, in particular those associated with its methods of authentication, face noticeable difficulties in evolving cyber threats and with the looming advent of quantum computing. Traditional OSPF authentication relies on shared secrets and redistributed keys whose confidentiality can be attacked by brute force and experienced cryptosystem attacks. Quantum computers will be breaking traditional cryptographic keys very fast. The current mechanisms of authentication are becoming quite out of date and no longer secure. All this discussion means that there is an increasing need for novel approaches that will offer volatile, more powerful forms of authentication mechanisms. QKD is a promising solution to this problem since it allows the generation and distribution of cryptographic keys under the laws of quantum mechanics. Therefore, because eavesdropping can be detected and it automatically leads to theoretically unbreakable keys, it only enhances the security of a network. It has the potential to create a secure and efficient OSPF authentication framework when combined with software-defined networking (SDN) techniques, which decouple the control plane from the data plane, providing centralized control and dynamic network management. With this system of control in software-defined networking, there can be an easier implementation and management of the difficult security protocols, like QKD, around the network. We thus propose a new framework that will integrate QKD with SDN to improve OSPF authentication. This integration, with the unbreakable security guarantees of QKD, flexibility, and efficiency of the SDN toward realizing strong and futureproof authentication, comes up with a novel framework. We will now walk through the architecture and implementation in this framework, showing how QKD can be smoothly integrated into an SDN environment for OSPF authentication key management.

This combination of technologies can dramatically reduce the risk of key compromise and improve the security posture of OSPF networks. A detailed analysis is carried out that presents the performance and security advantages

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of our proposed approach over traditional OSPF authentication mechanisms. Some experimental results, therefore, are presented to explain important improvements in key management, Listening Secret detection, and network security in general. It would therefore be that the proposed framework would address the limitation of current methods of authentication, thus paving the way for more secure and resilient infrastructures that are able to stand up against threats emerging in this fast-changing world, which includes quantum computing. The network might create certain encryption keys with QKD that could not be broken to ensure protection for data from marauding attackers. Software-Defined Networking helps effectively manage the network and allows easier updating or changing of the security protocols of the network. These two technologies merged together could make the OSPF networks much more secure. We believe that such a framework can be really helpful in securing data in modern networks. We aim to show that combining QKD and SDN can give a powerful and reliable solution for OSPF authentication. This study endeavors to make networks safer for everyone. 10^{-9}

LITERATURE REVIEW

Quantum mechanics Control the behavior of extremely small particles, smaller than 10^{-9} meters. Quantum computing uses Standards of quantum mechanics to perform faster and more effective calculations. It utilizes quantum bits, or qubits, for processing information. which can exist in a coexistence of the basis states, instead of existing in either 0 or 1. The paper [1] explores the threat quantum computing poses to traditional encrypted algorithms, like RSA, and examines Quantum Key Distribution and Post-Quantum Cryptography (PQC) as solutions. It highlights the practical challenges and costs of implementing QKD systems and marks the need for simulation frameworks. The study compares recent QKD simulation frameworks, revealing significant improvements in network performance metrics such as throughput, packet loss, delay, and convergence time for OSPF and Routing Information Protocol routing schemes in an SDN-based QKD network. The paper [2] by Monita, Munadi, and Irawati discusses the implementation of a QKD network using SDN to improve network security and performance. By utilizing SDN's centralized control and dynamic routing capabilities, the study compares OSPF and RIP routing protocols.The paper [3] by Yao, Wang, Li, Mao, Abd El-Latif, and Chen proposes the QOLSR routing protocol to enhance quantum key utilization in QKD networks. It addresses the challenge of integrating traditional routing protocols with the unique requirements of QKD, emphasizing efficient link-state awareness and path optimization based on key recovery capabilities. Simulation results illustrate QOLSR's effectiveness in improvingperformance, making it a good solution for large-scale QKD networks. The paper [4] by Liu, Rozenman, Kundu, Chandra, and De discusses the emergence of quantum key distribution as an important technology for future communication security. It highlights QKD's ability to provide unconditional security against quantum attacks, replacing vulnerable classical encryption methods. The survey focuses on ongoing efforts in standardization and identifies challenges hindering widespread adoption across separate variable and continuous variable QKD schemes. This study [5] explores how Quantum Key Distribution (QKD) impacts routing efficiency using SDN. It compares Link State and Distance Vector protocols, finding that Link State increases key usage sequentially with hops (5 to 14 keys), while Distance Vector consistently uses five keys. Processing times differ, with Link State taking 3.438 seconds and Distance Vector 2.687 seconds on average. Quantum computing's [6] advance threatens traditional cryptography, encouraging the search for quantum safe solutions like Quantum Key Distribution (QKD). QKD offers robust security based on physical laws but integrating it into networks is hindered by its point-to-point nature and distance limitations. Software-defined Defined Networking presents a promising approach to unify quantum and classical communications within existing infrastructure, advancing towards

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quantum-safe networks. Quantum Key Distribution (QKD) ensures secure key exchange using principles of quantum mechanics [7], important for applications in military, medical, and financial sectors. ADA- QKDN proposes a novel routing strategy integrating Software Defined Networking (SDN) [8] to optimize path selection based on application demands, enhancing QKD network efficiency by 10 percent compared to traditional schemes. Quantum Key Distribution networks offer secure key exchange using quantum principles, advancing from research to practical applications [9]. They connect nodes through optical or free-space links, ensuring longterm security and supporting diverse ICT applications with strength against faults and scalability for user needs. Software defined networking (SDN) [8] explores its transformation impact on network management, [10] focusing on its ability to centralize control, optimize network resources, and enhance flexibility through programmable interfaces and abstraction of the underlying infrastructure. Cryptographic techniques [11] for the control plane, vulnerabilities within OSPF, methods for intrusion detection, and specific techniques for securing the data plane. The focus is on enhancing OSPF's strength against attacks and ensuring the integrity of routing information in network environments.

METHODOLOGY

In this study, we set up a Software-Defined Network (SDN) environment using Mininet and the Ryu Software Defined Networking controller. The aim was to integrate a Quantum Key Distribution (QKD) system within this environment to secure OSPF authentication. The methodology involved the following steps shown in Figure 1. Setting up the SDN Environment, We used Mininet, a network emulator, to create a virtual network environment. Mininet allows us to simulate a complete network on a single machine, including hosts, switches, and routers. We installed Mininet on a Linux system and created a topology of several routers and switches. The Ryu SDN controller was chosen for its simplicity and ease of integration. Ryu is an open- source SDN framework that provides a platform for developing SDN applications. We installed Ryu on the same Linux machine and configured it to manage the Mininet topology. Ryu
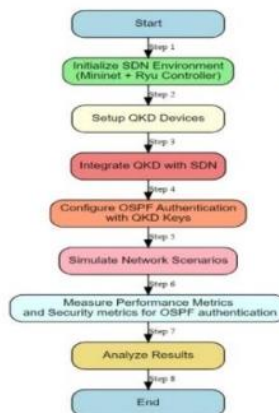
Figure 1: Architecture

Figure 2 Creating Topology

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- **Installing Mininet and Ryu:** We installed both tools on a Linux machine. Mininet was used to create the virtual network topology, and Ryu was configured as the SDN controller.
- **Creating the Network Topology:** A custom network topology was created using Mininet, including routers, switches, and hosts. The topology was designed to simulate a sensible network environment as shown in Figure 2.
- **Configuring the SDN Controller:** Ryu was configured to manage the network topology created by Mininet. This involved setting up the controller to communicate with the network devices and manage routing decisions.
- **Integrating Quantum Key Distribution (QKD):** We integrated a QKD system within the SDN environment to enhance OSPF authentication for better security. QKD systems use quantum mechanics principles to generate and distribute cryptographic keys securely. The QKD system was integrated with the Ryu controller to manage the key distribution for OSPF authentication.

```
# Configure QKD authentication on the switch (OVS)
s1.cmd('ovs-vsctl set bridge s1 other_config:qkd-authentication=yes')
s1.cmd('ovs-vsctl set bridge s1 other_config:qkd-authentication-key QAU@KeyQkd.com')

# Configure OSPF on the hosts
h1.cmd('sudo ip ospf authentication-key QAU@KeyQkd.com')
h2.cmd('sudo ip ospf authentication-key QAU@KeyQkd.com')
```

Figure 3. QKD Key Generation

- *Setting up QKD Devices:* QKD devices were set up to facilitate secure key exchanges between network nodes 3. These devices generate cryptographic keys using quantum mechanics principles.
- *Integrating QKD with Ryu:* The QKD system was combined with the Ryu controller to manage key distribution for OSPF authentication. This involved configuring the controller to use QKD-generated keys to verify OSPF messages.
- *Securing OSPF Authentication:* The QKD-generated keys were used to secure OSPF authentication. This ensured that the keys used for verifying OSPF messages were generated and distributed securely

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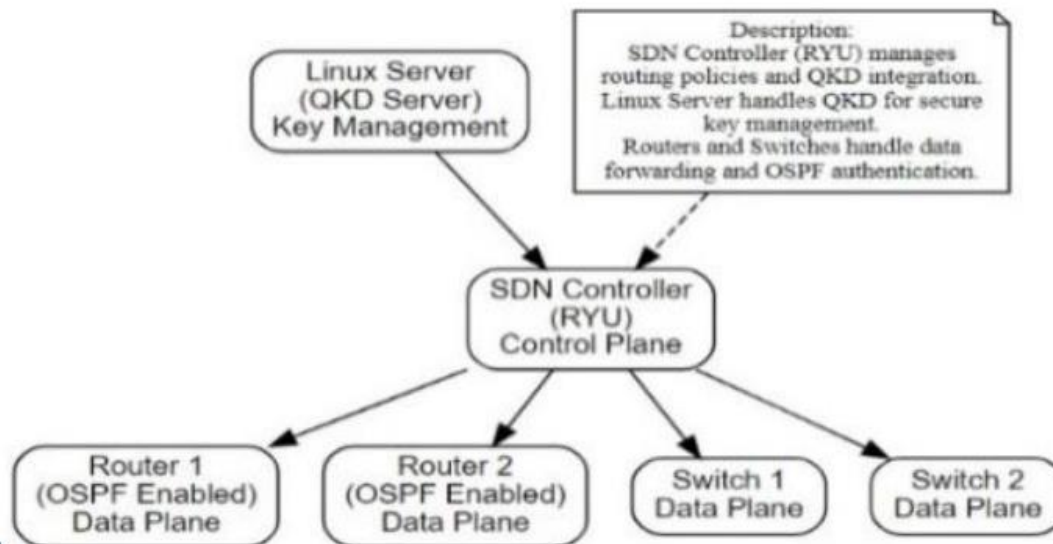
Figure 4. Architecture of Purposed work

- **Testing and Data Collection:** We conducted extensive testing to check the performance and security improvements brought by integrating QKD with SDN for OSPF authentication. The testing process involved the following steps:

  - *Simulating Network Scenarios:* Various network scenarios were simulated using Mininet, *including different network topologies and traffic patterns.*

    - *Measuring Performance Metrics:* Key performance metrics were measured to evaluate the impact of integrating QKD with SDN on OSPF authentication. These metrics included convergence time, packet loss, latency, and throughput.

RESULTS AND ANALYSIS

The results from our study indicate that integrating Quantum Key Distribution with SDN significantly enhances OSPF authentication. The following sections provide a detailed analysis of the performance metrics and security improvements observed during our experiments using the above lab scenario.

Performance Metrics:

Table I presents a comparison of network performance metrics between traditional OSPF with MD5 authentication and our proposed OSPF-SDN-QKD framework. The metrics include convergence time, packet loss, average latency, and throughput.

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Table 1: NETWORK PERFORMANCE MATRICES

Metric	OSPF	OSPD-SDN-QKD
Convergence Time	15s	10s
Packet Loss	1.2%	0.8%
Average Latency	20ms	15ms
Throughput	100Mbps	120Mbps

- o **Packet Loss:** Packet loss refers to the percentage of data packets that are lost during transmission. In our experiments, packet loss was reduced from 1.2% in traditional OSPF to 0.8% in the OSPF-SDN-QKD framework.
- o **Convergence Time:** Convergence time is the time taken for the network to reach a consistent state after a change, such as a link failure or the addition of a new node. Our results show that the convergence time decreased from 15 seconds in traditional OSPF to 10 seconds in the OSPF-SDNQKD framework Shown in Figure 1.
- o **Average Latency:** Latency is the time taken for a data packet to travel from the source to the destination. Our results show a reduction in average latency from 20ms in traditional OSPF to 15ms in the OSPF-SDN-QKD framework shown in figure 5.
- o **Throughput:** The rate at which data is successfully delivered over the network. Our experiments show an increase in throughput from 100Mbps in traditional OSPF to 120Mbps in the OSPF-SDN-QKD framework.

i) Probability of Key Compromise over Time: This equation models the probability that the cryptographic key used for OSPF authentication, secured with MD5, is compromised over time t. The term $\exp(-0.05 \cdot t)$ represents the decreasing likelihood of compromise over time due to increasing vulnerabilities and potential attacks. • OSPF Authentication with QKD and SDN:

Pcompromise MD5(t) = $1 - \exp(-0.05 \cdot t)$

Explanation: This equation models the probability that the cryptographic key, generated using QKD and managed by SDN for OSPF authentication, is compromised over time t. The term $\exp(-0.01 \cdot t)$ reflects the enhanced security provided by QKD, where the exponential decrease indicates a significantly lower probability of compromise compared to traditional methods.*ii) Comparison of Key Compromise Probabilities:* To illustrate the security enhancement, compare the probabilities at a specific time t = 100 hours: • For traditional OSPF (MD5):

Pcompromise MD5(100) = $1 - \exp(-0.05 \cdot 100) \approx 0.9933$

Explanation: At t = 100 hours, the probability of key compromise using traditional MD5 authentication is approximately 0.9933, indicating a high risk of compromise over time.*iii) OSPF with QKD and SDN:* Pcompromise QKD SDN(100) = $0.05 \cdot \exp(-0.01 \cdot 100) \approx 0.0498$ Explanation: At t = 100 hours, the probability of key compromise using QKD and SDN authentication is approximately 0.0498, significantly lower than the traditional MD5 approach.

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CONCLUSION

In conclusion, this paper presents a unique approach to enhancing OSPF authentication by uniting Quantum Key Distribution (QKD) with Software-Defined Networking (SDN). Our experimental results explain significant improvements in network performance and security, confirming the effectiveness of our proposed framework. Future research will focus on further optimizing the integration of QKD with SDN and exploring its application in other routing protocols and network environments. The integration of QKD and SDN presents an encouraging solution to the challenges posed by evolving cyber threats and the advent of quantum computing. By utilizing the strengths of both technologies, we can create a robust and futureproof authentication mechanism for OSPF and other routing protocols. This research contributes to the ongoing efforts to enhance network security and constructs the way for more secure and strong network infrastructures.

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The Commercial Efficiency of Pressure Swing Distillation of Ethanol-Ethyl Acetate Mixture

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*Abstract— —*Commercially available methods such as pressure swing distillation (PSD) have been developed to separate azeotropic mixtures. PSD provides solvent-free operation by adjusting pressure to pass azeotropic points without the need for an entrainer. This method is used for the mixing of ethanol and ethyl acetate to assess the process's commercial viability by calculating the energy needs and Total Annual Cost (TAC). A process simulation has been carried out using Aspen Plus software. The effectiveness and viability of the potential commercial process in separation may be assessed with the use of this benchmark study and process simulation. PSD is an azeotropic system that separates ethanol from ethyl acetate and has a high energy efficiency, a tolerable TAC, and high purity.

Keywords: Azeotrope; Aspen Plus; Data; property model; Energy; Total Annual Cost

INTRODUCTION

A mixture of liquids with nearly matching boiling points is called an azeotrope, often known as an azeotropic mixture. This combination transitions from the liquid to the vapor phases at a set temperature while keeping a consistent composition. We refer to this temperature as the Bancroft point. [1]. PSD is an effective technique for overcoming the azeotropic point in distillation columns by adjusting the internal pressure without the need for an entrainer. By taking advantage of the change in the azeotropic point under different pressures, PSD does not require a solvent. It's crucial to remember, though, that PSD uses greater pressures, which is linked to increased energy use. Its widespread usage is hindered by a number of factors, including as the design's complexity, the high cost required, and the difficulties with control and operation. [2]. Multiple studies have been conducted to compare the economic feasibility of utilizing PSD versus extractive distillation for separating azeotropic systems. It is found that PSD offers greater cost-effectiveness for certain azeotropic mixtures separation [3], [4]. Furthermore, in a comprehensive study by Liang et al., PSD was thoroughly examined, covering process control, dynamics, and thermodynamic models for different mixtures. [5]. Researchers have asserted that the integration of process intensification and heat integration can enhance the appeal of PSD as a separation method [6]–[8]. Furthermore, PSD has been shown to be effective for both minimum and maximum boiling mixtures, with no significant difference in energy consumption [9]. PSD has also demonstrated its capability to separate ternary mixtures [10]–[12]. Ethanol-ethyl acetate azeotropic system was selected to be separated by PSD technique. This mixture was selected due to the importance of ethanol and ethyl acetate individually in various industrial aspects such as food industry for flavor extraction, extraction and purification of active pharmaceutical ingredients, solvent for a wide range of substances and etc.

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METHODOLOGY

Azeotrope Mixture Selection Table 1: Selected azeotropic mixtures along their commercial occurrence and Bancroft point.

Mixture	Commercial Importance/ Occurrence	Azeotrope type	Azeotropic comp. @1 bar	Bancro ft pt (K)	Ref
Ethanol-Ethyl acetate	Fischer esterification reaction of acetic acid and the ethanol dehydrogenation	Minimum Boiling	0.45% Ethanol	344.5K	[13]

Table 1 provides the details of the selected mixtures for the proposed study. Ethyl acetate is made by the ethanol dehydrogenation process and the Fischer esterification reaction of acetic acid. In those procedures, the ethanol and ethyl acetate combination would unavoidably form a minimum azeotrope at atmospheric pressure that is impossible to separate using traditional distillation techniques[14].

PSD Process Description
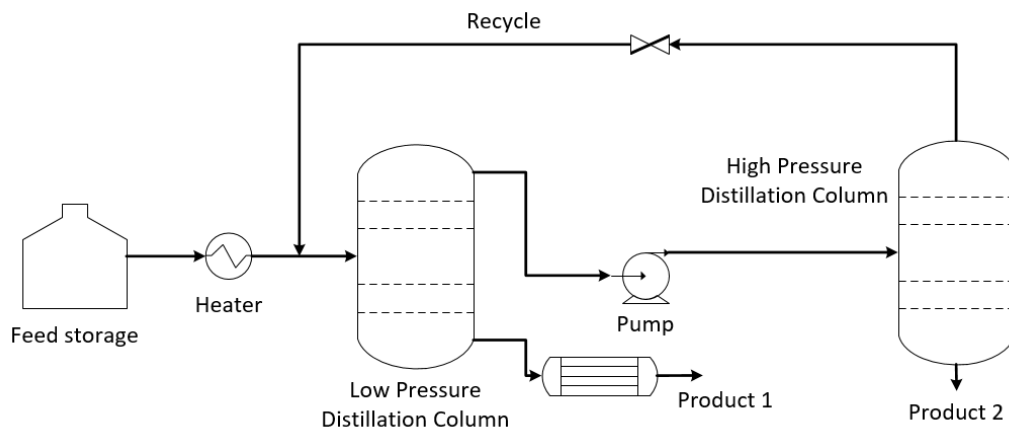
Figure 2: Process Flow Diagram for PSD.

Figure 2 illustrates the process flow sheet associated with PSD process. The PSD process consists of several units. Firstly, the azeotropic feed is heated to saturation and then enters the first distillation column at a low pressure. In the first column, one of the components is separated and discharged as the bottom product. On the other hand, the top product is a mixture with an azeotropic composition. This top product is then pumped to a second column at a higher pressure to shift the azeotropic point. The other component is then discharged as the bottom product from the high-pressure column. The top product of the second column contains a mixture of components with different azeotropic compositions. Therefore, the top stream is recycled back to the first column to complete the separation. The recycle stream is depressurized through the valve to decrease the pressure as that of the first column.

Column Design

The minimum number of stages are calculated by using the Fenske equation. An efficiency of 80% for each stage is then selected. This adjusts the total number of stages for the given column. The purity level for the product is

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constrained to above 99%. This reduces the degree of freedom for the column to one. By adjusting the number of stages other operating conditions, such as reflux ratio or distillate rate are then calculated to meet the desired product purity level.

Property Models (Vapor Liquid equilibrium)

VLE is a thermodynamic concept used in chemistry and engineering to describe the distribution of a chemical species between a vapor and liquid phase. At vapor-liquid equilibrium, each component in the liquid and vapor has a specific concentration, determined by the temperature and pressure [15]. To calculate vapor-liquid equilibrium (VLE), several parameters such as temperature, pressure, and phase compositions need to be determined. Various formulations have been proposed to facilitate this calculation, including Raoult's Law. Raoult's Law is commonly applicable in simple scenarios for a mixture of closely related components. By introducing additional factors that account for the interactions between molecules of different substances, Raoult's Law can be modified to apply to non-ideal solutions. [16]. Equation 1, represents the modified Raoult's law formulation.

$$y_i \bar{\varphi}_i^v P = x_i \bar{\varphi}_i^L \bar{\gamma}_i P_i^* \qquad \textit{Equation 1}$$

Where, $\bar{\varphi}_i^v$ and $\bar{\varphi}_i^l$ are the partial molar fugacity coefficients in vapor and liquid phases respectively. $\bar{\gamma}_i$ the activity coefficient, x_i is the mole fraction of the component in liquid phase, y_i is the vapor fraction of the component, P_i^* is the vapor pressure of the pure substance i and P is system pressure.

Several models have been developed and reported to accurately study the activity coefficient in phase equilibria calculations and predict VLE data for azeotropic mixtures. These models are based on theoretical backgrounds and have been rigorously evaluated by extensive experimentation. By employing these models, significant cost and time savings can be achieved while maintaining reliable results [17]. NRTL, Wilson, UNIFAC, and UNIQUAC are fundamental models used to estimate activity coefficients in thermodynamics. These models are employed to predict excess Gibbs energy, which is a measure of non-ideality in a system. The activity coefficients, necessary for phase equilibria calculations, are derived from the partial molar derivative of the excess Gibbs energy. These models provide a means to account for the effects of molecular interactions and deviations from ideal behavior in phase equilibrium calculations [18].

Model Validation

Figure 3, presents the prediction of the VLE data by different thermodynamic models. The maximum errors for the Wilson, NRTL, UNIFAC, and UNIQUAC models are 2.23, 2.34, 2.02, and 2.33 respectively. Although the error for the UNIFAC model is much lower, the Wilson model is the least computationally demanding and has been chosen for further investigations. Additionally, the difference between the errors of the UNIFAC and Wilson models is not substantial.

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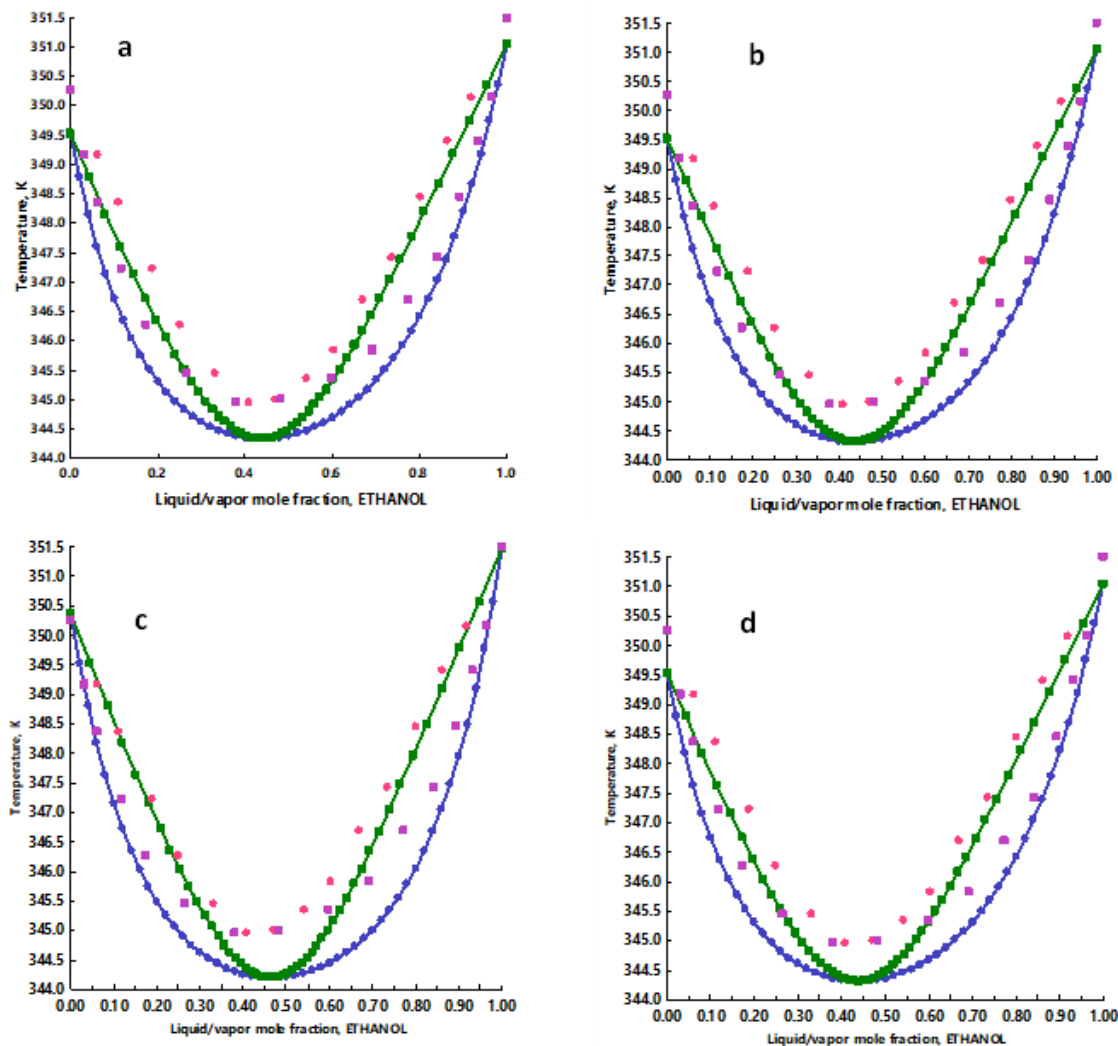**Organized by University of Wah**

Figure 3: Experimental data prediction by different models, a - Wilson, b - NRTL, c - UNIFAC and d - UNIQUAC, Continuous lines represent the models. Markers represent the experimental data[19].

Wilson model is an activity model, to determine the activity coefficients of components in a liquid combination. Using the Wilson equation as represented in Equation 10, one may compute the activity coefficients of individual components in a mixture, allowing for the prediction of a variety of thermodynamic features such as vapor-liquid equilibrium, liquid-liquid equilibrium, and excess heat with relatively low computational cost [20].

$$ln\gamma_i = 1 - ln\left(\sum_j A_{ij}x_j\right) - \sum_j \frac{A_{ji}x_j}{\sum_k A_{jk}x_k} \qquad Equation\ 2$$

Where

$$lnA_{ij} = ln\frac{V_j}{V_i} + a_{ij} + \frac{b_{ij}}{T} + c_{ij}lnT + d_{ij}T + \frac{e_{ij}}{T^2} \qquad Equation\ 3$$

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Vj and Vi are pure component liquid molar volume at the system temperature and aij, bij, cij, dij, and eij are the binary parameters that are regressed from VLE data.

Total Annual Cost analysis

The Total Annualized Cost (TAC) has been calculated by estimating several cost components. The direct cost, indirect cost, and working capital were estimated to calculate the total capital investment over a specified number of years. Additionally, the annual operating cost was calculated using Aspen Plus and then added to the annual capital investment to determine the overall TAC.

RESULTS AND DISCUSSION

Error! Reference source not found., represents the vapor-liquid equilibrium (VLE) diagram for the ethanol-ethyl a cetate binary system. At atmospheric pressure (1 bar), an azeotropic composition of 45 mol% ethanol was observed in the mixture. As the system pressure increases, the location of the azeotropic point shifts significantly. Specifically, the azeotropic composition changes to 52 mol% ethanol at 2 bar, 61 mol% ethanol at 4 bar, and 68 mol% ethanol at 6 bar. This demonstrates that applying higher pressure can considerably alter the azeotropic behavior of the ethanol-ethyl acetate mixture. The reason for this pressure-induced shift in the azeotropic point lies in the differences in the relative volatilities of the two components, ethanol and ethyl acetate. As the pressure increases, the vapor pressures of the two components are affected differently due to their distinct molecular weights and intermolecular interactions. This leads to a higher volatility difference between ethanol and ethyl acetate at elevated pressures.

While increasing the pressure can be an effective way to manipulate the azeotropic composition, it comes with a trade-off. Higher pressure operation requires additional energy input to power the necessary compression equipment, such as pumps. Therefore, a balance must be struck between the desired shift in the azeotropic point and the operational costs associated with the pressure increase. In this case, the analysis suggests that a pressure of 4 bar is the preferred choice, as it provides a significant shift in the azeotropic composition compared to atmospheric pressure, while still maintaining reasonable operational challenges. Increasing the pressure further to 6 bar would result in an even more pronounced shift in the azeotropic point, but the additional energy requirements may outweigh the benefits.

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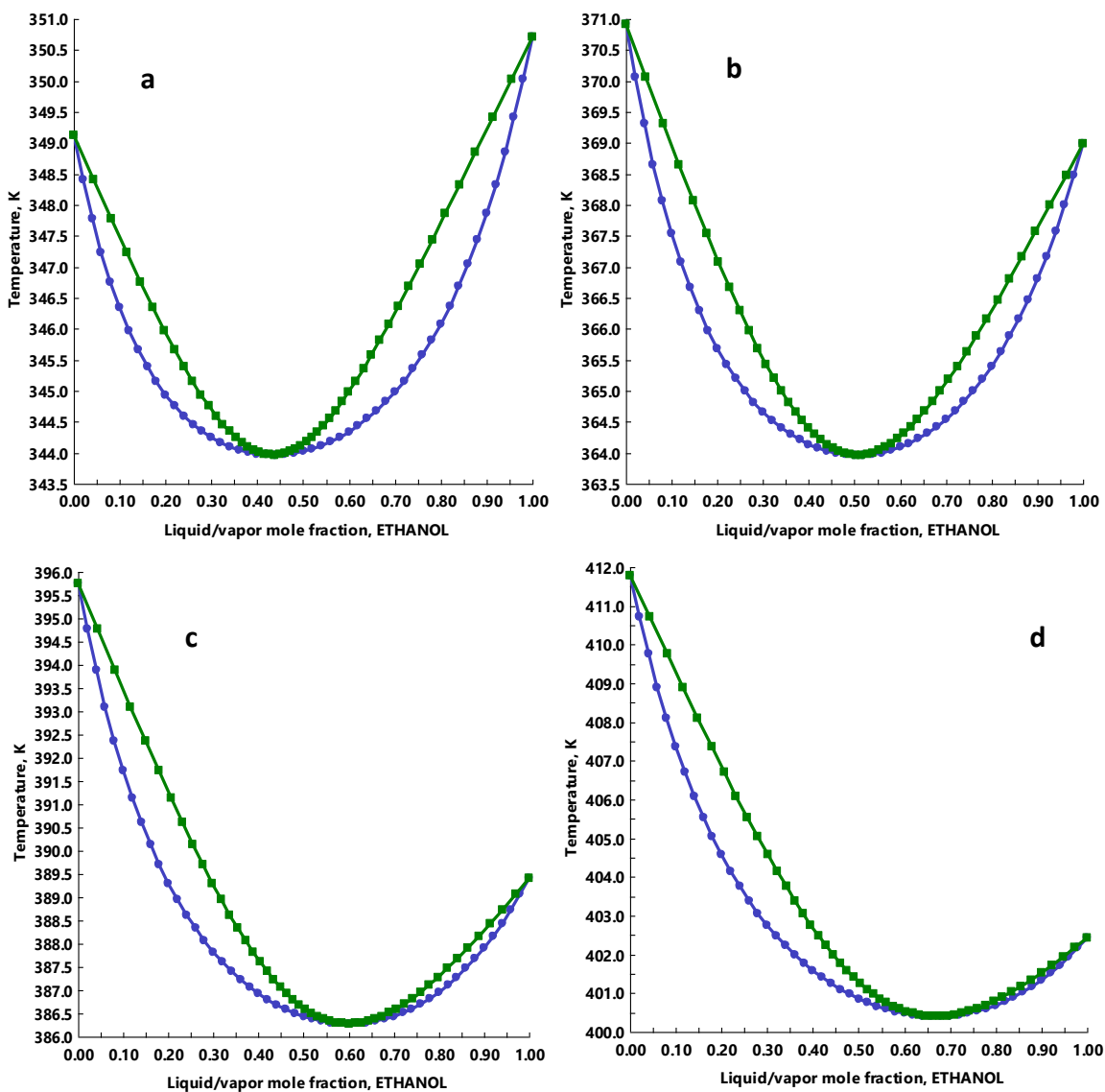**Organized by University of Wah**

Figure 4, VLE diagram for ethanol-ethyl-acetate system at different pressure, a = 1 bar, b = 2 bar, c = 4 bar , d = 6 bar.

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Table 2, Pinch analysis

Pump Energy (J/kg)	Cold Utility (MJ/kg)	Hot Utility (MJ/kg)
4.71	11.75	11.73

Table 2, the ethanol-ethyl acetate system is shown to have a high energy requirement for both cold and hot utilities, despite its components having a low heat of vaporization. The system exhibits a low average relative volatility, which further decreases rapidly with increasing pressure, necessitating higher column recycling. Moreover, as the azeotropic point approaches an equimolar composition with increasing pressure, higher recirculation rates from the second column are required to achieve the desired separation.

Table 3, Total Annual Cost analysis

TAC Million	Number of stages C1	Number of stages C2	Recycle rate (kmol/hr)
$39.88	10	10	2607

CONCLUSION

Pressure-swing distillation (PSD) is an effective method for separating ethanol-ethyl acetate mixtures. By shifting the operating pressure of the first distillation column from 1 bar to 4 bar, a high purity of 99% is achieved for the separated components. By leveraging the pressure-sensitivity of the ethanol-ethyl acetate system, and implementing thoughtful heat integration, the PSD method may produce the target high purity outputs while keeping the overall energy demands of the process at a reasonable level. This demonstrates the effectiveness of the PSD technique for separating this challenging azeotropic mixture.

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Synthesis, Spectroscopic Analysis, and Antimicrobial Properties of Pure and Copper Doped Cadmium Oxide Nanoparticles

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Abstract: The present investigation utilized the co-precipitation method to synthesize nanoparticles of cadmium oxide (CdO) and copper-doped cadmium oxide (Cu-CdO). The synthesized samples underwent various analyses, including Fourier transforms infrared (FT-IR), energy-dispersive X-ray (EDX), field emission scanning electron microscopy (FE-SEM), UV–Visible spectroscopy and XRD. Both samples had simple cubic structures and average grain sizes of 54 and 28 nm, respectively, based on the XRD analysis. The samples' surface textures were investigated using a FE-SEM. The EDX method was employed to examine the samples' elemental compositions. The vibrational modes were found using the FT-IR technique. Upon obtaining the diffuse reflectance mode UV-Vis spectra, the CdO and Cu-CdO samples' optical bandgaps were determined to be 2.83 eV and 4.52 eV, respectively. The antibacterial efficacy of the synthesized nanoparticles against gram-positive Micrococcus luteus and gram-negative Escherichia coli bacteria at different concentrations was evaluated using the Agar-well diffusion technique. In the present investigation, both samples exhibit noteworthy antibacterial activity against E. coli.

Keywords: Co-precipitation, XRD, UV–visible, FE-SEM, EDX, Agar-well diffusion.

INTRODUCTION:

The study and design of materials with dimensions between one and one hundred (nm) is known as nanotechnology. The physical and chemical characteristics of these materials will differ greatly from those of their bulk form. Because of their small size, nanoparticles exhibit a wide range of chemical and physical properties, such as optical, electrical, magnetic, and colloidal properties [1-3]. Nanoparticles have drawn a lot of attention because of their many uses in semiconductor materials, sensors, optoelectronic devices, photonics, computing, and biological domains [4-6]. Metal-oxide nanostructures can be developed and analyzed to identify fundamental phenomena in low-dimensional system applications and to design new high-performance nanodevices. Because of their optical and electrical properties, nano-sized semiconductor metal oxides are also a focus of research in the energy generation sector [7]. Due to its applications in numerous fields of study, especially optoelectronic devices like solar panels, light-emitting diodes, phototransistors, transparent electrodes, gas sensors, etc., the metal oxide semiconducting material CdO has drawn a lot of attention recently [8–10]. Cadmium oxide (CdO), an n-type oxide of the II-VI group, is naturally occurring in red monteponite or in rare mineral brown single crystals.

Because of its ionic nature, low resistance, high carrier mobility, and sufficient optical transmission in the visible range, nanoscaled CdO is a strong candidate for a wide range of technical applications in multiple domains.

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Compared to organic dyes, the performance of CdO nanoparticles is superior and they exhibit intriguing fluorescence properties [11]. The amount of time a fluorophore stays in the stimulated state before returning to its basic state and releasing a photon is known as its fluorescence lifespan [12]. Time-resolved fluorescence spectroscopy could be used to estimate a fluorophore's lifetime [13]. The relaxation process of the fluorophore is dominated by non-radiative decay when the energy gap between the energized and bottom states gets smaller. As a result, organic-based fluorophores do not provide enough information and do not have the optical characteristics needed to produce strong fluorescent signals. Using inorganic semiconductor nanoparticles is an alternate method to get around these restrictions related to organic fluorophores. The size, morphology, and bandgap of synthesized nanoparticles are used to adjust the lifetime, extinction coefficients, and quantum yield of these particles [14].

CdO nanoparticles made by a variety of synthesis methods, such as co-precipitation and microwave combustion, have been the subject of extensive study by numerous academics [15–19]. Using the microwave combustion method, a significant amount of metal oxide nanostructures in various shapes have also been synthesized. This method creates energy-efficient internal heating by allowing the microwave energy to directly interact with the reaction mixtures' dipoles [16]. The co-precipitation method, often known as the solid-state counterpart of the sol–gel process, is a successful soft chemical process for creating inorganic and metal-based nanoparticles. In this investigation, the co-precipitation approach offers a straightforward and economical synthesis strategy with readily available precursors. Numerous advantages of this method include an extremely narrow size dispersion, an eco-friendly solvent, and a high yield of products. CdO and Cu-CdO nanoparticles were created in the current study using the co-precipitation method. Comprehensive information is provided regarding the crystal structure, surface morphology, elemental composition, optical spectroscopy, and impact of copper doping on the antibacterial properties of CdO nanoparticles. Because the synthesized CdO nanomaterials are more resistant to pathogenic microbes, they could be used as an alternative to traditional antibiotics. It is important to consider the antibacterial impact of the CdO nanomaterials produced through co-precipitation techniques, as they are expected to possess a range of properties. Since most people struggle to keep up with the spiraling costs of curing pathogenic bacteria, finding an efficient low-cost method of blocking their growth and activity is imperative. The agar well method is a suitable way to test generated nanoparticles against different kinds of bacteria. This approach has been used by numerous researchers [20–22]. CdO nanoparticles have been introduced to the pathogenic microorganisms. This study delves into the impact of doping copper to CdO nanoparticles on their antibacterial efficacy against pathogenic microorganisms like Escherichia coli and Micrococcus luteus.

EXPERIMENTAL:

To create a uniform and one-phase inorganic material, the co-precipitation process, involves dissolving the starting chemicals in a general solvent first, followed by the addition of a precipitating agent. The precipitate can then be broken down at a high temperature to create the target material oxide. Co-precipitation helps to keep the required cations together in the reaction media and lowers the temperature at which the reaction breaks down. In our instance, the co-precipitation technique at 30 °C was used to create CdO and Cu–CdO nanoparticles using analytical reagent grades of cadmium chloride ($CdCl_2$), sodium hydroxide (NaOH), and copper chloride ($CuCl_2$). The necessary quantity of cadmium chloride was first dissolved in 100 milliliters of deionized water and vigorously stirred for one hour in order to form cadmium hydroxyl solution. The cadmium hydroxyl solution's pH was adjusted to 8 by gradually adding sodium hydroxide solution (a precipitating agent) drop by drop. After

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constant stirring for four hours, a milky white solution formed. After cleaning the precipitate with methanol, the precipitate was allowed to evaporate at room temperature, yielding white powdered cadmium hydroxide. After heating to 300 °C, the cadmium hydroxide particles were added to a hot air oven. The powdered cadmium oxide was obtained for later use after four hours. By adding 0.05 mol% CuCl2 to the Cadmium Hydroxyl solution and using the same synthesis method as before, the Cu–CdO nanoparticles were produced. In Figure 1, the synthesis process is shown schematically. The reaction was as follows:

$CdCl_2 + 2NaOH \rightarrow Cd(OH)_2 + 2NaCl$

$Cd(OH)_2 \rightarrow CdO + H_2O$
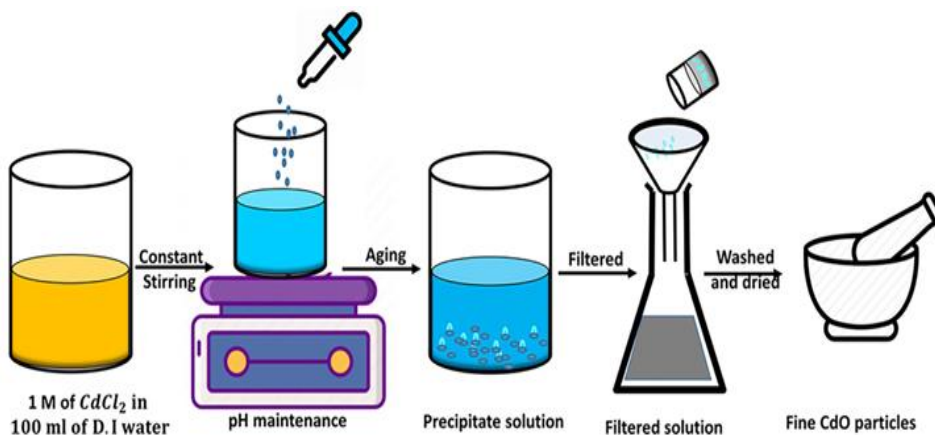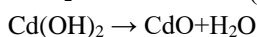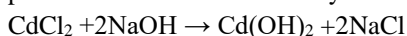
Figure 1: Schematic representation of CdO nanoparticles synthesis.

CHARACTERIZATION TECHNIQUES:

Using a D8-Advance-Bruker diffractometer, P-XRD measurements were carried out on the produced samples to offer insight into the structural phase of the generated nanoparticles. The surface textures of the produced particles were examined using a FE-SEM analyzer. Additionally, it provides crystalline information using the electron backscattered detection (BSD) system connected to a microscope to quantify EDX data. A Perkin-Elmer spectrometer was used to perform FT-IR spectroscopic measurements in the range of 4000–400 cm^{-1}. The absorption spectra were recorded in reflectance mode (DRS) using UV–Visible measurements. Diffusion on agar wells was used to test the generated nanoparticles' antibacterial properties against Escherichia coli, a gram-negative bacterium.

RESULTS AND DISCUSSION:

XRD Investigation:

Powder XRD is an important technique for determining crystal structure at the atomic level. It is a non-destructive technique with numerous applications for characterizing bulk and nanomaterials [23]. Figure 2 shows the XRD patterns of the as- synthesized CdO and Cu-CdO nanoparticles. XRD patterns show prominent and intensive diffraction peaks that correspond to CdO's simple cubic phase (JCPDS Card No: 78-1125). The XRD pattern of

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as-prepared CdO exhibits peaks at (111), (200), (101), (210), (220), (211), and (310) planes, which align with previously reported data [24]. In addition to these peaks, the XRD pattern shows several other small peaks that were not assigned. The additional peaks are thought to be caused by nanoparticle phase coagulation. The diffractogram shows that the samples have good crystallinity. The composition of nanoparticles remained unchanged after the dopant was added. The typical grain size of CdO and Cu-CdO was determined using the following Scherrer equation:

$$\text{Average grain size}, D = k\lambda/\beta_{hki}\cos\theta \qquad\qquad (1)$$

where D is the mean particle size measured in nanoscale, λ is the radiation wavelength, θ is the diffraction angle, hkl is the full-width at half maximum (FWHM), and k is set to 0.9. The XRD plots show that the CdO particles have primarily solidified with the (111) orientation. The highly intense peaks are used to estimate the mean size of the nanoparticles using Eq. (1). The diffraction curves for CdO and Cu-CdO nanoparticles showed average sizes of 54 and 28 nm, respectively. Cu doping in CdO nanoparticles reduces particle size by replacing some Cd^{2+} ions with Cu^{2+} ions in the CdO lattice. Cu^{2+} has a smaller ionic radius (0.073 nm) than Cd^{2+} (0.097 nm). When Cu^{2+} is introduced as a dopant, it replaces Cd^{2+} with tiny voids in the host lattice. These voids distort the lattice, affecting the size of Cu-CdO nanoparticles.
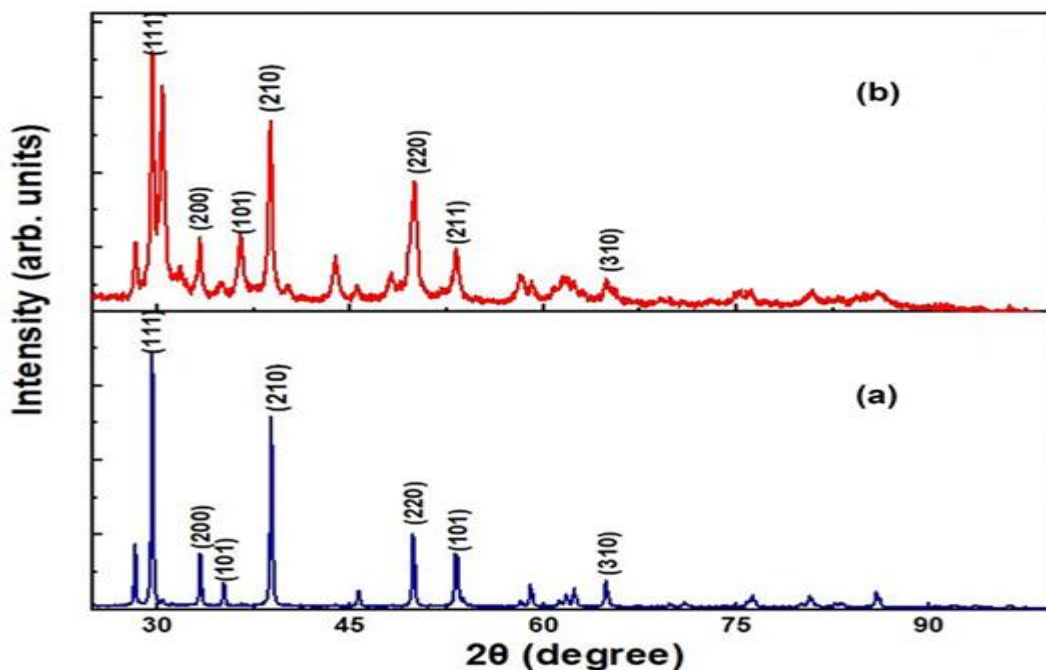
Figure 2: XRD analysis of a. CdO and b. Cu-CdO nanoparticles synthesis.

FE-SEM and EDX:
FE-SEM imaging can detect structures as small as a few nm. The FE-SEM provides high imaging performance at low accelerating voltages and close working distances. Physicists, chemists, and biologists use this technique to identify structures as small as 1 nm [25, 26]. Figure 3 shows FE-SEM images of CdO and Cu-CdO nanoparticles.

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The images show that the nanoparticles are agglomerated, homogeneous structures with clearly defined grain boundaries. These nano samples have almost spherical structures, with only a few voids in between.
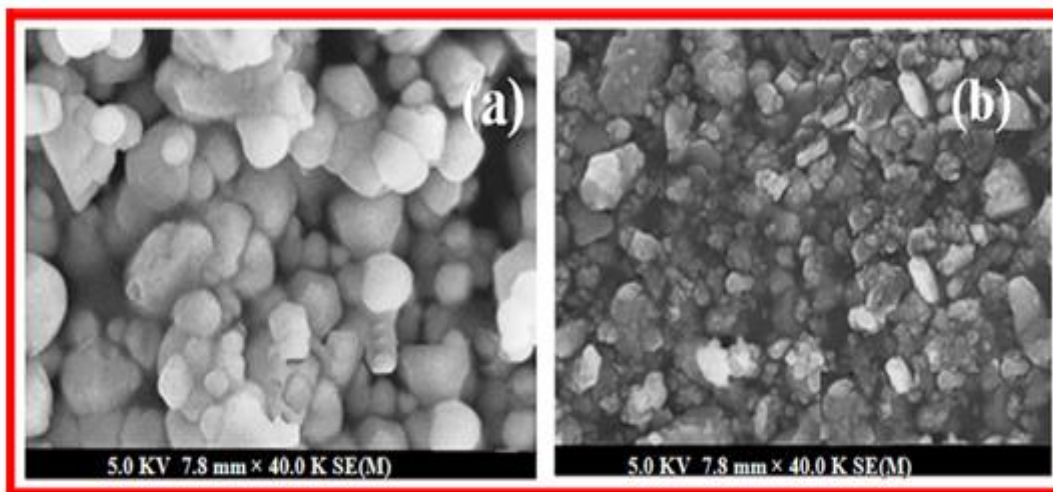

Figure 3: FE-SEM images of a. CdO and b. Cu-CdO nanoparticles.

Chemical compositions of as-produced samples were analyzed using EDX spectroscopy [27]. The spectra of prepared samples show characteristic peaks for Cd, O, and Cu, indicating the formation of CdO and Cu-CdO nanoparticles (Figure 4). The outputs for Cd, O, and Cu support the formation of pure and Cu-CdO nanoparticles. Table 1 shows the weight percentages of elements based on their EDX results. The availability of carbon, oxygen, cadmium, and copper in the right percentages facilitates subsequent formulations of CdO and Cu-CdO nanoparticles.

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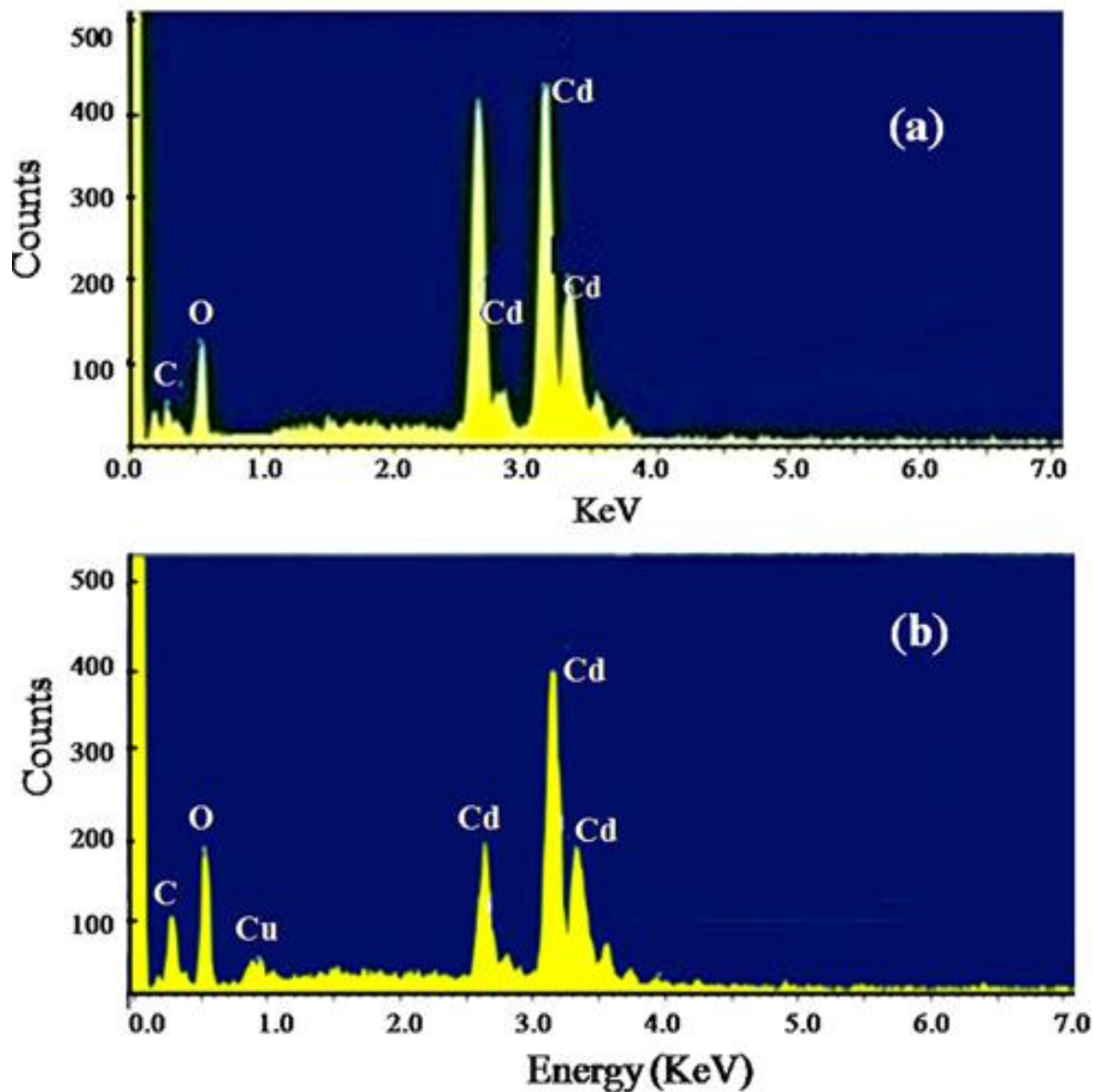
Figure 4: EDX spectra of a. CdO and b. Cu-CdO nanoparticles.

FT-IR Spectroscopy:

When determining the identity of substances, FT-IR is a very useful tool [28, 29]. The FT-IR technique has many uses, such as identifying compounds, monitoring processes, and identifying components in mixtures. The focus of this technique was to find functional groups of molecules that, when exposed to specific wavelengths, oscillate either by bending or stretching in different modes. These oscillations and their intensity are plotted against the

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wavenumber of light (cm^{-1}) at which the specimen is treated in order to create an FT-IR graph. Every compound has a different frequency at which it absorbs light, and every functional group has distinct absorption bands. Figure 5 shows the recorded spectra of the as-synthesised nanoparticles. The hydroxyl group in Cd (OH)$_2$ is stretched, resulting in the bands at 3465 and 3444 cm^{-1}. At 2928 and 2925 cm^{-1}, the band linked to C-H asymmetric stretching is visible.

The vibrations of the water molecule are linked to a peak at roughly 1628 cm^{-1}, which is most likely the result of water adsorption brought on by KBr compression of the powdery nanoparticles. The peak at 1448 cm^{-1} is attributed to the asymmetric stretching of water molecules that are connected to the produced CdO. Absorbance at 857 cm^{-1} is associated with the Cd–O bond's stretching vibrations. The generation of Cd–O is indicated by the bands at 618, 617, 465, and 441 cm^{-1}. The literature that is currently available indicates that the typical bands of the Cd–O are the intense I.R. peaks at approximately 500, 1000, and 1400 cm^{-1}. Consequently, we deduce that hydroxyl (–OH) and cadmium (Cd^{2+}) ions are present in the precursor nanoparticles that were formed.
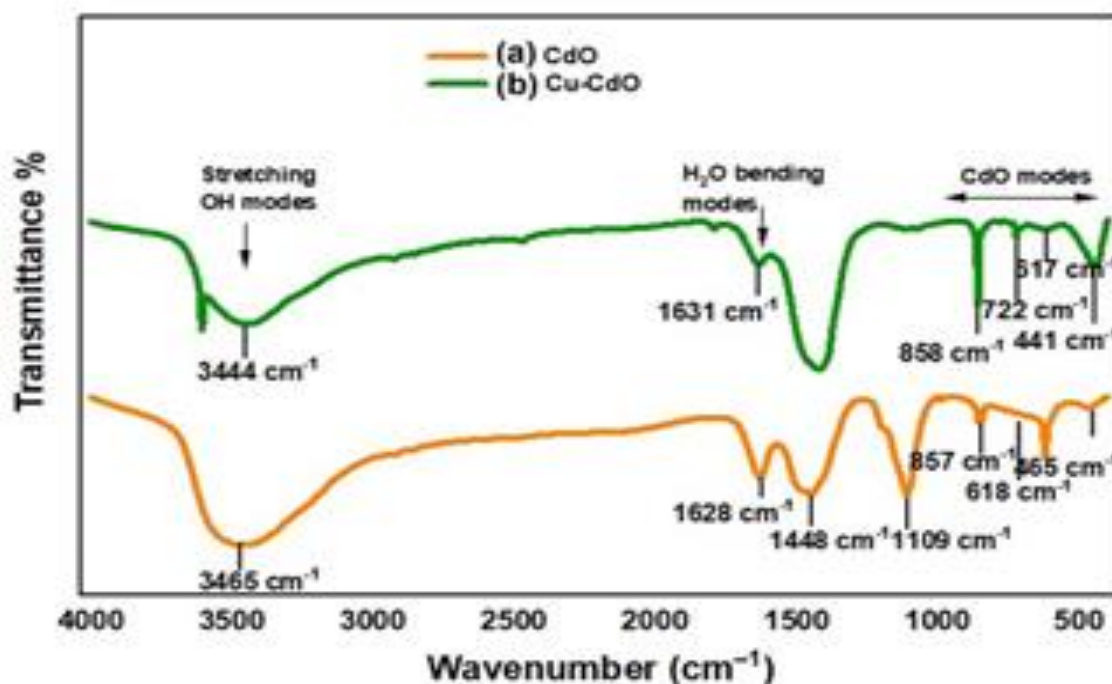
Figure 5: FT-IR spectra of CdO and Cu-CdO nanoparticles.

UV-Visible Spectroscopy:

With UV-Vis Spectroscopy, a material's chemical, molecular, and structural characteristics are recognized, determined, and quantified. The electromagnetic spectrum is absorbed or emitted in different amounts by different types of atomic particles. This characteristic makes it possible for spectroscopy to identify and evaluate the sample's nature [30]. The diffuse reflectance mode curves were measured in the 200–1000 nm range. The reflectance spectra that were recorded are shown in Figure 6, and the bandgap of the synthetic samples is shown

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in Figure 7. As demonstrated in Eq. (2), the reflectance spectra of a CdO and b Cu–CdO nanoparticles are utilized to convert the reflectance statistics into absorbance statistics.

$$F(R) = (1-R)^2/2R \tag{2}$$

where R denotes the reflectance (%) and F(R) is the Kubelka-Munk function. Tauc's plot is obtained by plotting the K-M function $[F(R)hv]^n$ vs photon energy h, where v is the beam's frequency and h is Planck's constant. For the prepared samples, the optical cut-off edge is detected at 273 nm. The absorption edge of Cu-CdO is blue-shifted in comparison to CdO. CdO's absorbance spectra have a distinctive cut-off edge at 436 nm, which rapidly decreases at longer wavelengths.
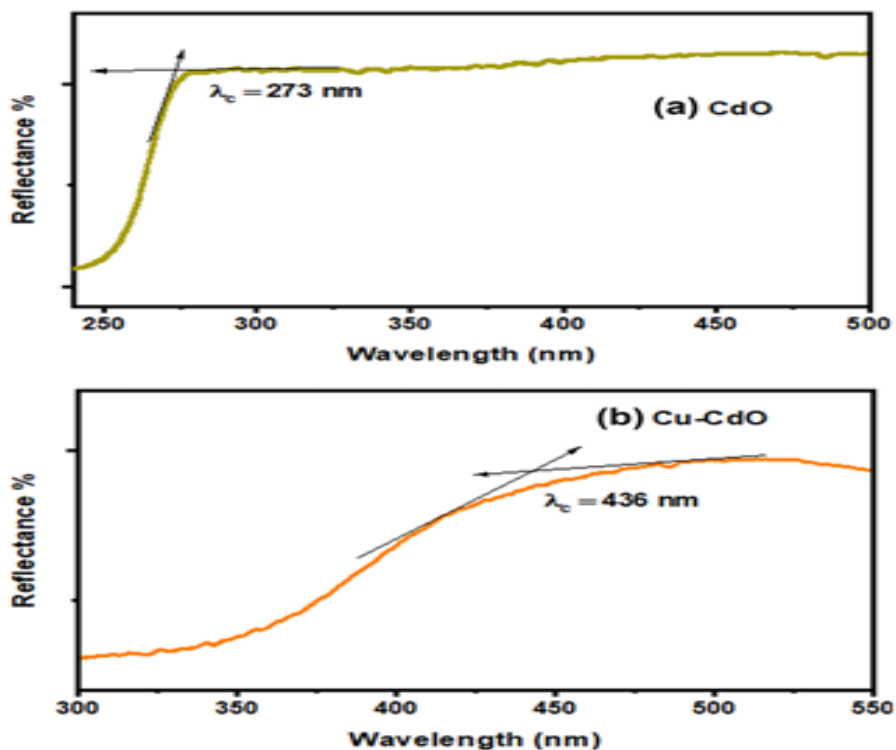
Figure 6: UV-Visible spectra of a. CdO and b. Cu-CdO nanoparticles.

For CdO and Cu-CdO nanoparticles, the optical bandgap (Eg) values that correspond to the absorption edges are 4.52 and 2.83 eV, respectively. The CdO nanoparticle's bandgap is greater than bulk CdO's (2.30 eV), suggesting a red shift brought on by the quantum confinement of nanoparticles [31].

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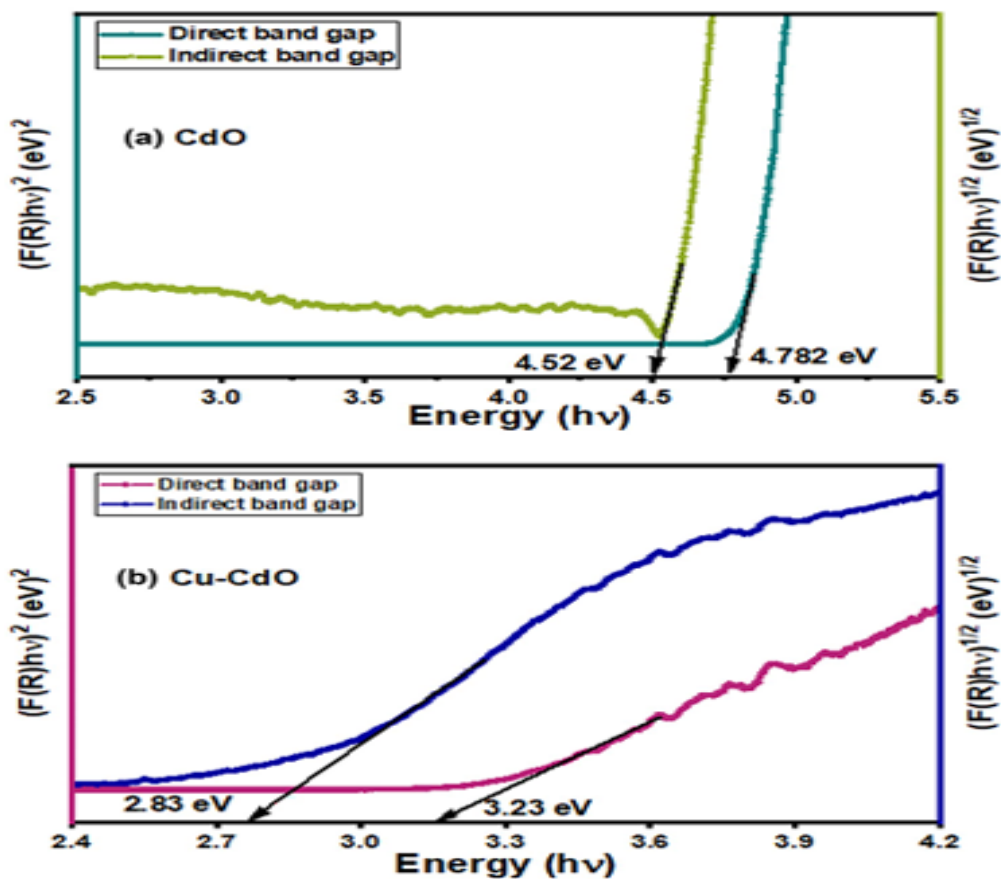
Figure 7: Band-gap values of a. CdO and b. Cu-CdO nanoparticles.

Antibacterial Activity:

Much attention is being paid to the high rate of resistance of different microbes to the majority of antimicrobial drugs. Pathogenic microbes resistant to antibiotics are a major threat to animal and human health. Because therapeutic antimicrobial agents are used so extensively, antimicrobial resistance continues to rise at an alarming rate. Mueller-Hinton agar is widely used to test for antibiotic susceptibility. Clinical diagnosis uses Mueller-Hinton agar [36-37]. The antibacterial effects of the produced nanoparticles against gram-negative Escherichia coli bacteria were tested at concentrations of 100, 150, and 200 µg/mL using the diffusion technique on agar wells. Figure 8 shows the antibacterial response of CdO and Cu-doped CdO nanoparticles, and Table 1 and 2 lists their zones of inhibition against E. coli. Samples create a well-defined zone around them due to the bacterial strains' susceptibility to CdO and Cu–CdO nanoparticles. The zone of inhibition that is visible on the agar plate indicates how much the nanoparticles have inhibited the effect. If the sample's inhibitory region is wider than 6 mm, it is generally regarded as having more potent antibacterial activity. In the current study, both samples exhibit significant efficacy against the bacteria. At higher concentrations, the antibacterial activity was more noticeable. Cu–CdO nanoparticles demonstrated a maximum inhibitory region of 23 mm, while CdO nanoparticles

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demonstrated a maximum inhibitory region of 18 mm for the E. coli at a concentration of 200 µg/mL. The bacteria's functional groups, such as -SH, -COOH, and -OH, in the cell membrane are reacted with by the nanoparticles before they penetrate the bacteria's membrane during interaction. The inactivation of DNA and cell proteins results in the death of bacteria [38]. Because of the production of cadmium ions and the presence of reactive oxygen species (ROS), CdO nanoparticles have a strong antibacterial effect. Increases in surface area, particle size, oxygen vacancies, and reactant molecule mobility are linked to higher ROS. ROS contain superoxide (O^{-2}) and hydroxyl (OH^-) radicals, which have the ability to damage cell membranes and DNA [39]. The bacteria and nanoparticles bind together due to their electrostatic affinity. There is no way for bacteria to grow here.

Figure 8: Antibacterial activity of CdO and Cu-doped CdO nanoparticles against E.coli.

Table 1: Zone of Inhibition of CdO nanoparticles against E.coli.

Sr. No.	Concentration (µg/ml)	Zone of Inhibition (mm)
1.	100	14
2.	150	16
3.	200	18

Table 2: Zone of Inhibition of Cu-doped CdO nanoparticles against *E.coli.*

Sr. No.	Concentration (µg/ml)	Zone of Inhibition (mm)
1.	100	15
2.	150	17
3.	200	23

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CONCLUSION:

The co-precipitation method was used in this work to create CdO and Cu-doped CdO nanoparticles. Powder-XRD, FE-SEM, EDX, FT-IR, UV-Vis, and antibacterial efficacy have all been used to characterize the samples. The CdO and Cu-CdO nanoparticles have simple cubic structures and average grain sizes of 54 and 28 nm, respectively, according to the powder-XRD study. The synthesized samples are porous and homogenous, as demonstrated by FE-SEM images. Using EDX spectra, the elemental composition has been determined. The generated samples' vibrational frequencies were determined using FT-IR analysis. The bandgap values of the CdO and Cu–CdO nanoparticles were 2.83 eV and 4.52 eV, respectively, based on UV–Vis spectroscopy. The produced nanoparticles' antibacterial activity against the gram-negative Escherichia coli bacteria was evaluated at different concentrations using the Agar-well diffusion method. At 200 µg/mL concentration, both samples demonstrated a significant antibacterial response against Escherichia coli. Escherichia Coli showed a maximum inhibitory zone of 23 mm for Cu–CdO nanoparticles and an 18 mm maximum inhibitory region for CdO nanoparticles. The results suggest that CdO and Cu–CdO nanoparticles could be applied as a coating to hand and surgical instruments to avoid contamination, especially from the dangerous bacteria.

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Synthesis and characterization of Ni-doped ZnO Nanoparticles for potential antibacterial activity against *E. coli*.

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Abstract: The physiochemical characteristics and antibacterial activity of highly ionic metal oxide nanostructures make them promising. Zinc Oxide (ZnO) nanostructures are known to have pathogen-inhibiting activity. When ZnO doped with different metals its activity enhanced. Ni-doped ZnO nanoparticles (NPs) were synthesized and investigated their antibacterial properties against *E. coli*. Ni-doped ZnO nanoparticles were synthesized by the co-precipitation method and subsequently characterized by different techniques such as scanning electron microscopy (SEM), X-ray diffraction (XRD), UV-visible spectroscopy, and Fourier transform infrared spectroscopy (FT-IR) and Energy Dispersive X-ray (EDX). The analysis of presenting a functional group of synthesized Ni-doped ZnO nanoparticles confirmed by FTIR spectra. Ni-doped ZnO nanoparticles have smooth surfaces in their morphologies, as proven by SEM image, and EDX analysis has verified the elemental presence of Ni, Zn, and O. The average grain size of 42 and 60 nm of the synthesized Ni-doped ZnO nanoparticles confirmed by SEM image. The antibacterial activity of Ni-doped ZnO nanoparticles was investigated through the Agar-well diffusion method. The synthesized Ni-doped ZnO nanoparticles showed better antibacterial activity against *E. coli* as compared to pure ZnO nanoparticles.

Keywords: Metal oxides, Doped, XRD, EDX, SEM, Co-precipitation, Agar-well diffusion.

INTRODUCTION

Nanoparticles are becoming increasingly important in science, technology, and medicine. They are incredibly small, which makes them highly reactive, especially when interacting with biological systems. This reactivity is one of their main advantages, they are designed to do things that larger particles or bulk materials just can't [1]. Transition metal-doped semiconductors have sparked significant interest due to their versatile applications. These materials are being used in a range of high-tech devices, including short-wavelength lasers, ultraviolet detectors, and field-effect transistors. They also play a crucial role in nonlinear varistors and highly sensitive chemical sensors. The diverse uses of these doped semiconductors highlight their importance in advancing technology and improving performance across various fields. The unexpected and amazing characteristics of compound semiconductor nanocrystals have attracted the curiosity of several researchers. ZnO nanoparticles have been the focus of significant investigation since last few decades because of their remarkable applications in the field of optoelectronics because of their high exciton binding energy and broad bandgap (3.37 eV) [2]. The effects of

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doping ZnO nanoparticles with transition metals like cobalt (Co), Silver (Ag), Iron (Fe), Manganese (Mn), and Copper (Cu) have recently caught the attention of scientists and researchers. Numerous studies have demonstrated that when ZnO is doped with different transition elements its properties will enhanced such as a striking shift in their various luminous and magnetic characteristics [3]. The room-temperature ferromagnetic behavior of zinc oxide nanoparticles doped with transition metals (Co, Mn, Fe, and Cr) has been studied by several researchers [4]. Nickel is one of the essential dopants to reach Curie temperature (Tc) above room temperature among all these magnetic metals. Different metals doped with ZnO and showed many applications as shown in Table 1.

Table 1. Different metals doped with ZnO Nanoparticles

Sr.No	Nanoparticles	Method	Particle Size	Structure	Applications	Reference
1	Ca-doped ZnO	Sol-gel Method	27-32 nm	Wurtzite phase	Sensors	[5]
2	Ag-doped ZnO	Precipitation Method	20.3 nm	Hexagonal Wurtzite	Antibacterial	[6]
3	Au-doped ZnO/Ag-doped ZnO	Combustion Method	20 nm to 10 nm	Hexagonal Wurtzite	Antifungal, Antimicrobial	[7]
4	Co-doped ZnO	Co-precipitation Method	21 nm and 35 nm	Hexagonal Wurtzite	Antibacterial Activity	[8]

The nanoparticles (NPs) of different materials of interest can be synthesized using a variety of chemical, physical, and biological methods. However, some chemical techniques were employed to use techniques such as spray pyrolysis, co-precipitation [9], hydrothermal [10], sol-gel, direct precipitation [11], and solvo-thermal to manufacture the ZnO nanoparticles.

SYNTHESIS OF ZnO AND Ni-DOPED ZnO NANOPARTICLES
Zinc acetate dihydrate (Zn (CH$_3$COO) $_2$·2H$_2$O) was dissolved in distilled water and stirred for an hour to produce pure ZnO nanoparticles. Sodium hydroxide (NaOH) solution was then added drop by drop to maintain a pH of 10. The mixture was stirred for about three hours at room temperature and allowed to age for 24 hours under the same conditions. After aging, the resulting white precipitates were centrifuged, filtered, and thoroughly washed with distilled water. Finally, the precipitates were formed and then calcinated at 500°C for 2 hours. Nickel acetate (Ni (CH$_3$COO) $_2$·2H$_2$O) was mixed with a zinc acetate solution in the correct proportions to produce Ni-doped ZnO

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nanocrystals. Aqueous NaOH was added drop by drop to reach a pH of 10. Ni-doped ZnO nanoparticles were formed through this process, following the same method used for creating undoped ZnO nanoparticles.

ANTIBACTERIAL ACTIVITY

The produced ZnO and Ni-doped ZnO NPs were tested for their antimicrobial properties against Gram-negative (E. coli) bacteria. The antibacterial activity of ZnO and Ni-doped ZnO was investigated using nanoparticles and the Agar well diffusion method. Specific microbe cultures were established at 35°C on nutrient broth by vigorously shaking the incubator at 200 rpm. Every isolated bacterial culture was evenly distributed throughout the plates using a sterile spreader. We initially uniformly spread 150 µL of the liquid culture over the nutrient agar plate's surface to set up a bacterial culture. We let the plates remain upright for roughly 20 minutes after spreading to enable the culture to seep into the agar. Next, we precisely made 9 mm wells in the agar using sterile micropipette tips. To prevent the sample from leaking out, each well was sealed from the bottom with 10 µL of molten agar. After sealing, we poured a 60 µL suspension of doped ZnO nanomaterials in distilled water (at a concentration of 60 µg/100 µL) into each well [12]. After that, the plates were incubated for 24 hours at 35°C. We saw a zone of inhibition build around the wells during this period, which suggests that bacterial growth was slowed down. To evaluate the efficacy of the nanoparticles, we measured these zones. Distilled water was used as a negative control. After that, we made another set of plates with wells loaded with nanomaterials and exposed them in the sunlight for two hours, maintaining the ideal incubation temperature.

CHARACTERIZATION OF PURE AND Ni-DOPED ZnO

Using an X-ray diffractometer, a precise analysis of the structural characteristics of undoped and Ni-doped ZnO nanoparticles was conducted. SEM was used to determine and predict the surface morphology or structural characteristics of both pure and doped synthetic materials. UV-visible spectroscopy, IR spectroscopy, and EDS were also used for the determination of absorption of light, functional group, and elemental composition of synthesized materials.

A.   X-ray diffraction (XRD) study of pure and Ni-doped ZnO Nanoparticles

Using the XRD technique, we examined the crystalline structure of Ni-doped ZnO and pure ZnO nanoparticles. The X-ray diffraction of Synthesized Pure ZnO and Ni-doped ZnO is shown in "Fig .1a, b". X-ray diffraction (XRD) patterns of the produced Ni-doped ZnO and pure ZnO samples. Without any imperfections or secondary phase production, synthesized nanoparticles showed the hexagonal wurtzite phase. The XRD patterns clearly show all the characteristic diffraction peaks associated with the Wurtzite structure, including the (100), (002), (101), (102), (110), (103), (200), (112), (201), (004), and (202) planes [13]. These peaks closely match the standard values from JCPDS card no. 01-079-2206.

When comparing the Ni-doped ZnO nanoparticles to the undoped (pure) samples, we notice a noticeable decrease in peak intensity in the XRD patterns "Fig.1a, b". This reduction suggests that doping with nickel has significantly impacted the crystalline structure of the ZnO nanoparticles, leading to a less crystalline material overall.

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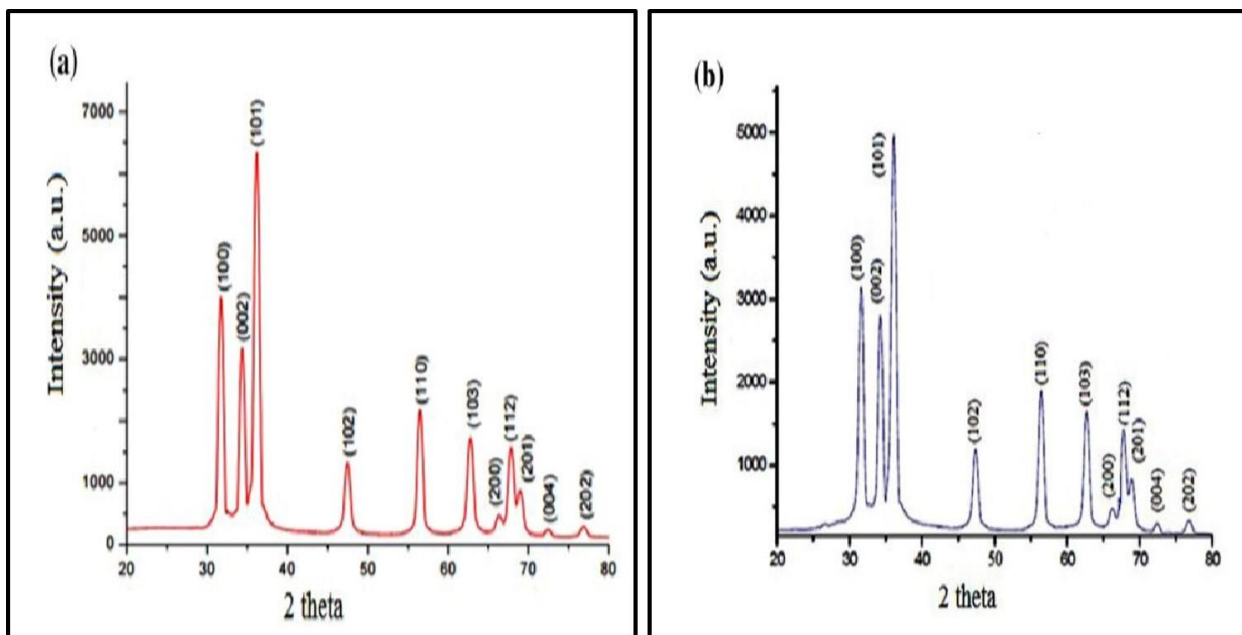**Organized by University of Wah**

Fig.1. X-ray diffraction spectra of ZnO and Ni-doped ZnO.

B.   Scanning electron microscope (SEM) Study of Pure and Ni-doped ZnO Nanoparticles

The analysis of the surface morphology of both pure and Ni-doped samples was done using scanning electron microscopy (SEM). The "Fig. 2a,b" displays the SEM pictures of and Zn0.95Ni0.05O nanoparticle samples, with about 65 and 60 nm, respectively, as the average particle size. The pure ZnO nanoparticle sample's SEM image showed that the nanoparticles have a considerable aggregation and are spherical. The "Fig.2b" clearly shows that the Ni-doped ZnO nanoparticles have minimal aggregation, appearing quite uniform in size with only slight variation. However, there seems to be a discrepancy between the nanoparticle sizes observed in the SEM micrographs and those estimated from the XRD spectra [14]. XRD measurements provide valuable insights into the crystallographic structure, while SEM analysis focuses on the particle size by examining distinct grain boundaries. By calculating the differences between these noticeable boundaries, we can better understand the crystalline surface area that effectively diffracts X-ray waves. This combination of techniques allows for a more comprehensive understanding of the material's properties.

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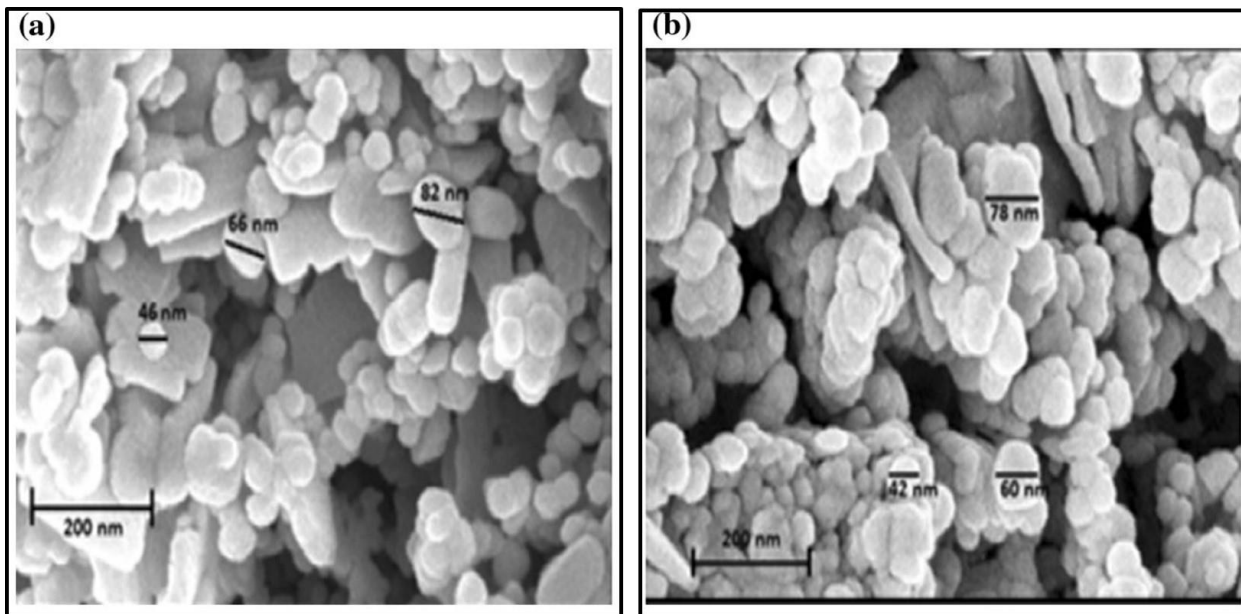
Fig.2. Image of Scanning Electron Microscope of ZnO and Ni-doped ZnO.

C.   *Energy dispersive X-ray spectroscopy (EDS) OF Ni-doped ZnO*

The ZnO nanoparticles that were produced, both doped and undoped, had their elemental composition evaluated by energy dispersive X-ray spectroscopy (EDS) as demonstrated. In "Fig.3". Ni, O, and Zn are confirmed to be present in the doped sample by the EDS analysis, and no other impurity elements or phases are detected. The "Fig.3" shows the Ni-doped ZnO NPs sample's EDS spectrum. The EDS spectra of the synthesized Ni-doped ZnO sample reveal that it primarily consists of Zn, Ni, and O elements. Notably, the spectral peaks for oxygen and zinc are found at 0.5 keV, 8.5 keV, and 9.6 keV, respectively. This analysis confirmed the presence of these elements in the sample.

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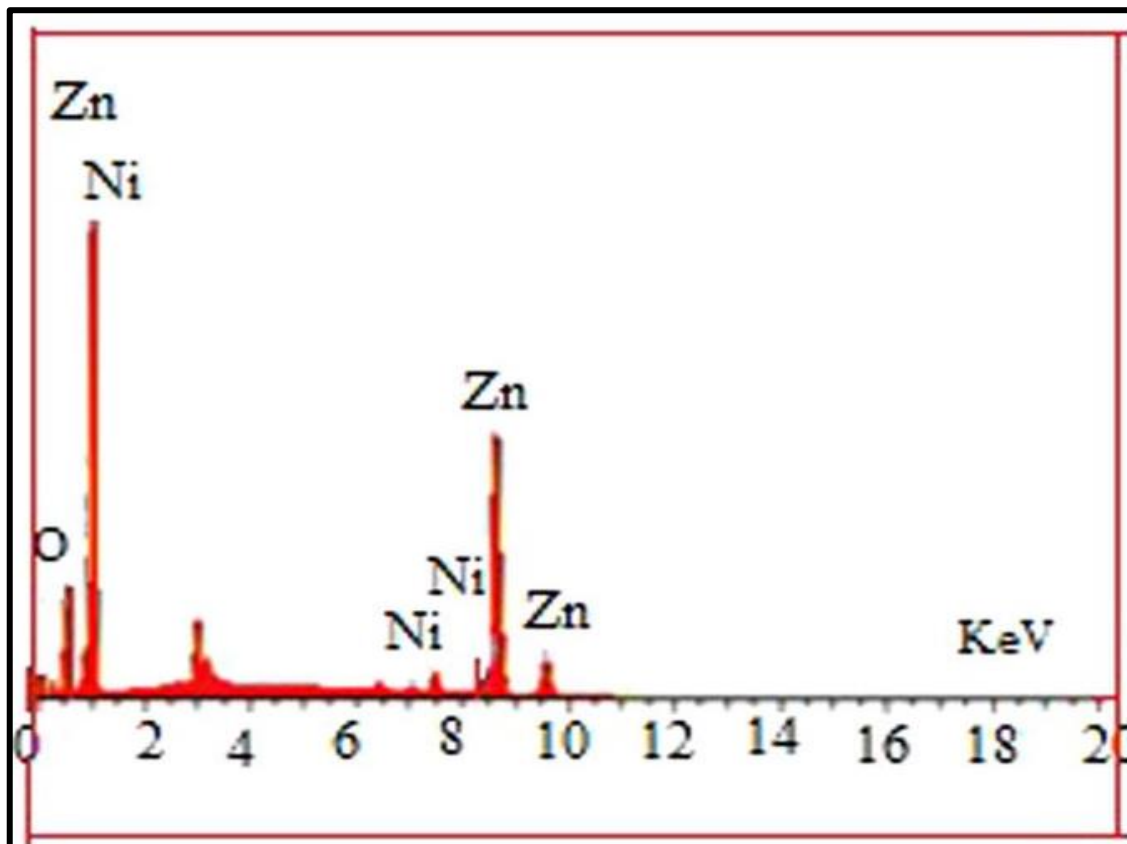
Fig.3. Graph of Energy dispersive X-ray spectroscopy (EDS) OF Ni-doped ZnO

Additionally, the XRD results reinforce the findings from the EDS, demonstrating that the Ni-doped ZnO nanoparticles were successfully synthesized using the wet chemical precipitation method. Together, these techniques provide a solid verification of the material's composition and structure.

    A.   UV-visible spectra of Pure and Ni-doped ZnO

As the size of the particle is lowered to the nanoscale, the optical characteristics of undoped ZnO NPs become more and more apparent. UV-visible absorption spectroscopy effectively studied the optical characteristics of both pure ZnO and Ni-doped ZnO NPs [15]. The group gap of these compound semiconductor nanoparticles differs because the ZnO crystal structure might have distinct crystal defects caused by different dopants. The "Fig.4" illustrates the UV–visible absorption analysis of pure ZnO and Ni-doped ZnO nanoparticles in the 300–800 nm wavelength range. The size of the nanoparticles and any imperfections or abnormalities in the grain structure are the only variables that affect the absorbance value. The absorption edge begins to shift toward lower wavelengths (blue shift) as the Ni doping concentration is varied from pure ZnO, further suggesting. If there is an increase in the band gap (Eg), which is caused by flaws or strain. The reduction in crystallite size of the Ni-doped ZnO sample caused by all of these causes further supports the results of our XRD spectra. With the absorption peak at 390 and 387 nm respectively, "Fig.4" displayed the absorption spectra of pure ZnO and Ni-doped ZnO nanoparticles. The

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undoped ZnO NPs' spectra show the edge absorption peak at 390 nm, which is caused by exciton recombination at ambient temperature. The band gap energy for both Ni-doped and undoped (pure) ZnO nanoparticles (Eg = hc/k).

The optical band gap value determined in our pure ZnO sample is smaller (3.19 eV) than the bulk ZnO material's typical band gap value (3.3 eV). However, a fair agreement between the observed and the Eg value is noted in the literature [16]. The integration of Ni_2? Ions into the ZnO host lattice are responsible for the rise in band gap energy with an increase in Ni concentration. The combination of quantum confinement effects and zinc doping in ZnO nanoparticles can lead to increased band gap energy and a shift in absorption towards shorter wavelengths, making them suitable for various applications, such as optoelectronics and photocatalysis.
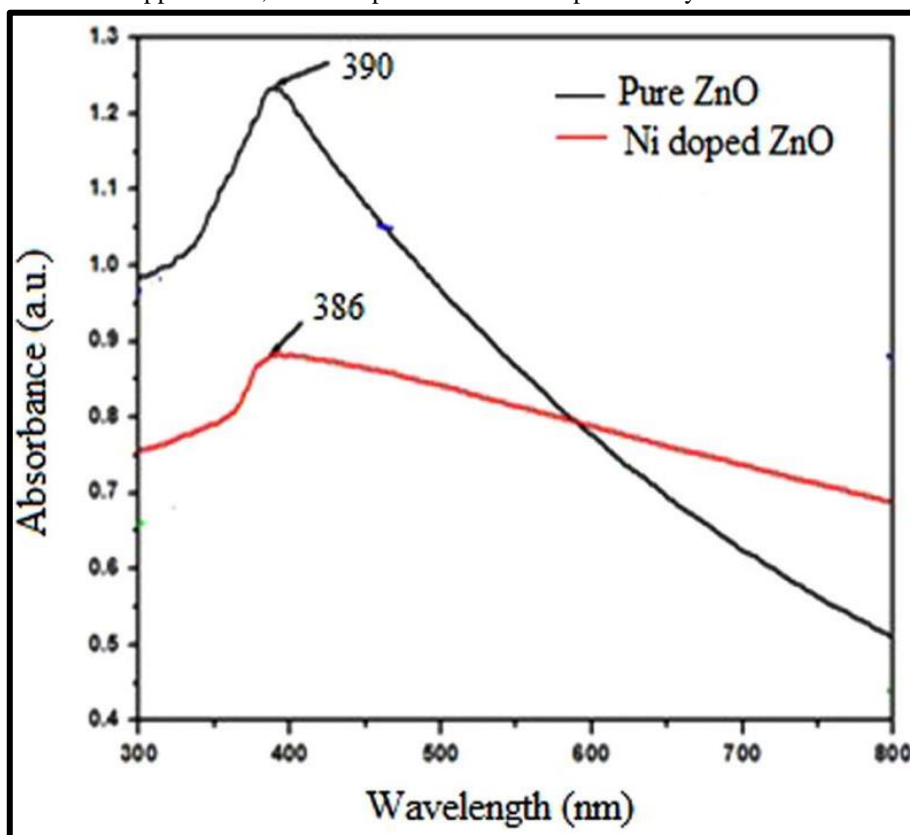
Fig.4. Uv-Visible spectra of Pure ZnO and Ni-doped ZnO.

B. FTIR study of pure (undoped) and Ni-doped ZnO nanoparticles

The material's elemental constituent and the existence of different functional groups in the material were obtained using an FTIR spectrum. It also provides details about potential incoming and outgoing species that could be present on a material's surface. The FTIR spectra pure and Ni-doped ZnO are found to have a variety of series with peak ranges ranging from 400 to 4000 cm^{-1}. These series demonstrate the presence of different functional groups and chelisorbed species. Aside from this, the vibra-tional frequencies of doped and undoped ZnO nanoparticles

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were discovered using FTIR spectroscopy analysis. The "Fig.5" illustrates the FTIR spectra of the pure and Ni-doped ZnO NPs. The vibration mode of the O-H group is indicated by the appearance of an absorption peak between 3025 and 3655 cm^{-1} [17]. The peaks of absorption detected with the value of 3458 cm^{-1} in both the Ni-doped and undoped samples are caused by the O-H stretching of surface-absorbed H2O molecules. The symmetric and asymmetric character of the C–H group is responsible for the peaks located at 2855 and 2955 cm^{-1}. Due to the presence of CO2 molecules in the air, an absorption peak was seen at 2340 cm^{-1} [18]. The presence of nickel in the ZnO lattice structure caused the weak absorption band, which was detected at 870 cm^{-1}, to have a Ni–O vibrational frequency [19].
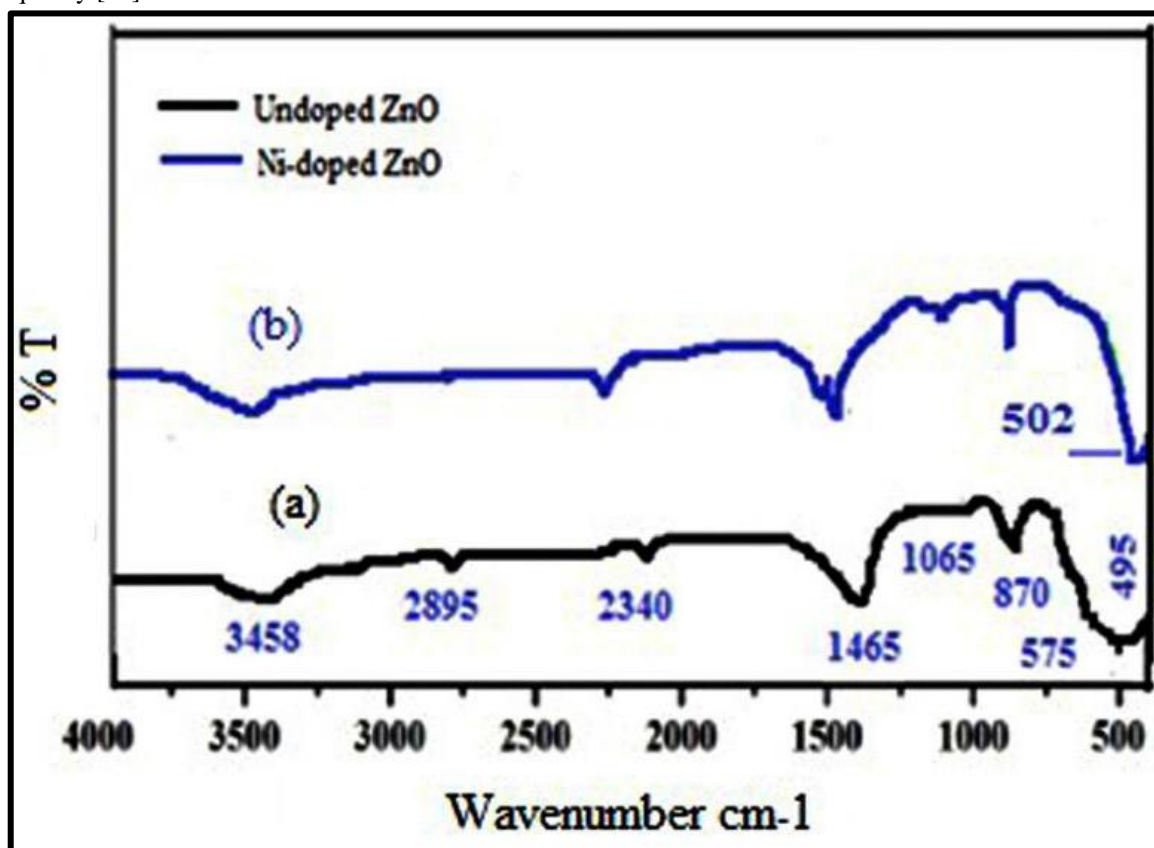
Fig.5. FTIR spectra of Pure and Ni-doped ZnO.

ANTIBACTERIAL ACTIVITY OF PURE AND Ni-DOPED ZnO NANOPARTICLES

In the current study, E. coli was tested using both pure and Ni-doped ZnO nanoparticles, employing a nanoparticle diffusion approach. Numerous studies have highlighted the antibacterial efficacy of ZnO, attributing it to several key factors. Nanoparticles often exhibit enhanced antibacterial properties due to their larger surface area, which allows for increased interaction with bacterial cells. Additionally, the presence of oxygen vacancies in ZnO can lead to the generation of reactive oxygen species (ROS) [20]. These ROS play a crucial role in disrupting bacterial cell membranes and metabolic functions. Moreover, the release of Zn^{2+} ions contributes to the overall antibacterial

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effect, as they can interfere with various cellular processes in bacteria. Reactive oxygen species (ROS) such as hydroxyl radicals, superoxide, and hydrogen peroxide can cause significant DNA damage, potentially leading to cell death. The generation of ROS is influenced by the surface area and crystalline size of nanoparticles, particularly those with enhanced photocatalytic activity. Larger surface areas and smaller crystalline sizes facilitate the creation of more oxygen vacancies, which in turn boosts the production of ROS [21]. In the case of ZnO nanoparticles, these oxygen vacancies are crucial for their antibacterial properties, and their formation is linked to the availability of Zn^{2+} ions. Ni-doped ZnO nanoparticles showed enhanced activity as compared to the pure ZnO nanoparticles. Ni-doped ZnO showed a 22mm zone of Inhibition, Pure ZnO showed a 13mm zone of Inhibition and control showed no zone of Inhibition as shown in "Fig.6".
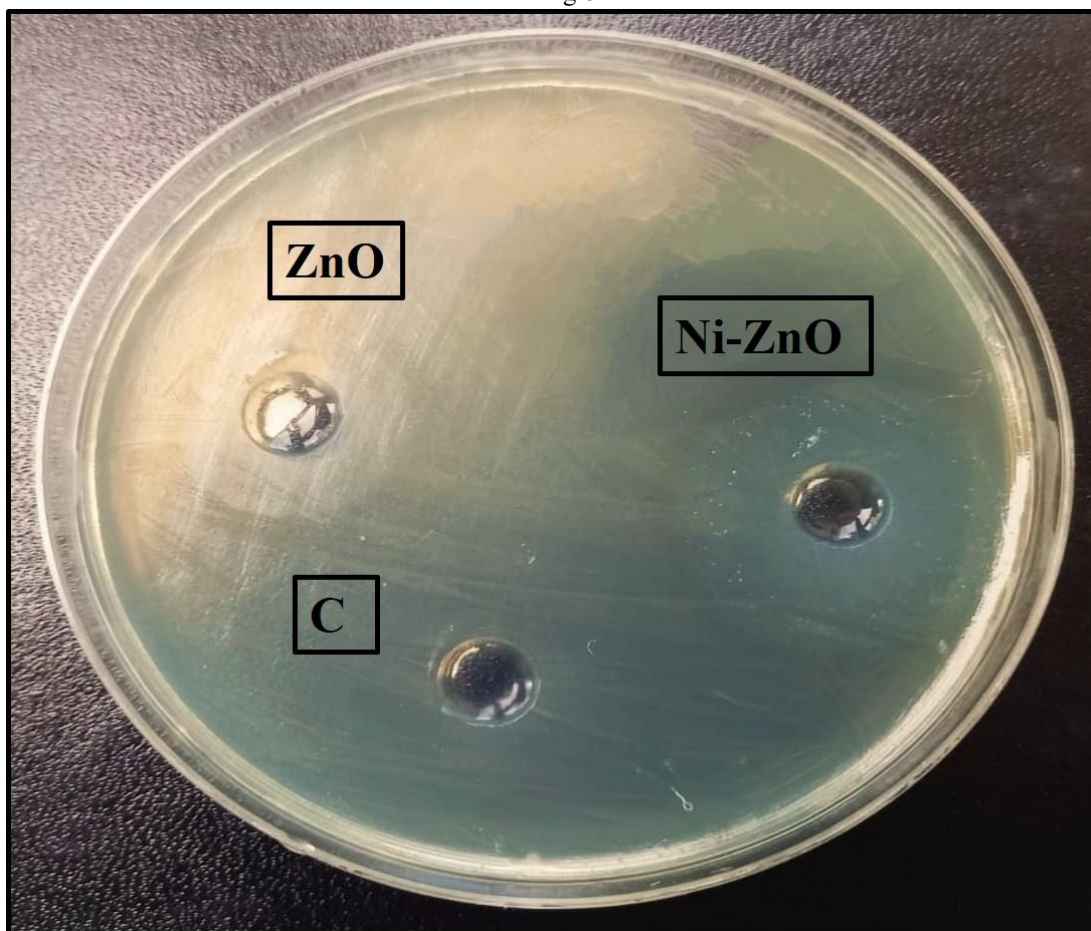
Fig.6. Zone of inhibition of Synthesized Pure and Ni-doped ZnO Nanoparticles against E.coli.

CONCLUSION

Through chemical precipitation method synthesis of pure and nickel-doped ZnO nanoparticles with a distinct wurtzite structure was successfully accomplished. XRD spectra verified that Ni ions had been integrated into the structure. Zn ion location within the host ZnO matrix. Using the SEM method, the spherical morphology of both

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pure and doped ZnO nanoparticles was verified. The elemental composition of Zn, O, and Ni was validated by EDS spectroscopy, which also demonstrated the existence of nickel ions as dopant ions in the host lattice. In comparison to pure ZnO nanoparticles, the UV absorption spectrum of the nickel-doped sample shows a blue shift in wavelength. This indicates an increase in the band gap, suggesting that Ni^{2+} ions have been successfully incorporated into the ZnO matrix. Additionally, the Ni-doped ZnO demonstrates enhanced antibacterial activity compared to pure ZnO. In energy storage, it can enhance the performance of zinc-based batteries. For magnetic devices, its unique properties make them suitable for electronics, advancing data storage technology. In biomedicine, its antibacterial characteristics could lead to safer coatings for medical devices and improved drug delivery systems. Additionally, in solar cells, Ni-doped ZnO can increase efficiency by boosting charge carrier mobility. These applications highlight the material's promise for future technological advancements.

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A Review of Sustainable Methods for Synthesizing Zinc Oxide Nanoparticles and Their Applications

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Abstract—This review provides an overview of sustainable methods for synthesizing zinc oxide nanoparticles (ZnO NPs) and their diverse applications. Green synthesis approaches using plant extracts, microorganisms, and other environmentally benign sources are discussed, highlighting their advantages such as low cost, eco-friendliness, and scalability. The synthesis methods are categorized based on the mechanisms involved, including biological, chemical, and physical approaches. The review also covers the characterization techniques commonly used to analyze the synthesized ZnO NPs. Furthermore, the applications of ZnO NPs in various fields such as biomedical, environmental remediation, and catalysis are detailed, emphasizing their unique properties and potential benefits. Finally, future perspectives and challenges in the sustainable synthesis of ZnO NPs and their applications are discussed, providing insights for further research and development in this promising field.

INTRODUCTION:

A relatively young topic of research, "green nanotechnology" focusses the creation of nanoparticles by living cells using biological processes [1] . This topic is crucial to medical, biotechnology, electronics, nuclear energy, fuel and energy, and electrical engineering. Biological methods using green synthesis tools are preferable for producing nanoparticles from one to 100 nanometres. This is because these techniques are safer, greener, non-toxic, and cheaper than comparable technologies. The environmentally friendly synthesis of nanoparticles using live cells and biological processes is more efficient and produces more particles than comparable technologies [2] . Plants include many of the components and biochemicals needed to make green nanoparticles. Plants can also reduce and stabilise. Compared to biological, physical, and chemical processes, green synthesised technologies are more durable, non-toxic, cost-effective, and environmentally friendly. They also hurt the environment less [3] . Phytochemicals, extracellular, and intracellular nanoparticles are used to synthesise green nanoparticles. Synthesizing nanoparticles from plant extract is cheaper and more effective. Because plant extract contains many phytochemicals, they may stabilise and reduce metal ions to form metal nanoparticles. This is because plant extract includes several phytochemicals [1].

ZnO Nanoparticles:

Zinc oxide nanoparticles (ZnO NPs) are attractive in many sectors due to their unique properties. However, existing ZnO-NP production processes employ dangerous compounds that harm persons and the environment [4] . This paper examines the entire process of making zinc oxide nanoparticles (ZnO NPs) from plant extracts. We also explore biomedical uses of these nanoparticles. According to the research, zinc oxide nanoparticles are made from many plant extracts. These extracts contain the plant's leaves, fruits, seeds, roots, and roots. These biological matrices contain phytochemicals such flavonoids, terpenoids, alkaloids, and phenolic compounds. Also prevalent are phenolic compounds. Compounds that undergo bio reduction can reduce and stabilise. Environmentally responsible ZnO nanoparticles have several medical applications. It may have antibacterial, anti-inflammatory,

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and anticancer effects. Nanoparticles are used in wound dressings, medicine administration, imaging, and biosensing [5]. Environmentally produced zinc oxide nanoparticles (ZnO NPs) are more biocompatible and less hazardous than conventionally processed ones. Because ecologically friendly techniques have been improved. This makes them appealing for scientific and medicinal purposes [6] .

Heavy Metals and their Toxicity:
Heavy metals are toxic and have large densities and atomic weights. Pollution also comes from heavy metals. Scientists call these "heavy metals". Despite the fact that little amounts of heavy metals, such as cobalt, a component of vitamin B12, are needed for the body to operate, prolonged or excessive exposure to these metals can affect several physiological systems. Even though heavy metals are necessary for life, this is the situation [7] . The fact that "heavy metals" has been defined differently in scientific literature is important. Metalloids like As and Se are now considered "heavy metals," defined as "naturally occurring metals with an atomic number greater than 20 and an elemental density greater than 5 weight grammes per millilitre." Metalloids are non-metals included in "heavy metals"[8]. Representative metals from this group have been chosen for biosorption study. This group includes lead, copper, zinc, nickel, cobalt, chromium, and cadmium. The lone exception to the metals considered is arsenic, a very dangerous contaminant. The sole exception. Biosorbents are being studied for elimination [9] .

Table 1: Zinc oxide nanoparticles synthesized from different plant and plant part extracts and their significance.

Plant	Plant part	Shape and Size	Applications	Reference
Bryophyllum pinnatum	Leaves	126nm	Photocatalytic degradation of industrial contaminants	[10]
Brassica oleracea	Leaves	52nm	Environmental and antipathogenic applications	[11]
Lawsonia inermis	Seeds	10nm	Antibacterial	[12]
Grewia asiatica	Seeds	29nm	Degradation of industrial wastewater dyes	[13]
Tinospora cordifolia	Roots and Stems	74nm	Degradation of MB dye	[14]
Peltophorum pterocarpum	Fruit	59nm	Antifungal	[15]
Artocarpus gomezianus	Fruits	59nm	Degradation of MB dye	[16]
Pomegranate granatum	Fruits	156nm	Photoprotective	[17]
Avicenna marina	Leaves	29.1nm	Removal of toxic metal ions (Cd2+ and Pb2+	[18]
Zingiber officinale	Stems	30-35nm	Antibacterial	[19]

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ZnO NANO PARTICLES AND HEAVY METALS:

Recently, zinc oxide nanoparticles (ZnO-NPs) have gained attention since they may be synthesised environmentally using plant extracts. Because it can be used in so many businesses. This synthetic technology reduces health and environmental risks by eliminating the need for potentially toxic chemicals and reliance on non-renewable resources [20]. These ZnO-NPs might be used in wastewater and soil remediation to eliminate pollutants and improve ecosystem health. Both are environmental cleanup methods. Nanoparticles with a 3.2 eV band gap and large surface area can produce superoxide ($O2-°$) and hydrogen radicals. These radicals can generate holes (h+) and electrons (ec). This causes pollutants to oxidise and reduce in their valence band (VB) and conduction band (CB), resulting in photo catalysis-induced dye degradation (95–100% of MB, MO, and RhB dyes), heavy metal ion reduction and removal ($Cu2+$, $Pb2+$, $Cr6+$, etc.), and pharmaceutical drug degradation. In the following paragraphs, we will explain the several plant extracts used to make environmentally friendly

Table 2: Plant extracts that are utilized in the environmentally friendly synthesis of ZnO NPs.

Metal	Industrial source	Effects on Human Well-Being	Reference
Arsenic	Mining, smelting, pesticide manufacturing, wood preservatives	Skin lesions, malignancies of the skin, lungs, bladder, liver, and kidney; cardiovascular problems; neurotoxicity; developmental impacts; diabetes.	[9],[22]
Lead	Metallurgical, electroplating, metal finishing industries, manufacturing of paints, storage batteries, petroleum refining and drainage from ore mines	May cause pregnant sickness, increase the risk of lung, stomach, and bladder cancer, harm the kidney, neurological system, reproductive system, liver, and brain, and impede the early stages of fetal development.	[23]-[24]
Mercury	Metal smelting, coal production, waste disposal, and chemical synthesis	Prenatal abnormalities, neurotoxicity and nephrotoxicity, and cognitive impairment in children.	[25]-[26]

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Nickel	Alloy production, electroplating, production of nickel–cadmium batteries	Allergy, lung fibrosis, kidney and cardiovascular disorders, lung and nasal cancer.	[27]-[28]
Zinc	Electroplating, hot-dip galvanizing, metallurgy, production of batteries, pigments	immune system disorders, prostate issues, diabetes, and macular degeneration.	[29]-[30]

zinc oxide nanoparticles. We also explore these extracts' potential in environmental pollutant adsorption, photocatalysis, and heavy metal removal [21] .
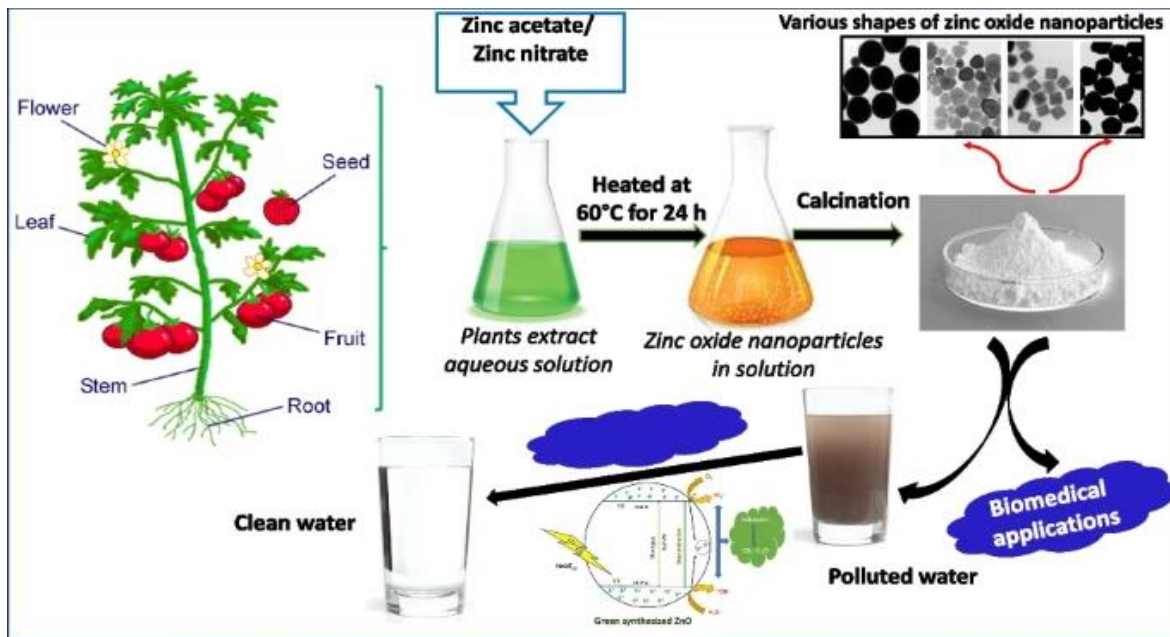
Figure 5 Plant extracts that are utilized in the environmentally friendly synthesis of ZnO NPs

ADVANTAGES OF GREEN SYNTHESIS:
Even at low concentrations, nanoparticles (NPs) are antimicrobial. This is due to their unique chemical and physical characteristics and high "surface-to-volume" ratio [21] . They can also withstand high heat and pressures, and some are safe to eat because they contain important minerals. This makes them more robust to harsh environments [31]. Despite the expanding use of nanoparticles (NPs) in food packaging, concerns about their toxicity and health risks continue to affect consumer uptake and perception. Many studies have shown that nanoparticles may be transferred from containers to food. This has been shown. Experimental studies have shown that nanomaterial mobility and migration are rare compared to other migration rates. This has been shown by

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several tests [32]. This has led industry leaders and researchers to focus more on "green or environmentally friendly production" of nanomaterials. Green synthesis uses microbes, plant extracts, bioactive chemicals, and other natural resources. Conventional chemical and physical synthesis methods offer several benefits over green ones. These benefits include being cheaper, easier to use, safer, devoid of toxins and harmful chemicals, renewable, energy-free, and not requiring high pressures or temperatures [33] .
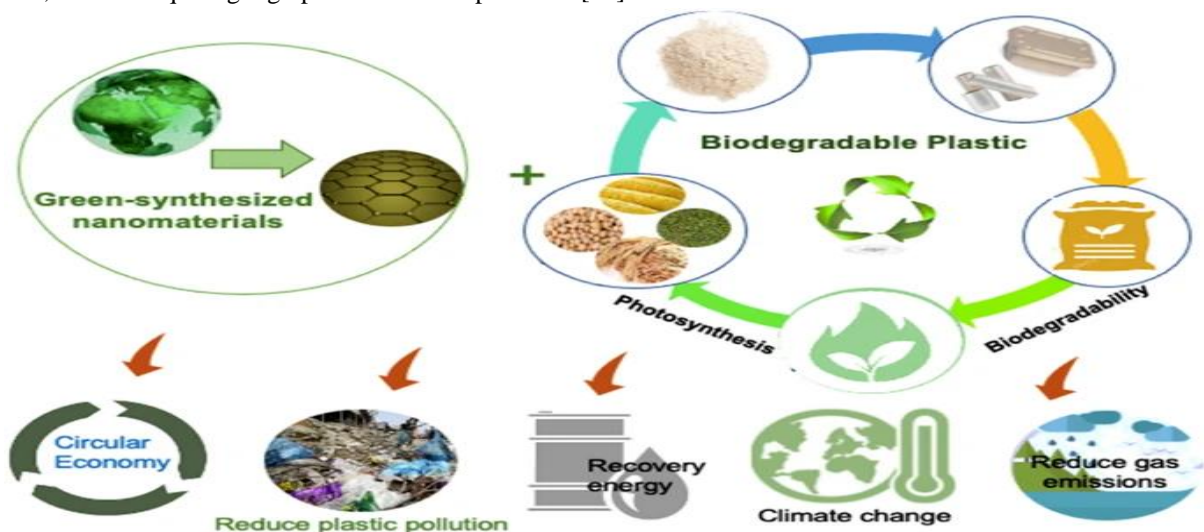
Figure 6 Green synthesis techniques

VARIOUS METHODS OF SYNTHESIS:
Many researchers have used zinc oxide nanoparticles to provide medicine for a range of illnesses [2]. Zinc is a micronutrient needed by all living things, including plants, animals, and humans. Scientists found that ZnO nanoparticles improve plant physiology and growth. Nano fertilizers boost productivity, fruit quality, juice sugars, and maturity index. It was found via investigation [34]. Numerous manufacturing methods can produce ZnO nanoparticles, each with its own advantages. Spray pyrolysis, laser ablation, physical vapor deposition, microwave-aided hydrothermal processing, sol-gel, vapour condensation, thermal hydrolysis, and many more techniques come under this category [35]. This study emphasizes on hydrothermal, sol-gel, microwave-aided, co-precipitation, green synthesis, and other methods.

Synthesis by hydrothermal process:
ZnO synthesis uses many procedures, including the hydro-thermal method. This is because it allows easy up-scaling and crystallite formation management [36]. In comparison to other methods for making nanoparticles, the hydrothermal approach is highly effective for zinc oxide nanoparticles. This is because it has several advantages over other methods. Unlike processes that need high temperatures or expensive gear, this technique is easy to access and economical because it is so easy to set up. Its effectiveness, affordability, and low danger make it an appealing alternative for researchers. Hydrothermal processes allow tight control over particle size, morphology, and size distribution, ensuring large-scale output consistency. Because the approach allows precise control over these elements. This is possible since the method provides for excellent control. Since it runs at low temperatures

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and benefits the environment, its sustainability requirements must be considered. The researchers altering reaction temperature, precursor molar ratios, alkaline solution concentration, and solvent type tried to enhance zinc oxide nanoparticle qualities. This was done to maximise hydrothermal method benefits. The goal was to synthesise tiny crystalline particles while conserving energy. A detailed investigation of how these factors affect nanoparticle characteristics achieved this. During synthesis, zinc acetate dihydrate (ZAD) and sodium hydroxide (NaOH) were dissolved in deionised distilled water (DDW) in their respective amounts for accurate molar ratios. This was done for outcomes. These solutions were then mixed with organic solvent methanol to create a precursor. Zinc hydroxide (Zn (OH)2) precipitate was formed as a white slurry by dropwise addition of NaOH to correct pH. This was done to attain the goal. After mixing and transferring the mixture to a Teflon-lined autoclave, the reaction was performed at various temperatures for a predetermined duration. After the reaction, the solid product was collected, washed to remove excess ions, and dried for further study. Solid product was used. In the later investigation, nanoparticles generated under different conditions were tagged to identify them. So, nanoparticles might be recognized. The researchers wanted to study how temperature, precursor molar ratios, solvent concentration, and shape affect zinc oxide nanoparticle crystalline size, functional groups, energy band gap, morphology, and elemental composition [37].

This study employed zinc precursors zinc nitrate (Zn(NO3)2), zinc acetate (Zn(CH3CO2)2), and zinc chloride (ZnCl2) to produce zinc oxide (ZnO) nanoparticles hydrothermally. Hydrothermal synthesis was chosen because it was cheaper, safer, and needed lower temperatures [38]. 50 milliliters of distilled water and a readily accessible sodium hydroxide (NaOH) solution dissolved each zinc salt in the right quantities. This was done individually. To do this, magnetic stirring was used. After that, these solutions were autoclaved for further processing. After synthesis, the powders were air-dried at room temperature and washed multiple times to remove impurities [39].

First, zinc nitrate and sodium hydroxide were dissolved in deionized water to generate a solution. It was done to build the solution. They were chosen as precursors because they produce zinc and hydroxide ions, which are needed to make ZnO nanoparticles. This was because both compounds can perform the above roles. After then, the liquid was aggressively agitated to ensure equal precursor mixing. The homogeneous solution was then hydrothermally treated. The solution is heated and pressurized before being deposited in a Teflon-lined sealed reactor. This is for process execution. Twelve hours were spent at 180 degrees Celsius with this solution. Maintaining this temperature throughout the workout. A regulated crystallization procedure using zinc and hydroxide ions created zinc oxide nanoparticles during this time. Nanoparticles were made this way. After hydrothermal treatment, the reaction mixture autoclave cooled naturally to room temperature. This continued till room temperature. After the reaction, the ZnO nanoparticles in the solution formed white precipitates. After carefully collecting the precipitates, they were cleansed to remove any environmental pollutants. Deionised water and ethanol were used to wash. ZnO nanoparticles were dried at 70°C. This removed any remaining moisture and ensured their durability following cleaning. Nanoparticle properties can be preserved by drying them at a specific temperature. This prevents agglomeration and sintering. Considering everything, this painstaking synthesis produced superb ZnO nanoparticles suitable for many applications, including the Hydrogen Evolution Reaction [40].

ZnO nanoparticles were made using two hydrothermal methods. Temperature- and pH-altered synthesis were used. Both methods were used to get the intended outcomes. Zinc acetate dihydrate was dissolved in dry water for temperature-sensitive synthesis. Participants then received a citric acid-sodium hydroxide solution. After placing the reaction mixture in a Teflon-lined steel autoclave, it was hydrothermally treated for 24 hours at 100–200

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degrees Celsius. After being filtered, washed with ethanol and water, and dried at 60°C for a day, the objects were not processed further. Analysis showed that the temperature was utilized to mark samples. Zinc acetate dihydrate was dissolved in distilled water for pH-changed synthesis. Drops of sodium hydroxide were applied to restore pH to the required range. A pH meter was used to regulate pH, and values ranged from 7.5 to 13.5. All values were computed. Following transport in Teflon-filled steel autoclaves, the reaction solutions were hydrothermally treated at 160 degrees Celsius for 12 hours. After treatment, the items were filtered, rinsed with ethanol and water, and dried at 60°C for 24 hours. Following pH correction, samples were numbered according to their corrected values. These synthesis methods in the hydrothermal treatment process may produce ZnO nanoparticles with pH- or temperature-dependent properties. This is because hydrothermal treatment produces nanoparticles [36].

This procedure weighs zinc salts and mixes them with varied amounts of sodium hydroxide. The technique is performed after adding salt mixes to a container with PEG, PEI, TMAH, and HMTA. A pH meter calibrated to detect pH and standard solutions is needed to change pH between 11 and 13.75. To achieve the goal, this is required. Drying salt combinations at different pH levels using ultrasonic, microwave, or air oven methods. Some tests add sodium hydroxide (NaOH) gradually at five milliliters per minute until the desired pH is reached. Keep adding until the required pH is obtained. The nanoparticles dissolve in an acidic solution after mild centrifugation. After hydrothermal precipitation in an alkaline media, nanoparticles retract. The product is homogenized and put in a stainless steel, Teflon-coated autoclave. The procedure continues till the product is finished. After that, the autoclave is heated to 160 degrees Celsius under autogenous pressure. Nanoparticles, a white product, are washed and dried with distilled water at 60 degrees Celsius. This synthesis approach optimizes zinc oxide nanoparticle manufacture for a variety of purposes, including antimicrobial coatings [41].

Synthesis by Sol-gel method:

ZnO nanoparticles have been synthesised using several methods in recent years. These include sol-gel, low-temperature hydrothermal, and chemical solution techniques. Sol gel is considered the most cost-effective and needed technique. Sol-gel techniques allow growth and reaction conditions to be controlled, which is another benefit. It can also change nanomaterial properties, which is intriguing. Several aspects affect nanomaterial properties and phase structure during synthesis. These factors include pH, nanomaterial environment, and solution development stirring time [42].

This approach uses sol-gel technology to make zinc oxide nanoparticles. Zinc acetate dihydrate, deionised water, sodium hydroxide solution, and isopropanol are used in the operation. Zinc acetate dihydrate was dissolved in deionised water and stirred to create a homogeneous solution. It was done for optimum uniformity. This was done to simplify. To obtain pH 3, NaOH is added drop-by-drop. Slowly adding isopropanol yields a clear solution. This ensures goal achievement. A 100-degree Celsius solution is mixed for 24 hours. The solution is dried in an oven for 48 hours and repeated. The third and last stage in making crystalline ZnO nanoparticles is annealing the dried sample at 350 degrees Celsius for four hours in normal air. Normal air is used for this procedure. This process yields a crystalline, uniform product that may be used in many ways [42].

Two grammes of zinc acetate dihydrate must be dissolved in fifteen millilitres of distilled water to make zinc oxide nanoparticles. After then, the liquid was swirled until it was completely clear. The mixture was then sonicated for 10 minutes at room temperature to ensure good mixing. This ensured quality control. Whisking ten millilitres of deionised water and eight grammes of sodium hydroxide took place at the same time. Keeping the pH at 12 when titrating the sodium hydroxide solution into the zinc acetate dihydrate solution is crucial. This created a white

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precipitate. The precipitate was calcined for two hours at 300 degrees Celsius after drying for thirty minutes at 100 degrees Celsius [43].

Synthesis produced zinc oxide (ZnO) nanoparticles. The sol-gel method detailed this process. First, 9.7 g zinc acetate dihydrate was dissolved in 150 ml distilled water. At 35°C, the mixture was stirred for 30 minutes. Finally, the mixture's chemical makeup was examined. At the same time, 4.5 grammes of potassium hydroxide (KOH) and 80 millilitres of deionised water were combined and stirred. After progressively adding potassium hydroxide to zinc acetate dihydrate, the mixture was agitated for eight hours to form a gel. This was done for the intended consequence. After that, the gel was held at room temperature for one day to settle. To remove contaminants, the gel was rinsed and filtered with distilled water after 48 hours of hoover oven drying. To eliminate impurities from the gel. After filtering, the wet powder was dried in a hoover oven at room temperature for 15 minutes. The cleaning was followed by this. The dry product was pulverised into a fine powder and calcined at 300 degrees Celsius for two hours to generate pure ZnO nanoparticles. This was repeated until the product was done [44].

This procedure synthesises zinc oxide nanoparticles using the sol-gel method. Chelating and stabilising agents are made from natural starches. Potato peelings were gathered, cleaned, crushed, filtered, dried, and de-agglomerated to extract starch. Zinc oxide was made using chelating ingredients like maize and potato peel starch. The sol-gel process achieved this. Thermogravimetric Analysis (TGA) on a dry xerogel determined the calcination temperature. The thermogravimetric investigation was done in nitrogen at 25–1000 degrees Celsius. De-agglomeration revealed that the powder was made of maize starch and potato peel fibre. The Rietveld refining method was used to determine unit cell characteristics. This study investigates if natural starches can make zinc oxide nanoparticles. Thermal and structural characteristics of these nanoparticles will also be provided [45].

This method describes ZnO nanoparticle synthesis using the sol gel method. NaOH was completely dissolved in a 12:1 M solution in a 500-millilitre beaker of ethylene glycol ($C_4H_{12}O_6Zn$). These combinations were swirled continuously for 30 minutes at 80 degrees Celsius. After that, a water-dissolved organic solvent was slowly added to the reaction mixture. This was repeated until pH reached 9.0. The technique was shaken continuously for three hours to produce a consistent solution [46].

Synthesis by Microwave assisted method:

Microwave heating is a promising organic and inorganic chemistry synthesis method because it heats quickly and uniformly while saving time and energy. This is because microwave heating has several benefits [47]. Microwave heating uses ionic conduction and dipolar rotation to transform electromagnetic radiation into thermal energy. To attain the goal, several processes are used. The reaction mixture's components can be heated according to their microwave absorption. Because microwaves permeate compounds. Microwave-assisted synthesis has several advantages over traditional techniques. This technology offers faster reaction speeds, a wider range of reaction conditions, higher yields, selectivity due to microwave absorption quality, careful reaction parameter control, and simpler handling for efficient parameter optimization [48].

Zn $(NO_3)_2$ $6H_2O$ precursor and CH_4N_2O fuel were dissolved in deionised water at a 1:5 M ratio and agitated for 30 minutes to produce ZnO NPs using microwave-assisted chemical combustion. This approach yielded ZnO NPs. The combination heated, dried, decomposed, and suddenly combusted into a frothy, solid powder. After 10 minutes of microwave radiation, the mixture was heated. Ammonia (NH_3), water vapour (H_2O), nitrogen gas (N_2), and carbon dioxide were released after burning. Combustion produced ZnO nanoparticles. CZnO nanoparticles were produced and annealed at 500 degrees Celsius for one hour to promote crystallisation. The intended outcome was

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achieved by repeating this method. Additionally, ZnO nanoparticles were irradiated with γ at three dosages: 25 kGy, 50 kGy, and 75 kGy, using a Co-60 source. After this treatment, the samples were labelled 25CZ, 50CZ, and 75CZ. Using this method, ZnO nanoparticles may be made faster and more efficiently. Additionally, it offers γ irradiation, which may be used in other radiation-induced applications [49].

This approach created ZnO nanoparticles using microwave irradiation. ZnO nanoparticles result from this technique. After adding 0.5 mmol zinc sulphate to a beaker with 100 mL DI water, the following results were observed. After that, the mixture was microwaved at 400 watts for 30 minutes during continuous mixing at room temperature. This was done three times. After heating the ZnO to 200 degrees Celsius for 10–15 minutes, the white precipitate was washed many times with water and ethanol. This was done several times. A similar approach was used using zinc acetate and zinc nitrate precursors under the same reaction conditions to get the same result [50]. This method dissolved zinc acetate dihydrate (9.5 g, 0.04 mol) in deionised water (150 mL, 8.26 mol). After that, NH4OH was added to raise the pH to 9. The mixture was microwaved 20 times at 180 watts. Each cycle delivered 6.40 minutes of radiation, 20 seconds on and 10 seconds off. After being vacuum-filtered, the white precipitate was dried and calcined (in 500°C air for two hours at five degrees Celsius each minute). The currently manufactured powder is called ZnO/MW [51].

In the presence of melamine (MEL) or grape pomace of Barbera extracts (E), a similar approach was used. After dissolving the combination in 50 mL and 200 mL of deionised water, extracts (E, 0.101 g) or melamine (Mel, 4 g) were added to raise the pH to 9. We achieved the necessary pH level. Zinc acetate dihydrate, dissolved in 50 mL of deionised water, weighed 6.41 g, and had a molecular weight of 0.029, was dropwise added to the extract solution. These additions occurred simultaneously. The combination was subjected to 180W of microwave radiation for 20 cycles of 20 seconds on and 10 seconds off, totaling 6.40 minutes. After vacuum filtration, the white precipitate was calcined (in air at 500 degrees Celsius for two hours at five degrees Celsius per minute) and dried (at 90 degrees Celsius for a night). The material illustrated in the next paragraphs has ZnO/E/MW and ZnO/MEL/MW designations [51].

The aerial roots of F. benghalensis were gathered to create nanoparticles using this approach. To remove contaminants, the item was carefully rinsed with tap water. After washing, the aerial roots were air-dried in the shade for three months. After grinding the aerial roots, 250 grammes of powder and ethanol were introduced to the soxhlet apparatus. To produce the intended impact. For 72 hours, the ethanolic extract was held between 80 and 90 degrees Celsius. The extract was concentrated at 40–50 degrees Celsius under low pressure. Two techniques are used to make zinc oxide nanoparticles (ZnO NPs). The first method adds plant extract to zinc chloride (A-ZnO NPs). Next, gradually adding sodium hydroxide precipitates white ZnO nanoparticles. About the second method. The precipitate is removed from the sediment after drying, rinsing, and separating. The second method, B-ZnO NPs, uses the same mechanism to speed nanoparticle manufacturing. After mixing the plant extract and zinc chloride, microwave irradiation is applied. Precipitate is handled using a similar technique as before [52].

This method produced ZnO and Zn0.5-xCrxO nanoparticles (NPs) with x values of 0.02, 0.04, and 0.06 M. This was done via microwave-assisted chemical combustion. The precursors for Zn0.5-xCrxO nanoparticles were zinc nitrate hexahydrate and Cr (III) nitrate nonahydrate, and the fuel was urea. During mixing, deionised water dissolved the compounds at ambient temperature. Zinc and Cr precursor solutions were mixed at various molar ratios. By immediately mixing the fuel and precursor at a 1:5 molar ratio and stirring for 30 minutes, a homogeneous mixture was achieved. After being transferred to a beaker, this clear solution was microwaved for 10 minutes. To make pure Zn0.5-xCrxO nanoparticles [53].

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Synthesis by Co-precipitation method:

The production of ZnO nanoparticles has been shown utilizing chemical bath deposition, co-precipitation, hot injection, hydro-and solvothermal, and microwave aided methods. Co-precipitation was chosen to manufacture ZnO nanoparticles due to its high yield, low cost, and purity [54].

Aloe barbadensis miller's Aloe Vera Gel (AVE) and distilled water make a pale-yellow solution. Agitation and filtration yield this solution. This led to the AVE solution. This operation starts the co-precipitation process for zinc oxide nanoparticles (ZnO NPs). Sodium hydroxide, silver nitrate, copper nitrate trihydrate, and zinc nitrate hexahydrate are also produced simultaneously during precursor solution production. The precursor solution is combined with one-to-one AVE extract at 80 degrees Celsius. Repeat until pH reaches 10. After settling for a while, centrifugation is used to collect the precipitate. Final steps in making a fine powder from precipitate are drying and milling. This follows multiple ethanol and distilled water washes of the precipitate. After that, it is calcined at 250 degrees Celsius for four hours to make zinc oxide [55].

The chemical wet co-precipitation method may be used to synthesize zinc oxide (ZnO) and nickel-doped ZnO nanoparticles. The next step is to dissolve 2.202 grams of zinc acetate dihydrate in 100 milliliters of DI water after dissolving 1.125 grams of KOH in 10 milliliters. This is necessary for completion. First, the zinc acetate solution is aggressively agitated while the potassium hydroxide solution is added drop by drop. This process continues until precipitate is produced. After that, a hot plate heats the precipitate for three hours at 70 degrees Celsius. After the reaction, the white precipitate is centrifuged and washed with DI water. To dry, it is kept at 80 degrees Celsius for 24 hours. The powder is then annealed in a furnace at 600 degrees Celsius for four more hours and repeated. This technique must be repeated to maintain synthesis consistency. This will produce equivalent outcomes. Synthesis of pure zinc oxide and nickel-doped zinc oxide nanoparticles requires careful zinc acetate and potassium hydroxide solution mixing. This ensures the greatest quality. These nanoparticles are precipitated, cleaned, dried, and annealed [56].

Chemical ZnO nanoparticles were made by co-precipitation. First, 400 grams of Nigella sativa seed were ground into powder. After that, the powder was dissolved in 600 milliliters of ethanol for 24 hours at 100 degrees Celsius for the experiment. After a day on the hot plate, the solution should be withdrawn, cooled, and strained through filter paper. The extraction of Nigella sativa seeds generated a dark green liquid. An eco-friendly synthesis approach created zinc oxide nanoparticles [57].

The manufacture of zinc oxide nanoparticles (ZnO NPs) doped with *Plectranthus chaudocanum* (PLE) extract involves many steps. After gathering *P. chaudocanum* L. leaves from Vietnam, washing and drying them in the air, they are powdered into a fine powder. Ten grams of powdered leaves are ultrasonically extracted at 60°C for an hour. The mixture is 1:1 ethanol and distilled water. This method follows a well-established protocol. To get *P. chaudocanum* extract, chill the extract before centrifuging and filtering. After that, the extract is stored at 4°C for subsequent use. This extract is employed as a dopant to make ZnO nanoparticles for this study [58].

Chemical co-precipitation was used to manufacture zinc oxide (ZnO) and its doped forms. In the initial step, distilled water was used to dissolve ZnCl2, LaCl3, CeCl3·7H2O, and 0.1 M EDTA. Titrating the solutions with 4 M NaOH while spinning them allowed the pH to reach 12 and achieve the desired outcome. After that, the solutions were agitated and heated to 60°C for two hours. Next, they were cleaned with distilled water till pH reached 7. After crushing all the white precipitates, they were dried at 100 degrees Celsius for 18 hours and calcined at 550 degrees Celsius for 4 hours [59].

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Green synthesis of ZnO Nanoparticles:

There are many techniques to make zinc oxide nanoparticles (ZnO NPs). Physical, chemical, and biological approaches are used. Physical and chemical therapies are effective, but they use toxic substances, making them environmentally harmful. Additionally, these procedures may be costly. Biochemical approaches, especially green synthesis using plant extracts, are cheaper and less environmentally destructive, therefore they have garnered interest. Flavonoids, glycosides, polyphenols, terpenoids, and enzymes are used in these processes. This eliminates the need for additional chemicals. This makes the procedure cost-effective and eco-friendly. This method is sustainable [60].

Zinc oxide (ZnO) nanoparticles must be synthesized using environmentally friendly processes. algal or algal extracts might be used to reduce and cap amounts. Phytochemicals and biomolecules from algae reduce metal ions and create nanoparticles. Both reactions need algal compounds. Several substances are needed to operate. Metal stress causes algal cells to synthesize physiologically active chemicals. Bioactive molecules that bind metal ions and produce nanoparticles are released. Nanoparticles are released by their molecules [61].

The harvested Pisonia alba leaves were meticulously cleaned to remove dust and dirt. This started the production of zinc oxide nanoparticles (ZnO NPs). After that, a mortar and pestle crushed the leaves into powder. Then, fifty milliliters of water and ten grams of dried leaf powder were refluxed at 100 degrees Celsius for two hours. The mixture was filtered using Whatman No. 1 filter paper to make aqueous leaf extract. This was done after mixing. Beginning ZnO nanoparticle production required cooling the aqueous extract to four degrees Celsius. While this happened, 0.1 M zinc acetate dihydrate was produced. After that, it was combined with 50 mL of deionized water and kept at room temperature for 15 minutes before adding to the leaf extract. The liquid was vigorously stirred for two hours at 70 degrees Celsius using a magnetic stirrer. After the reaction, the precipitate was allowed to settle before being centrifuged at 6000 RPM for 15 minutes to separate it from the reaction solution. To remove precipitate from reaction environment. Washing with deionized water removed any remaining impurities, and the precipitate was dried in an 80-degree Celsius air oven. This was done several times. After synthesis, the sample was calcined in a muffle furnace at 500°C for two hours. After grinding and drying, ZnO nanoparticles were stored in an airtight container [62].

Zinc oxide nanoparticles (ZnO NPs) are made using an environmentally friendly method. Filling a beaker with 100 milliliters of 0.1 M zinc sulfate in water was the first step. Next, twenty milliliters of room-temperature neem extract were added one drop at a time. To lower pH to 12, 2M sodium hydroxide was added to the mixture. After that, the mixture was churned for four hours at 60 degrees Celsius to create a bright yellow paste. After filtering, the filtrate became light yellow to pale white, indicating that the zinc salt had become ZnO nanoparticles. The hue changed quickly once the operation began. This discovery was confirmed by UV-Vis spectra. After drying in an 80°C oven for 12 hours, the filtrate was formed into a paste. This paste was annealed in a ceramic crucible at 500°C for three hours. Light white powder was produced. This technology produces zinc oxide nanoparticles, which may be used in many sectors, in a profitable and ecologically beneficial way [63].

ZnO nanoparticles (NPs) were synthesized utilizing an environmentally friendly approach. Fresh fruits were cleaned, dried, crushed, and sieved to make a fine powder. This technique was repeated to make an N. latifolia fruit extract in water. This was done several times. In forty milliliters of deionized water, twenty grams of this powder boiled for thirty minutes at sixty degrees Celsius. Thirty minutes were spent boiling. After filtration, the successful fruit extract was used immediately. Nanoparticles were made by adding five grams of zinc nitrate hexahydrate to fifty milliliters of this extract. The mixture was then boiled in a beaker with a magnetic stirrer at

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60–80 degrees Celsius. The mixture was stirred until yellow precipitates developed. After washing with distilled water and ethanol, the product was calcined at 400 degrees Celsius for two hours. The product was then oven-dried at 60°C for four days. In order to study the white powder later, it was placed in an airtight container. This method makes zinc oxide nanoparticles (ZnO NPs) profitable and ecologically friendly, which may be used in many industries. This method is eco-friendly [64].

Synthesis of ZnO by laser ablation technique:
Pulsed laser ablation in liquids (PLAL) is one of the easiest and most versatile methods for nanostructured material production. Also known as PLAL. PLAL outperforms existing methods in several ways [65].

The research produced colloidal metal nanoparticle solutions using high-purity ZnO targets and in-liquid, room-temperature pulsed laser ablation (PLAL) technology. Using ethanol to clean and polish the metal target and ultrasonic water filtering to remove impurities were also used. The method incorporated both procedures. After cleaning, the target was placed in a glass vial with five milliliters of distilled water and four millimeters of liquid height above the target. This preserved the water's form. During blasting the metal target, 400, 500, and 600 millijoule pulses were used. To get the intended result. After water removal, colorful colloidal solutions with nano-metallic particles were created. The water's hue changed after removal [65].
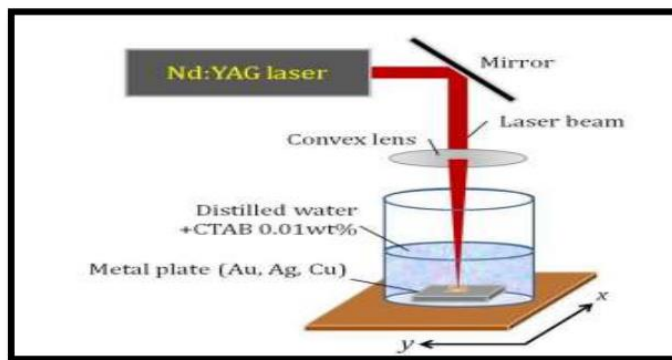
Figure 7 Pulsed Laser Ablation in Liquids (PLAL).

A target composition of 99.9% pure zinc was ablated for 30 minutes in 80 milliliters of purified water to produce zinc oxide (ZnO) nanoparticles (NPs) using pulsed laser ablation (PLA). Measurements of target mass loss before and after ablation yielded an average particle concentration of 0.3 m/L. This was done by assessing goal mass loss. Next, the colloidal solution was dried in air at 60 degrees Celsius, and the remaining powder was calcined in a muffle for four hours at 400 degrees Celsius. Colloidal solutions generated by ablation of silver (Ag) and zinc (Zn) targets were collected to develop a composite material. This was done to obtain components. Ag:ZnO was made by mixing these solutions at 1:199. It was done to produce compound. After fifteen minutes in an ultrasonic bath, the colloids were dried in air at 60 degrees Celsius. Finally, they were calcined at 400°C. Two names were given to the NP samples. These were ZnO and ZnO-1Ag [66].

Pressing 99.8% pure zinc powder against a 2 x 2 x 0.2-centimeter zinc metal target produced zinc oxide (ZnO) nanoparticles (NPs). This produced ZnO nanoparticles. After that, this target was placed at the bottom of a revolving beaker with three milliliters of deionized water. Focused laser beams were used for ablation. The

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aqueous layer above the zinc pellet was 0.7 millimeters throughout the experiment. This allowed experiment findings to be replicated. Using a 110-millimeter plano-convex lens, the zinc pellet's laser beam spot size was calculated at 1.5 millimeters. This was done for accurate measuring. This was done to generate enough laser fluence. Naoparticles were created by changing the laser's power to 400, 600, and 800 mJ per pulse for each of 300 pulses. This was done by adjusting laser intensity [67].
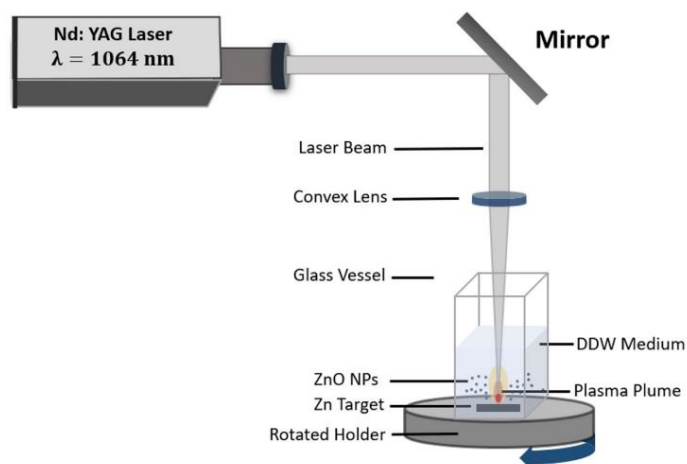
Figure 8 laser ablation (LA) procedure

An Au plate was ablationed after being soaked in three milliliters of deionized water (DW) in a glass vial for the experiment. The laser ablation (LA) procedure used 200 800-mJ pulses. The target was stationary throughout. A zinc pellet-bottomed glass beaker received three milliliters extra DW. We next individually irradiated the beaker contents using the same conditions as the gold ablation. Gold nanoparticles (NP) solution from pale pink to deep pink as laser intensity rose. However, zinc oxide nanoparticle (ZnO NP) solution became pale gray to pale yellow. Au/ZnO nanocomposites (NCs) were made by mixing Au and ZnO nanoparticles in 1:1, 3:1, and 1:1 volume ratio. After mixing the two colloidal solutions, a 532 nm laser concentrated 800 mJ of second harmonic laser pulses on the solution. Laser pulses targeted the solution surface [68].

APPLICATIONS OF ZnO NANOPARTICLES
Environmental cleanup uses zinc oxide nanoparticles due to their high reactivity, adsorption capacity, and photodegradability. This is due to particle characteristics [69]. because they have these traits. ZnO nanoparticles remedy environmental contaminants for numerous reasons. These approaches include heavy metal removal, organic pollutant degradation, and antibacterial drugs [70]. This lengthy research evaluates ZnO nanoparticles for environmental remediation. In this essay, ZnO nanoparticle efficiency and methodologies are examined in detail. A variety of studies and articles were used to create the overview.

Photocatalytic Degradation of Organic Pollutants
Zinc oxide nanoparticles are effective photocatalysts that remove organic pollutants in UV light [71]. ZnO forms electron-hole pairs when exposed to UV rays. This is the effect of UV exposure. A essential condition must be

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satisfied before the event may occur. Reactive oxygen species (ROS) are released into the environment anytime electron-hole pairs exist. ROS are reactive oxygen species. Remember that reactive oxygen species include hydroxyl radicals. Organic compounds are oxidized by reactive oxygen species (ROS). "Reactive oxygen species" is "REO." This method breaks down complex contaminants into simpler components that are easier to manage [72].

Akpan and Hameed observed in 2009 that zinc oxide (ZnO) photocatalyzed methylene blue degradation under UV light [73]. The data show a decrease in efficiency. ZnO nanoparticles have more reactive sites and photocatalytic activity than bulk ZnO due to their larger surface area-to-volume ratio. Because ZnO nanoparticles have a larger surface area than volume. This is because nanoparticles have more surface area than bulk ZnO. Nanoparticles cause this. Nanoparticles induce this. Saravanan et al. (2013) investigated many methods to improve the material's photocatalytic degradation and visible light absorption. One way was adding silver to zinc oxide [74].

Heavy Metal Removal

Additionally, ZnO nanoparticles have showed encouraging results in heavy metal adsorption and removal from contaminated water. These findings are confirmed [75]. They showed promising results in this area. Large surface areas give these nanoparticles many active sites for heavy metal ion adsorption. Because nanoparticles are tiny. Due to nanoparticles' tiny size. Several studies have examined its ability to remove lead (Pb), cadmium (Cd), mercury (Hg), and arsenic (As) from aqueous solutions. ZnO nanoparticles have been studied for element removal [76].

Sharma and colleagues studied nanoscale ZnO nanoparticle adsorption of lead (II) ions in 2010. Research was done. After discovering that pH affects adsorption, they determined that pH 5 is optimum. The conclusion was this. The study found that ion exchange-controlled adsorption. Investigation findings led to this conclusion. This method utilized ZnO's surface hydroxyl groups to benefit [77, 78].

Antimicrobial Activities

ZnO nanoparticles' antimicrobial properties aid water disinfection. Zinc oxide nanoparticles kill germs, fungi, and algae. Reactive oxygen species (ROS) damage microorganism membranes, proteins, and DNA, causing antibacterial activity. ROS do this [78].

Jones and colleagues (2008) found that ZnO nanoparticles kill Staphylococcus aureus and E. coli. Particles harm cell membranes, killing them. This characteristic may also inhibit biofilms in water treatment systems, improving water purification [79].

UV Protection

Zinc oxide nanoparticles are used in sunscreens and other personal care products because they absorb UV light. This is because nanoparticles are used in many goods from different sectors [80]. Nanoparticles protect skin from the sun's harmful spectrum by deflecting and absorbing UV A and UV B rays. This is possible without leaving the white residue of normal zinc oxide formulations. This is possible. Unlike other organic UV filters, ZnO nanoparticles do not degrade in sunlight, making them a good choice for long-term protection. This has huge benefits [81].

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Electronics and Photonics

Zinc oxide nanoparticles are widely used in electronics due to their semiconductor properties, fast electron mobility, and large bandgap. Because they have these traits. Differentiators, sensors, and transparent conductive coatings can be manufactured with their help [82]. Photonics uses zinc oxide nanoparticles to make light-emitting and laser diodes. The reason is because ZnO nanoparticles release light when activated. Nanoscale particle size, which enables quantum confinement, also increases this capability [83].

Catalysis

Zinc oxide nanoparticles, versatile catalytic agents, are used in many chemical processes. They were used in biodiesel and organic chemical synthesis. Nanoparticles interact with reactants due to their huge surface area, increasing their catalytic activity. Biodiesel may be made from vegetable oils and animal fats using ZnO nanoparticles. These nanoparticles drive oil esterification and transesterification. Since biodiesel is made from these two fats, this is crucial.

Gas Sensing

Gas sensing applications may benefit from ZnO nanoparticles' ability to absorb gasses and adjust their electrical resistance. One of their biggest sensitivities is to VOCs, CO, and hydrogen. ZnO nanoparticles are appealing options for safety monitoring systems, air quality sensors, and emission controls for industrial and automotive applications [84].

Antifouling and Anticorrosion

If ZnO nanoparticles offer antifouling and anticorrosion, chemical coatings can reach their full potential. Ship hulls can be protected against barnacles and algae with nanoparticle-containing marine paints. Possible adverse effect. This improves fuel economy and automotive maintenance costs. ZnO nanoparticle coatings resist metal corrosion, making them helpful in humid or harsh conditions. Another benefit is that these coatings don't rust [85].

Biomedical Applications

ZnO nanoparticles are antibacterial, antifungal, and anticancer, making them potentially useful in biomedicine. Dental composites and wound dressings include these compounds to prevent infections and deterioration [2]. Their potential as drug delivery vehicles, particularly for targeted cancer therapy, has been examined. Because they form reactive oxygen species, they can selectively kill cancer cells [86].

Energy Storage and Generation

Energy businesses use zinc oxide nanoparticles to make batteries and supercapacitors. Because ZnO nanoparticles allow electrons to move quickly through the substance. They also make dye-sensitized photoanodes for solar cells. They increase conversion efficiency by providing a large surface area for dye absorption and electron transport into the cell. This project aims to improve conversion efficiency [87].

Food Packaging

Food packaging materials are being treated with zinc oxide nanoparticles to increase safety and shelf life. These compounds prevent infections and protect objects from the sun due to their antibacterial and UV-blocking properties. Both of these features are linked to therapeutic efficacy. ZnO nanoparticles may be used in many

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practical applications, demonstrating their versatility and potential in many technological and industrial fields. Every application can use ZnO's unique chemical and physical capabilities at the nanoscale, proving that material science is crucial to the development of new solutions and the advancement of existing technologies[88]. Zinc oxide (ZnO) nanoparticles have several environmental remediation applications. These nanoparticle-based solutions alleviate environmental issues through photocatalytic, adsorptive, and antibacterial properties [89]

Water Treatment
ZnO nanoparticles are commonly used in water filtering. They also eliminate viruses, heavy metals, organic and inorganic pollutants, and other impurities from water [90]. This is why they're valuable. Zinc oxide nanoparticles can clean industrial effluent with heavy metals and colors. This gives zinc oxide nanoparticles considerable uses. These nanoparticles can reduce treatment costs and improve efficacy compared to traditional medicines [79].

Air Purification
Due to their photocatalytic characteristics, zinc oxide nanoparticles can degrade VOCs and other air contaminants [91]. ZnO nanoparticles emit reactive oxygen species when exposed to UV radiation. When reactive oxygen species are present, poisons convert into water and carbon dioxide. This application manages a structure's air quality, which must have low volatile organic compound levels for human health [92].

Soil Remediation
Due to their size and form, ZnO nanoparticles may clean up heavy metal, pesticide, and other toxic soils. This can be done by eliminating soil toxins. Chemical reactions can stabilize or reduce pollutants [93]. Zinc oxide nanoparticles can transform dangerous chromium (VI) into less damaging chromium (III) in polluted soils, reducing environmental risk [21].

Antibacterial Treatment for Environmental Surfaces
ZnO nanoparticles can clean hospital surfaces with their antibacterial capabilities [94]. It's possible. ZnO nanoparticle coatings prevent illness and clean. Because they minimize bacteria and germs [95].

Photocatalytic Degradation of Pesticides
Some ZnO nanoparticles can break down pesticides on agricultural goods and runoff water. To get the desired result [96]. UV radiation activates these compounds' photocatalytic activity. This helps break down complicated pesticides. These toxins are banned from the food chain and rivers to protect humans and the environment [72].

Oil Spill Cleanup
Hydrophobic ZnO nanoparticles absorb water, make it difficult to dissolve, and remove it, extracting crude oil. Nanoparticles enable this. This equipment helps with oil leaks, which can harm the environment[97]. ZnO nanoparticles might agglomerate oil, making cleanup easier. Thus, oil collection and removal from water surfaces would be easy [98].

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Enhancing Bioremediation

Zinc oxide nanoparticles can help bioremediation by promoting contaminant-degrading bacteria. Zinc oxide nanoparticles may produce this environment [99]. This atmosphere is created by promoting a better environment. Nanoparticles may speed up microorganism-generated organic pollution removal. This will improve cleaning efficiency [100].

Sediment Remediation

Zinc oxide nanoparticles can breakdown and immobilize sediment organic and inorganic pollutants [93]. Nanoparticles accelerate pollutant breakdown, explaining this. This use is necessary to restore industrial and urban runoff-damaged aquatic habitats [101].

Antifungal Applications

ZnO nanoparticles are antibacterial and antifungal[102]. In damp situations, these antifungal properties may be essential for mold and mildew management. With this software, buildings and other structures may maintain their air quality and structural integrity [103]. The following examples demonstrate that ZnO nanoparticles may perform environmental remediation tasks. Their success in many contexts shows that they might be one of the most sustainable and adaptable solutions to some of the most pressing environmental issues. This is because they've succeeded in many settings [21].

CONCLUSION

Zinc oxide (ZnO) nanoparticles have become an efficient environmental cleanup tool in recent years. Most of these nanoparticles' usage solve environmental issues. These photocatalytic, adsorptive, and antibacterial compounds allow interventions in many domains of research. These qualities simplify oil spill management and air, water, soil, and sediment cleaning. Other benefits come with these features. ZnO nanoparticles may remove heavy metals, break down organic pollutants, and minimize microbiological concerns, demonstrating their flexibility. Zinc oxide nanoparticles can improve technology and the environment in UV protection, electronics, energy storage, and food packaging.

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N-doped Graphene Surfaces as efficient electrochemical sensor — A brief Review

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Abstract— Toxic analytes (NO, SO_2, HCN, $COCl_2$, HF, CO_2 etc) are extensively discharged due to agricultural, industrial and domestic effluents. Current review investigates efficient, reliable; with enhance surface area, fast in response, inexpensive N-doped graphene surfaces as an electrochemical sensor. The adsorption of toxic analytes on these surfaces was acquired by energy of interaction NBO, FMO, NCI, and QTAIM analyses. Increased values of interactional energies e.g. -15.99 kcalmol^{-1} indicates that toxic analytes physiosorbed onto the surfaces. The maximum reduction in HOMO-LUMO energy gaps toward toxic analytes indicates excessive sensitivity of these surfaces. NCI and QTAIM results also confirm that N-doped graphene surfaces exhibit high chemical activity toward the adsorbed toxic analyte as compared to pristine graphene. The distinctive dimensional structure, ultra-high stiffness and semiconductor characteristics build nitrogen doped graphene surfaces as auspicious candidates for future applications in electrode materials, molecular sieves and nano-scale gas sensing devices.

Keywords—nitrogenated graphene, interaction energy, electrochemical sensor, electron density difference (EDD)

INTRODUCTION

Agricultural, industrial and domestic effluents are the major source of toxic analyte in the environment. Nitric oxide (NO), carbon dioxide (CO_2), ozone (O_3), Sulphur dioxide (SO_2), phosgene $COCl_2$, HCN etc. are few toxic analytes causes health and environment hazards [1]. Combustion of fossil fuels actively generates CO_2 which promotes global warming, burning of coal and oil results SO_2 and SO_3 which are the major component of air pollution [2]. Toxic analyte leaves detrimental impact on living beings and environment therefore the design of an efficient, reliable, with high surface to volume ratio, fast in response and inexpensive electrochemical sensor has gained great interest [3].

Different spectroscopic techniques, liquid or gas chromatography and immune adsorbent assays (enzyme linked), semiconductor nanowire may also use for the detection of toxic analytes [4]. As these techniques are expansive, depends on skilled operator and unable to detect at lower concentration so requirement of an efficient alternative is focus of study [5]. Graphene and its derivatives such as graphene oxides, reduced graphene oxides possess large surface area which enhances their adsorption, sensing and separation characteristics. Due to zero band gap of graphene, it cannot be use in high performance optoelectronic devices. A lot of research work and various approaches have been considered to enhance the band gap of graphene which in turn enhance its sensing abilities [6]. Doping (n-type or p-type) can improve the electronic and optical properties of graphene with increased charge mobilities but uniform porosity and properties are still great challenges for graphene. It is the need of time to

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explore better surfaces with uniform pore size for assimilation and sensing of toxic agents, which can overcome the limitations of the existing 2D materials like graphene [7].

In 1928 Baek and Co-workers had synthesized nitrogenated 2D materials (C_2N-h_2D crystal) with uniform hexagonal pore size. All atoms are sp^2 hybridized and exhibit higher surface activity for the adsorption of small gaseous molecules as compared to pristine graphene [8]. Xu et al enumerated that C_2N have uniformly distributed electron rich holes which promotes efficient adsorption for gas sensing. Current review is the theoretical exploration of N-doped graphene (C_2N surfaces) as potential electrochemical sensor for toxic pollutants. Sensing and adsorption of toxic analytes on C_2N framework analyze via optimization, NBO, FMO, NCI (non-covalent interaction), and QTAIM (Quantum theory of atom in molecule) [9]. This brief review article will give an insight to the chemical structure of N-doped graphene surfaces (C_2N) and help to tailor the design of further surfaces via doping.

COMPUTATIONALPROPERTIES USED FOR OPTIMIZATION, ELECTRONIC AND NON-COVALENT INTERACTIONS:

Computational methods employ the consequences of theoretical chemistry incorporated into systematic computer programs to enumerate the structures and characteristics of molecules and solids [10]. The adsorption of toxic analytes was studied in a way that distinct orientations of analytes on N-doped graphene surface had optimized using M05-2X OR M06-2X 6-31G ++ (d,p) level of theory at Gaussian 09 package. The optimized geometries were visualized by Gauss View 6.0. The energies of interaction in various complexes were calculated by using formula:

$$\Delta E = E_{complex} - \left(E_{analyte} + E_{CN}\right) \qquad (1)$$

Here $E_{complex}$, E_{CN} and $E_{analyte}$ are energies of complex, surface and analyte respectively. Electronic properties were explored by using DOS (density of states) analysis and frontier molecular orbital analysis. Selectivity, sensitivity, conductivity and resistivity are some important characteristics of sensors may determine through this application. High values of HOMO-LUMO band gap associated with resistivity whereas low HOMO-LUMO gap shows high conductivity. Electronic properties further explored through NBO (Natural bond) analysis which illustrate the transfer of charge either through surface to analyte or analyte to surface. Reduced density gradient is another important phenomenon show relationship with electron density as follows:

$$\text{RDG}(s) = \frac{1}{2(3\pi^2)^{\frac{1}{3}}} \frac{V_\rho}{\rho^{4/3}} \qquad (2)$$

Where $\rho > 0$ indicates repulsive interaction and $\rho < 0$ attractive ones. Visual analyses of attractive and repulsive interaction explain through 3D NCI Plot. NCI isosurfaces provide details of interaction present between analytes and N-doped graphene. Detail understanding of non-covalent interactions was possible through QTAIM analyses. To discriminate the nature of covalent interaction factors like electron charge density (ρ), Laplacian ($\nabla^2\rho$), energy density (H(r)), -V/G and E_{int} play vital role. NBO analysis was used to evaluate the charge transfer between N-doped graphene and analyte. FMO analysis was performed to evaluate the variance of conductivity after the interaction between analyte and N-doped graphene surface.

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Comparison of data from the applications of N-doped graphene surfaces as electrochemical sensor:

Interaction energies and optimized geometries of C_2N and analyte Complex:

The computed structure of N-doped graphene (C_2N) consists of two C-C bonds (1.42 Å, 1.47Å) and one C-N bond of 1.34 Å which indicate three mode of bonding. Six nitrogen atoms periodically arrange to form a ring of 5.5 Å in a simple unit. These extremely electronegative atoms on the pores of C_2N surface formed a framework to capture and bound the toxic analytes [11].
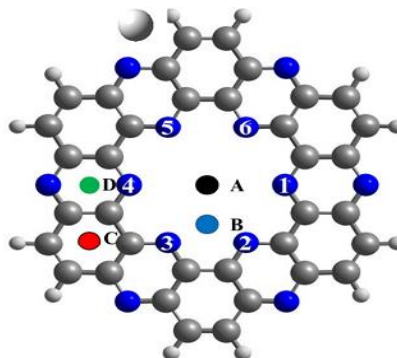
Fig. 1: Binding mode and optimized geometry of C_2N

This geometry indicates four adsorption sides i.e. center of cavity, centre of nitrogen N-atoms, on the top of the ring and on the top of benzene. HCN, HF, H_2S, NH_3 and PH_3 are the analytes adsorb on nitrogen doped graphene surface.

Table 1: interaction energies of analytes on nitrogenated graphene surface

Analyte	Intermolecular bond Analyte…..C_2N	Bond length (Å)	E_{int}	(ΔG) Kcal/mole
HCN	H_9......N_1	2.81	-15.24	-6.35
	H_9...... N_2			
	H_9...... N_3			
	H_9...... N_4			
	H_9...... N_5			
	H_9....... N_6			
HF	H_8……..N_5	2.9	-13.10	-4.10
	H_8……..N_6	2.44		

NCI Analysis

Here Non-Covalent Interaction investigations are utilized to envisage and discriminate van der Waals, hydrogen bonding and repulsive interactions [12]. These 3D and 2D isosurfaces shows strong electrostatic interactions @C_2N surfaces. Strong attractive interactional peaks appear at $(\lambda_2)\rho > -0.01$ a.u. and non-covalent dispersive peaks at $(\lambda_2)\rho < -0.01$ a.u. in 2D NCI plot.

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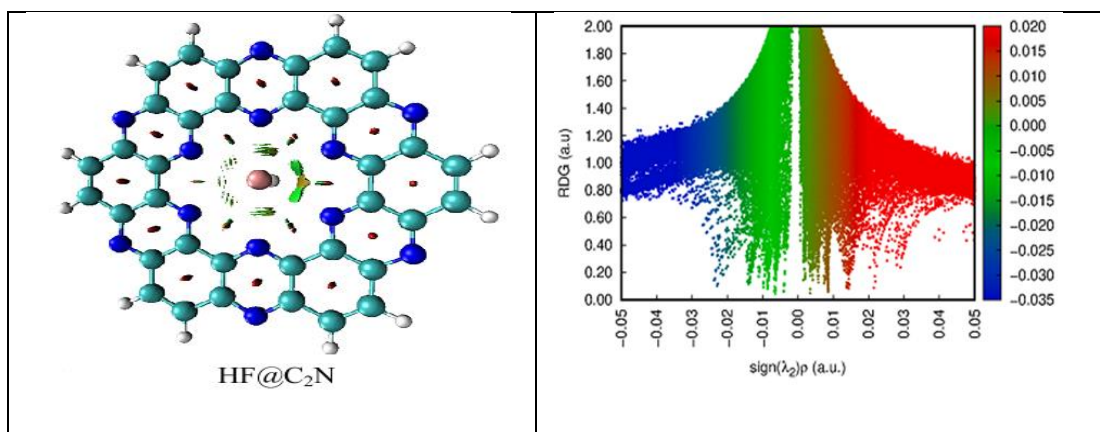
Fig. 2: 2D graph and 3D Isosurfaces of HF analytes adsorb at N-doped (C$_2$N) graphene surface

NBO Analysis and FMO Analysis

Electronic properties (conductivity, resistivity and sensitivity) are insistent by charge transfer examinations which may take place from analyte to C$_2$N or vice-versa. Sensing ability of N-doped graphene surfaces towards toxic analyte comprehend by NBO. The charges transfer values are -0.018e- (HCN), -0.007e- (HF), Negative values indicate that charge is transfer from C$_2$N surface to toxic analytes as surface is electron rich due to the presence of Nitrogen atom and analyte act as positive charged bodies.

In FMO HOMO-LUMO energy gap explains the conductivity and stability of analyte surface complexes. One fragment of highest occupied molecular orbital overlaps with other fragment of lowest unoccupied molecular orbital the phenomena of interaction may occur among surface and analyte [13].

Table 2: NBO charges and FMO analysis for analytes@ N-doped Graphene surface

Name of complexes	HOMO	LUMO	E$_{H-L}$ (eV)	NBO charges
C$_2$N	-5.40	-2.68	-2.72	_
HCN@C$_2$N	-5.53	-2.82	-2.71	-0.018
HF@C$_2$N	-4.46	-2.76	-1.70	-0.007

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QTAIM Analysis

Non-covalent interactions can be study in various molecular systems through quantum theory of atoms in molecules. This theory was proposed by Badar to analyze intermolecular non-bonding forces. Ionic interactions, H-bonding and V. Waals forces are focus of theory [14].

CONCLUSION

In current review we explored nitrogen doped graphene surfaces as efficient electrochemical sensor for the adsorption and sensing of toxic analytes. Interaction energy analyses proves that all analytes physiosorbed on C_2N surface. We analyzed NCI, QTAIM, FMO and NBO calculations to get a deep insight on non-covalent interactions. Appearance of isosurfaces in NCI analysis confirms the presence of intermolecular forces between analytes and N-doped graphene. HCN > HF is the trend of adsorption energies. FMO analyses confirmed the significant change in electronic properties. HOMO-LUMO energy gap reduces in case of complex as compared to bare N-doped graphene. NBO charge transfer analysis further elaborated the detection of toxic pollutant via N-doped graphene. These findings (enhanced characteristics) prove that nitrogen doped graphenes (CN_2, C_2N, C_3N, etc) are efficient electrochemical sensor as compared to pristine graphene.
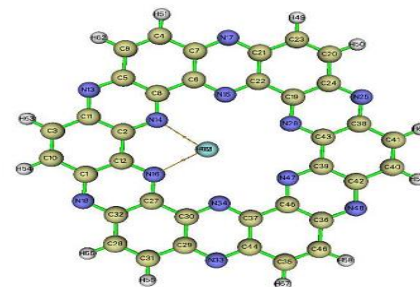
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A complete review of Early Detection of Bearing Faults techniques and suitable Machine Learning Vibration Analysis

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Abstract—One of the most common causes of any catastrophic failure of a rotating machine is due to faulty bearing. To maintain the health of machinery we must consider early detection of faults for the safety of both humans as well as machinery so we have to detect this in its initial stages. These small flaws might lead to machinery malfunctioning. From the various maintenance methods, the vibration measurement method was mostly used to access the accurate health condition of rotating machinery. This paper presents a complete road map for vibration measurement method techniques which are statistical moments of the rectified data, cyclostationary function, HFRT and FFT method, signal processing methods, time domain, frequency domain and spike energy analysis, Partial correlation integral algorithm. Then a brief analysis of different machine learning techniques on different factors to figure out suitable for the industrial environment. Numerous approaches of machine learning like Support vector machine (SVM), relevance vector machine (RVM), artificial neural network (ANN), decision tree (DT) K-nearest neighbor (KNN), and support vector regression (SVR) are compared based on the complexity of input data, theoretical background, and its industrial applications.

   Keywords: Bearing, Fault Techniques, vibration measurement method, Analysis learning technique, HRFT & FFT methods.

INTRODUCTION:

For the health state and monitoring the data of machine, faults diagnose play the main stream role(1,2). These two issues are concerned with machine management. Traditionally the faults are detected by the great experience and master knowledge of the engineers. A skilled engineer diagnoses the faults by notching the difference noise and brings into service advanced techniques for signal processing and analyse these vibration signals. There is a need for an automatic system to diagnose the faults accuracy and maintenance of the machine. Artificial intelligence looks for automatically find and realize the health states of machines(3–6)

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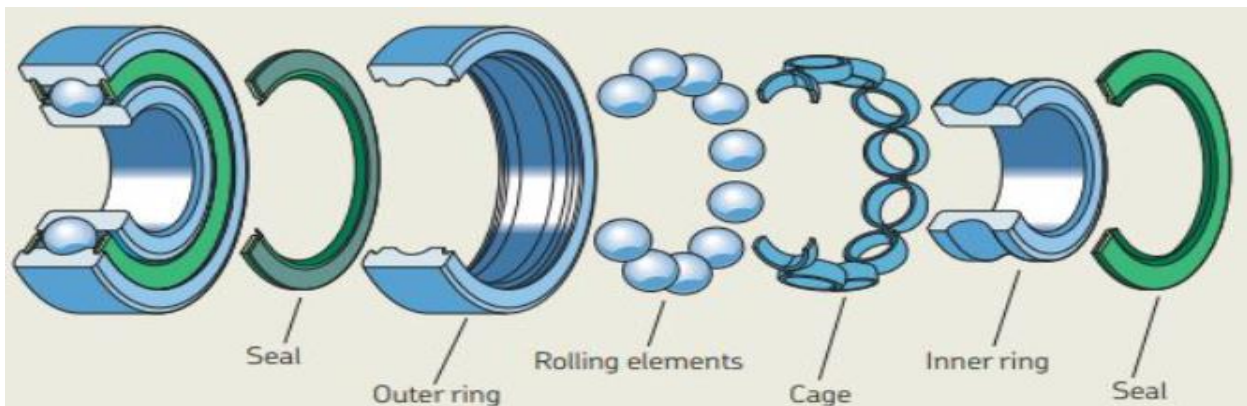
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Figure 9 : https://images.app.goo.gl/TPMVxDJXGy6m51en8

And also as they require a small amount of lubrication they are often referred to as antifriction bearings(7)..This type of bearings can operate with low friction and as they are suitable for high-speed shaft speeds that require large amount of strength. There are different sub parts of rolling bearing: an outer race, an inner race, rolling elements that have to work with large amounts of dynamic loading and have to work with high speeds, and optionally a housing around these rolling elements which is normally called bearing housing, as shown in Figure 1. A detailed introduction to rolling element bearings is available in (8,9). Faults can be occurred in any of these parts, and they are oftenly single point defects such as chips or dents (10). As all of these parts are moving respectively each other so if one part fault it will cause the major effect on other element which causes high resonance frequency on overall structure. As if the rolling element damage it may result in a complete failure of the rolling bearing or a reduction in operating efficiency of the bearing arrangement. To operate efficiently we must have to consider environmental conditions as well as the details of the bearing arrangement and lubricant. Breakdown of bearing does not always due to bearing itself problem but can be by some other factor. Damage due to bearing defects in material or workmanship is exceptional (11).In machines that spin and whir, those rolling element bearings often get hit with unbalance forces thrown around by the machine itself. This kind of treatment leads to all sorts of issues in those bearings, and, guess what, it's not good for the entire rotating machine. The thing is, these bearing problems mess with how the rotating machinery works, causing glitches from small-scale setups to big industrial setup. Now, keeping tabs on these issues involves watching them like they're doing a motion, a simple harmonic motion. You see, as the vibrations go up and down in very irregular ways, it's like the machinery way of telling us something's not quite right in there (12–16)

The difference between the human and machine is taken out by its sense of intelligence. The human brain can analyze the data and information while the machines has not such ability and take decision before 1940(17). In 1943 the first Neural Network Model was introduced and Artificial intelligence era was started. By creating artificial intelligence machine which is capable to think like a human (18).The term machines learning was used first time used in the 1950 as the technique of Artificial intelligence. (17)

Intelligent fault diagnosis indicates machine learning to train the system to find out the problems. It refers to theory of the machine learning like the KNN, naive Bayes, ANN, support vector machine(19) to achieve the purposed

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aim to develop a diagnosed model that automatically construct relationship between collect data and wellness of machine(20)

Defects in the bearing can be identified by the frequency manner in vibration spectrum. The amplitude of the frequency of vibration spectrum with respect to the energy level is difference. The faults in bearing can be analyse with different methods like experimental method, numerical simulations and numerical simulations. (21)

The manufacturing community in recent years has focused on searching for various techniques, and methodologies to improve the bearing designs. For instance, the mentioned attributes apply to various studies. Mathematics models, computer aided engineering (CAE) and experimental models have to realize all the approaches. This paper plays the main objective of presenting an overview of the vibration measurement technique, vibration measurement sensors, machine learning in the field of fault detection.

Vibration Measurements:

Vibration measurement analysis is one the most important and basic method to find the vibration in running rotating body. Since when the defect occurs in the machine it will vibrate with more speed as compare to normal vibration of body. Through simulation analysis of disruptive signals and a comprehensive examination of their effects on various parameters, researchers have gained valuable insights into the behavior of statistical parameters essential for bearing condition monitoring. Employing statistically efficient methods, frequency estimation of complex signals originating from faulty rolling element bearings operating under conditions of very low shaft speed and light load has been achieved. Following frequency estimation, a straightforward notch filter is employed to eliminate specific frequency components, thereby enabling a more precise analysis of vibration signals. (23). The collected data helped to determine and validate four different types of defects in rolling element bearings: outer raceway, inner raceway, ball, and combinations of these defects. Additionally, it included data representing the normal state of the bearing. These assessments were conducted across four different running speeds and two load levels for thorough analysis and validation, (24). Another way to perform or analyzing bearing vibration signals, based on cyclostationary analysis, was proposed, (25)In cyclostationary analysis, the presence of distinct modulating frequencies offers a straightforward means of comprehension. This approach is demonstrated through graphical simulation results and experimental measurements across various fault scenarios common in industrial bearings. Synchronous averages prove particularly useful in examining the calculation of envelope signals or time-domain signals affected by high-frequency vibrations resulting from spalling damage in bearings, (26). Then signal analysis are applied in which the signal of running machine taken out in the form of time domain and then converted into frequency domain by using (FFT). To indicate the value for defect RMS values are obtained in the time domain and the high frequency resonance technique (HFRT) is used in the frequency domain. These indicated values are obtained for different rotation speeds and different loading or unloading conditions for different housing structure of bearing. Various signal processing approaches are employed to obtain most sensitive to the defect for different cases. For failure detection or diagnosis of bearing we must have all the information regarding to bearing of that machine. Any accelerometer is used to gather vibration data, (27) the vibration in any bearing placed in rotating machinery are calculated by introducing artificially defects by using electrical discharge machining on Both inner and outer race to find the better results. Furthermore, shown in this paper, (28). After the research on real-time vibration signal demodulation, it was determined that the designated filter effectively serves the bearing system. To pinpoint localized bearing defects, a dynamic loading model is proposed for improved accuracy. Additionally, defective and healthy structures are compared graphically for better understanding, shown in (29).In

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another paper the high-frequency resonance technique is employed for frequency domain analysis. Subsequently, investigations are conducted at low RPM to assess the impact of rotational speed on rolling element bearing diagnostics. Efforts are made to identify an optimal sensor placement for enhanced results. Following this, three distinct analyses—time domain, frequency domain, and spike energy—are applied to detect various bearing defects, (30). For the most accurate and approximately perfect results. Then faults are detected using off-the-shelf portable vibration analysis (vibrometer) hardware and software, (30). The partial correlation integral algorithm is primarily utilized for analyzing machine vibration data collected over the lifespan of rolling bearings. Through this algorithm, the dimensional exponent is computed, showing a tendency to increase over time as the bearing's remaining useful life decreases, (31). From the dimensional exponent, it's easy to differentiate between a healthy bearing and a bearing close to failure using graphical analysis. So, from that it is easy to conclude the condition of the bearing by using the surrogate data test method. Furthermore, the dimensional exponent can predict fault in real time from real-time vibration data from the accelerometer(27).Another method are The dynamic simulation method seeks to locate local defects by combining piecewise functions with the contact mechanism situated at the edge of the defect., (32). Vibration spectra were acquired and scrutinized to identify the locations of defects on running surfaces. The vibration signals recorded by the accelerometer underwent analysis for various comparative purposes or differentiation. Time-domain graphical parameters and frequency-domain modified Peak Ratio were computed and compared. However, the research indicated that ultrasound techniques outperformed vibration acceleration measurements in early detection, particularly for low-speed bearings studies shown in this paper,(33). At lower speeds, kurtosis and crest factor demonstrate superior effectiveness in fault detection, while ultrasound signals prove to be more efficient for average speeds. The data predominantly comprises frequency domain information captured by the sensors, indicating that the modified peak ratio was particularly effective, as evidenced in the referenced paper. This underscores the importance of adapting analysis techniques to the machinery's operational conditions for enhanced accuracy in fault detection. Which is more define in this paper (36) The algorithm's validation was carried out using two distinct sets of experimental data obtained from bearings in motors under both loaded and unloaded conditions, while also accounting for the presence of noise in the data. Various parameters were scrutinized in this study to assess the impact of altering sample size, load variations, and fault sizes. The experimental findings suggest that bearing fault detection is straightforward, and the algorithm demonstrates effective noise tolerance. A surface contact mechanism was employed for sensor data acquisition, ensuring high-precision measurements. ((34)). Various assumptions are explored for the stepwise function in the enveloping signal analysis. Specifically, the resonance frequency of the first mode of vibration signal is decomposed into sinusoidal functions of the modulated signal. Experimental research confirms the high effectiveness of the envelop detection method for diagnosing bearing faults, particularly in identifying the first mode frequency. Additionally, a mathematical model has been formulated to describe vibration in ball bearings, with faults simulated in the bearing race. (35). Various forces acting on the outer ring of the rolling element are considered. Experimental data is collected for signal analysis, which is then subjected to FFT analysis. A comparison of vibration patterns between defective and normal bearings is carried out using analytical domain analysis in finite element software. Peak and RMS values are utilized for condition monitoring, enabling a comparison between fault and healthy responses. (35) A finite element model of the bearing housing was developed to analyze vibration signals in the frequency domain. This paper provides a detailed examination of the effects of shaft rotation and load on the vibration characteristics. (36). The analysis encompasses vibration signals

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obtained from ball bearings afflicted with single and multiple-point defects occurring on the inner race, outer race, ball, and combinations thereof.(37)

Machine learning
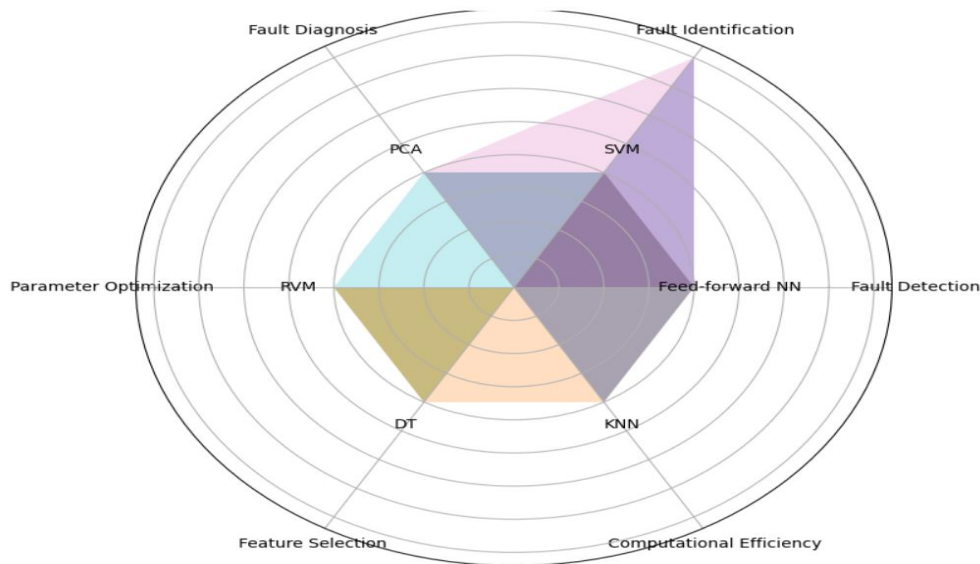
Before the model selection the most important aspect is to find out which parameter is needed to be hit first and then classifier hyper parameters need to be done carefully in algorithms. The features and performance of the system are determined by specific parameters. If these parameters are not set correctly, it can make finding a solution difficult and inaccurate. Additionally, in these models, choosing the right parameters is essential. To streamline this process, feature selection is merged to eliminate redundant and irrelevant features.

Types of Approach	Method (Ai)	**Application**	Advantages over other
Feed-forward neural network	ML (Shallow Learning)	FD	Effective in the preliminary stage of fault detection.
Support Vector Machines (SVM)	ML (Shallow Learning)	FD, Identification	Kernel functions for fault detection; colony algorithms are used for Parameter optimization.
Principal Components Analysis (PCA)	ML (Shallow Learning)	Fault Detection	Statistical graph analysis were more easily.
Relevance Vector Machines (RVM)	ML (Shallow Learning)	Fault Detection, Identification	Outstrips SVM in terms of kernel functions; Fault identification is done in more effective manner.
Decision Trees (DT)	ML (Shallow Learning)	Fault Identification	Used to find data trend in fault identification.

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K-Nearest Neighbor (KNN)	ML (Shallow Learning)	Fault Identification	Weighted KNN with squared inverse feature weighting for fault diagnosis.
Artificial Neural Networks (ANN)	ML (Deep Learning)	Fault Detection, Identification	Fault detection of large data trends is; Effective in decision-making terms.
Colony Algorithm	Optimization	SVM Parameter Optimization, Feature Selection	Synchronal SVM parameters are more optimization; and Improve accuracy.
New Methodology	K-Nearest Neighbor	Fault Diagnosis	Introduction of WKNN with squared inverse feature weighting for improved performance.
Statistical Approaches (SVM, ANN, DT, KNN)	ML (Shallow Learning)	Data Trend Analysis	Used for bearing fault detection and analysis; SVM and ANN highlighted for precision.

At every stage of the system, selecting the appropriate technique or method is a critical step that influences the outcomes in fault diagnosis. Choosing methods in this stage was often done through trial and error. Summing up these methods, they involved using distance insight and modifying neural network architecture for supervised incremental learning of the dataset. Feature selection methods include wrapped, embedded, hybrid, and filter techniques. When comparing these methods, many research studies highlight the advantages of each method in their own terms. These results were summarized in the table.

CONCLUSION:

Combining the power of analyzing vibrations and using smart computer techniques opens up exciting possibilities for spotting problems in machinery, especially in those rolling element bearings. These fancy methods like neural networks and support vector machines, when paired with detailed vibration analysis, help engineers pinpoint faults more precisely and quickly. Of course, there are some hurdles to overcome, like figuring out the best settings and which features to focus on. But researchers are hard at work ironing out these kinks. As technology keeps advancing, we're looking at a future where machine maintenance gets even better, keeping our industrial equipment humming along smoothly for longer.

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Distributed Anomaly Detection in Networks Using Machine Learning and Federated

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Abstract— Anomaly detection is essential for protecting vital systems in a variety of fields, such as environmental monitoring and cyber security. This study uses UGransome dataset for examine the effectiveness of combining federated learning methods which machine learning models for anomaly identification. In situation when data can not be centralized data sources owing to legal or practical limitations, federated learning is especially appropriate since it permits cooperative model training across decentralized data sourcing while protecting data privacy. This study tackles related to data heterogeneity and privacy problems by utilizing cutting-edge machine learning methods, to efficiently identify anomalies within distributed datasets. Test results show how well the suggested federated learning strategy works to improve anomaly detection accuracy while preserving data privacy.

   Keywords—Anomaly Detection, Federated learning, Security and Privacy

INTRODUCTION

The rapid growth of connected devices and the quick development of Internet technologies in recent years have resulted in an unparalleled rise in the amount and variety of network traffic. As a consequence, the risk of cyber-attacks and network intrusions has escalated, posing significant threats to the security and integrity of data. Traditional network security measures, such as firewalls and signature-based intrusion detection systems (IDS), are often inadequate in detecting sophisticated and emerging threats, particularly zero-day attacks. These attacks exploit previously unknown vulnerabilities, making them difficult to detect and mitigate using conventional methods. Intrusion Detection Systems (IDSs) have become an essential layer of the network defences against potential intrusions Denial. An IDS watches all incoming and outgoing packets on the network, analyses them for anything suspect (on a code level), pinpoints discrepancies that indicate their actions may be an intrusion attempt as opposed to normal operation, creating alerts accordingly. Nevertheless, conventional IDS approaches suffer from the burden of relying on predefined rules and signatures that do not scale well with new/evolving threats. To address this limitation, there arises interest in using Machine Learning (ML) based for network traffic anomaly detection.

Based on a learning experience of normal behaviour, ML-based IDS can also recognize variations being the symptoms of possible intrusions and even to detect zero-day attacks. There are however many challenges despite promising the capabilities of machine learning to improve IDS for better performance. One of these is the need for plenty of labelled training data so that

proficient models can be developed. Encouraging elaboration: Not all attack scenarios can be accurately labelled and dataset collection for unseen attacks (like zero-days) is unfeasible Powerful network data may even be too sensitive to collect in one place and provide the opportunity for model training, so also centralized ML model training raises concerns about how network security protection should change with respect of breach prevention, governance or worst-case failure. A third problem is the dynamic and distributed nature of modern networks. This

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could lead to a lower detection accuracy and the presence of many false positives. Additionally, running in real-time analysis of network traffic can require a good deal of computer power and have scalability issues if working on large scale implementations. In order to solve these problems, this study explores the usage of Federated Learning (FL) for network intrusion detection. Federated Learning is a kind of decentralized machine learning where multiple people contribute to training the model in iterations using locally relevant data. This benefits data privacy by ensuring that only model changes are communicated and aggregated, while keeping the sensitive network-specific information on local devices. The UGransom dataset, an extensive benchmarking dataset for anomaly detection is employed in this work to evaluate the effectiveness of proposed approach. The utilized data set provides broad conditions of network traffic that are both normal and malicious allowing generative model construction. So, let's concentrate on anomaly detection methodologies that pinpoint anomalous patterns which may constitute an indication of looming intrusions.

RELATED WORK

ML-based anomaly detection requires substantial data to define normal behaviour, expected noise, and deviations. In complex environments, centralizing data for training and testing may be infeasible due to resource constraints, security/privacy concerns, and high communication latencies. Federated ML addresses this by enabling on-device learning across multiple entities, reducing the need to centralize data [1]. Anomaly detection seeks out deviations in data that diverge from expected normal behaviour, holding crucial implications across diverse domains. For instance, anomalous network traffic could signify a compromised system transmitting sensitive data illicitly. These anomalies, categorized broadly into performance and security-related issues, encompass scenarios like broadcast storms and malicious attempts to overload networks, disrupting legitimate services [2]. This study defines" isolation" as the act of separating an instance from others. Isolation-based methods gauge each instance's likelihood of isolation, identifying anomalies with the highest susceptibility. This concept is implemented using randomly generated binary trees, where anomalies exhibit shorter paths due to fewer partitions in their occupied regions and early separation during attribute-based partitioning [3].

Anomaly detection has been extensively studied (surveyed in (3-5), with major methods including distance-based techniques using nearest neighbours or clusters, one-class SVMs trained on normal data, and methods based on fidelity of reconstruction such as PCA. Recent advancements involve deep neural networks, particularly autoencoders and variational autoencoders, which learn to reconstruct normal data and detect anomalies by identifying high reconstruction errors [4]. Param pottupadam and Moldovann propose that traditional machine learning (ML) algorithms display promise, while ions present an alternative avenue. Deep learning, despite its need for abundant training data, offers distinct approaches. Nonetheless, its performance may not consistently outperform traditional ML models across all applications [5]. The authors in propose a signature-based IDS for detecting DoS and routing attacks in IoT networks, utilizing centralized and distributed components. The main detection module operates on the central router, while lightweight modules near IoT devices monitor and report traffic. Despite efficient pattern- matching capabilities on modern systems, signature-based approaches are limited to known attack patterns, struggling with novel attacks or advanced techniques like encrypted channels [6]. There is no universally accepted anomaly detection technique applicable across all domains, which complicates the search for domain specific methods. For instance, techniques effective in domains with labeled datasets, like internet activities or financial transactions, may not translate well to domains like Water Quality Anomaly Detection (WQAD), which often deal with unlabelled datasets [7].This research tackles the complexities of

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anomaly detection through a method that integrates blockchain based federated deep learning. Federated learning avoids the centralization of training data, thereby improving efficiency and confidentiality. By utilizing blockchain technology, updates to models are securely logged, ensuring transparency, resilience and the ability to audit. The combination of these technologies establishes accountability and non-repudiation, essential for detecting tampering and maintaining the integrity of machine learning models [1]. Federated Learning (FL) has attracted considerable attention in the context of Industrial Internet of Things (IIoT). Wang et al. proposed an anomaly detection method utilizing a composite autoencoder model to detect anomalies by analyzing error distributions, aimed at identifying abnormal devices. Genge et al. developed an anomaly detection system specifically tailored for aging IIoT devices, highlighting the gradual degradation of IIoT physical components as they age. Liu et al. fl=CNN-LSTM-based Deep Anomaly Detection Integrated with FL.

Diverse aspects of Federated Learning (FL) have been covered by a variety of previous studies. Qin et al. concerns about FL clients who could return bad weight due to adversarial attacks or because of undetected failures, and this can hurt the global model Their proposed solution evaluates the local model of each client on a pre-filtered data at server and discards models with high loss values, because they are not shared regardless. The goal of Liu et al. and Ye et al., weights to be communicated the most over FL One approach by Liu et al. in this work involves compressing gradients that are larger than a certain threshold and sending only the rest [8]. In recent time, the advancements of Artificial Intelligence such as deep learning and data mining has shown great potential towards security applications. But is still moving many other barriers to strong security across these systems. The vulnerability of machine learning (ML) algorithms to adversarial attacks, where bad actors could inject incorrect data while the model is being trained and take advantage of blind spots fell into agreement [9].

FEDERATED LEARNING BACKGROUND

Federated Learning (FL) is a decentralized machine learning approach where multiple users collaborate to train a model while keeping data on local devices for privacy. Unlike centralized methods that gather data in one place, FL distributes training across devices, ensuring sensitive data stays local. Horizontal Federated Learning (HFL) uses datasets with different samples but the same features, like hospitals sharing structured data. Vertical Federated Learning (VFL) involves datasets with different features but the same sample, such
as e-commerce and banking data for credit scoring. Federated Transfer Learning (FTL) adapts models between domains with little data overlap, enabling collaboration across diverse datasets.

PROPOSED APPROACH

This method integrates Random Forest (RF), Support Vector Machine (SVM) and Naive Bayes(NB)—based on federated learning (FL), in order to enhance the network intrusion detection. The goal is to build an accurate, privacy-preserving zero-day flow-based anomaly detection system in a distributed network environment. For training and assessment purposes, the UGransome dataset serves as a thorough baseline for a range of network traffic scenarios.

- *Federated Learning Hierarchical Structure*

To implement Federated Learning for network intrusion detection, the proposed approach employs a hierarchical structure comprising multiple layers

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- ▪ *Local Nodes*
- Local nodes represent the individual devices or network entities that generate and store data. Each node independently trains local models (RF, SVM, NB) on its own data without sharing raw data with other nodes or a central server. These nodes are responsible for the initial training phase, model updates, and local anomaly detection.
- Federated Learning with an edge server, the expression describes how the edge server aggregates model updates from multiple local nodes. Here, w ei represents the aggregated model parameters at edge server i, m i is the number of local nodes connected to edge server i, and w cj are the model parameters from the j-th local node. Each local node trains its model on local data and sends the updated parameters to the edge server. The edge server then averages these parameters, creating an intermediate aggregated model, which it forwards to the central server for global aggregation. This hierarchical aggregation process reduces communication overhead, enhances scalability, and preserves data privacy by ensuring that raw data remains on local nodes

$$wei = \frac{1}{mi} \sum_{j=1}^{mi} wcj \qquad\qquad wg = \frac{1}{K} \sum_{k=1}^{K} wmk$$

- Federated Learning (FL) with a global server, how the global server aggregates model updates from multiple participating edge or client devices m k. Here, w g represents the aggregated global model parameters, K denotes the total number of participating devices, and w m k signifies the model parameters sent from the k-th device. Each device m k independently trains its model on local data, capturing unique aspects of their respective datasets while learning without sharing raw data. After training, each device sends its updated model parameters w m k to the global server. The global server then averages these parameters using the equation provided, producing a refined global model w g that integrates insights from all participating devices.

EXPERIMENTATION AND EVALUATION

Data Background: The suggested method combines the advantages of several machine learning methods, including Random Forest (RF), Support Vector Machine (SVM), and Naive Bayes (NB), to improve network intrusion detection through Federated Learning (FL). The objective is to create a reliable, privacy-preserving anomaly detection system that can recognize zero-day assaults in a distributed network.

Preprocessing: The provided code preprocesses the Ugransome dataset by utilizing forward fill to handle missing values, using labelencoder to encode categorical variables into numerical values, and maybe scaling the features for uniformity. To make the evaluation of the model easier, the dataset is then divided into training and testing sets.

Performance and Evaluation Matrices: In Figure2. the Ugransome dataset, accuracy was used to evaluate how good machine learning models are. besides precision and recall f1-score. While precision measures the proportion of genuine positive predictions made, recall tells you what portion of actual positives were correctly identified by the model and accuracy computes total correct. F1-score provided a balance between recall and precision. In

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Confusion matrices showed real and fake negative, positive results essentially fined details. In Figure 3. The Random Forest classifier had the best performance of classifying network anomalies, as it was able to strike a balance between precision and recall while maintaining high accuracy.
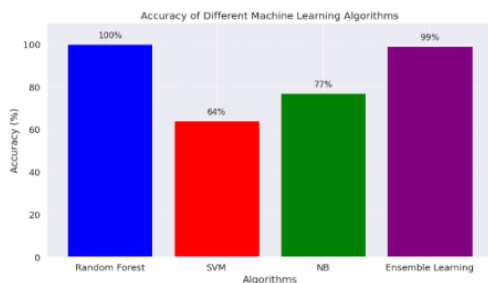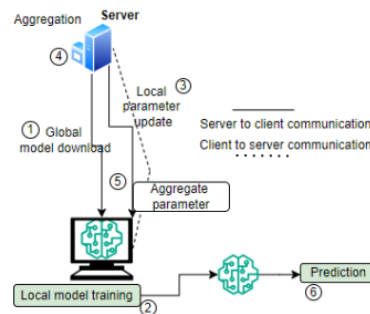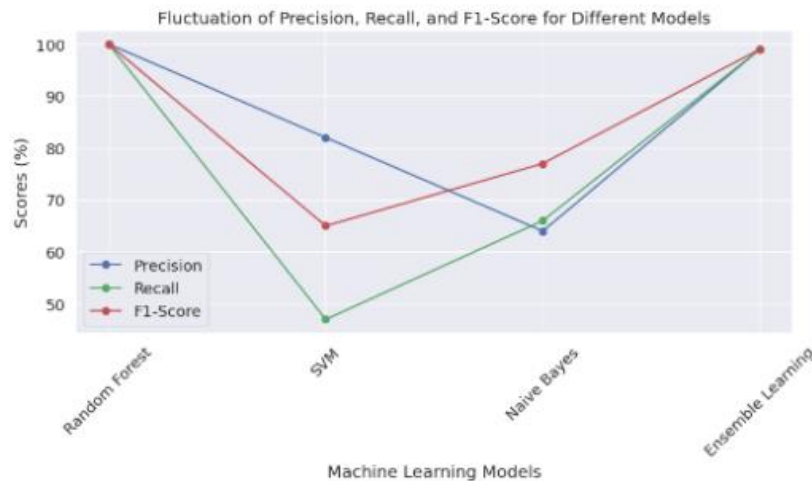

Figure 2. Accuracy Graph

Figure 1. Architecture of FL

■ *Performance EvaluationFigure 1. Architecture of FL*

This subsection discusses the performance evaluation results and experimental setting. Figure 3. Here we are the performance of local model improves when they trained in an FL environment.

Figure 3. Confusion Matrix Table

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Table 1. Confusion Matrix for Different Algorithms with Precision, Recall, and F1-Score

Algorithm	TP	FP	FN	TN	Precision	Recall	F1-Score
Random Forest	94.5	5.5	3.2	96.8	100	100	100
SVM	81.7	18.3	23.9	76.1	82	47	65
Naive Bayes	65.4	34.6	33.7	66.3	64	66	77
Ensemble Learning	98.6	1.4	1.9	98.1	99	99	99

CONCLUSION

The UGransome dataset has been used for perform a study with to illustrate how different machine learning models in combination Federated Learning (FL) can be effective on distributed anomaly detection in networks. Federated Learning for Data Localization ensures that data privacy is retained, whilst allowing one or more parties to train a joint model on the local datasets. It solves the problem of privacy challenges with central systems and heterogeneity among data. Building upon the proposed FL architecture.

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Intelligent Computing Approach for Investigating Blasius Equation

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Abstract-Intelligent computing has become an efficient approach for elucidating computational fluid dynamics (CFD) problems. This research article aims to study the Blasius equation, a basic mathematical model narrating the laminar steady-state flow of an incompressible fluid across a semi-infinite flat plate using a Backpropagated Artificial Neural Network (ANN) optimized with Levenberg-Marquardt Algorithm (LMA). Blasius equation is a nonlinear differential equation of third order that falls under the category of boundary layer flow. The dataset for the Blasius equation is obtained by Adams's numerical method. The generated data set is divided into three subsets, 80% for training, 10% for testing, and 10% for validations of ANN. Using ANNs for approximating the BE's solution, boundary layer characteristics may be predicted effectively and reliably. The proposed technique performs well compared to the traditional methods regarding reliability. The outcomes produced using ANN-LMA demonstrate the technique's effectiveness in resolving complex CFD problems and provide a numerical solution of the BE across a semi-infinite flat plate (BE-SIP). Performance can be validated through MSE-based training arcs. Moreover, error histograms, regression metrics, training estate analysis, and fitness curve plots confirm the trustworthiness, stability, and durability of the ANN-LMA approach. A small Mean Squared error of order 10^{-10} is obtained, verifying the accuracy of the proposed strategy. The observed Correlation value is one, signifying the finest regression.

Keywords—Intelligent Computing Approach, Artificial Neural Networks, Blasius Equation, Levenberg-Marquardt Algorithm

INTRODUCTION

Artificial intelligence has gained popularity for unraveling Computational fluid dynamics (CFD) flow features. Numerous researchers nowadays are attracted to dealing with CFD problems through Intelligent computing techniques. This article describes a strategy based on ANN for solving the Blasius equation along with BCs, which is given by

$$\frac{d^3f(x)}{dx^3} + \frac{1}{2}f(x)\left[\frac{d^2f(x)}{dx^2}\right] = 0, x \in [0,\infty] \tag{1}$$

$$f(0) = 0 = f'(0), f'(x) = 1, x \to \infty \tag{2}$$

Here, f(x) is the flow function. In boundary layer theory, the Blasius equation explains the fluid's velocity profile on a semi-infinite interval [1]. The power series solution for the Blasius equation is found in the literature [2]. The search for better, broadened, simpler, and more precise techniques is a persistent and ongoing endeavor. A variety of techniques have been utilized for finding numerical solutions for this problem, such as Adomian's decomposition Technique [3]. Wazwaz [4] utilized variational iteration Algorithm for solving BE. Parand [1] resolved the BE numerically by the sinc-collocation technique. Moreover, the Blasius equation has been solved by the Rational scaled generalized Laguerre function collocation method by Parand et al. [5]. Miansari et al. [6] adopted the Homotopy perturbation method for examining the BE. Collocation techniques based on rational

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Chebyshev functions are implemented for investigating the Blasius Equation by various researchers [7, 8, 9, 10, 11].

ANNs are a subclass of artificial intelligence consisting of interconnected nodes. ANNs are developed to be flexible in many settings based on data that enters the network during the learning process, both internally and externally. The learning technique seeks to build a network of links (weights) that may offer a representation for the set of training objects. Probabilistic computations are generated primarily by constructing ANNs and improving these by combining both linear and non-linear searching approaches for tackling several differential equation challenges. Current advancements in probabilistic computational techniques allow for the creation of chaotic cornea-shape models [12], Astrophysics' nonlinear systems [13], pantograph-based mathematical model equation of delay differential [14], financial model [15], nonlinear unipolar electrohydrodynamic pump flow model [16], plasma physics [17], computational intelligence for Mathieu's frameworks for parameter stimulation., upward triggered pendulum, and dirty plasma designs [18], singular differential system [19], nonlinear Emden-Fowler formula [16], plasma physics [20], electromagnetism and fluid mechanics issues [21], prediction of inelastic displacement demands [22] ground motion prediction design [23] in the investigation of the nonlinear responsive transport system of the fluid in softer tissues and micro-vessels [24].

Numerous researchers have recently utilized ANN while investigating the boundary value problem (BVP). The well-known strength of neural networks has been used to solve Differential problems, both nonlinear as well as linear, including those in the field of nanotechnology, fluid dynamics difficulties depending on the theory of combustion: thin film flow ignition of fuel, magneto-hydro-dynamic problems, nonlinear Pantograph systems, and others [25]. The optimization algorithm that is most frequently utilized is the Levenberg-Marquardt Algorithm (LMA). In various problems, it works better than other conjugate gradient algorithms and basic gradient descent. It combines the strength of gradient descent and Newton's method. These facts motivate the writers to investigate novel techniques and apply them to develop a precise and workable computational model for dealing with fluid dynamics challenges, such as BE-SIP. Thus, the literature review depicts that physical and data-driven aspects of the Blasius Equation have not been extracted through the ANN-LMA approach. The features of this study are the following

➢ The ANN-LMA is implemented to extract the detailed features of the Blasius boundary layer flow model.
➢ Performance training arcs, regression metric analysis, error distribution graphs, fitness curve plots, and statistical evaluation of the ANN-LMA approach confirm the validity of the proposed strategy.

The rest of the article is systematized such that Section 2 describes the solution methodology, Section 3 interprets the results, Section 4 helps conclude the study and Section 5 includes the citations of the references.

SOLUTION METHODOLOGY
The laminar steady-state flow of an incompressible fluid across a semi-infinite flat plate is considered. Flow is depicted in Fig. 1.

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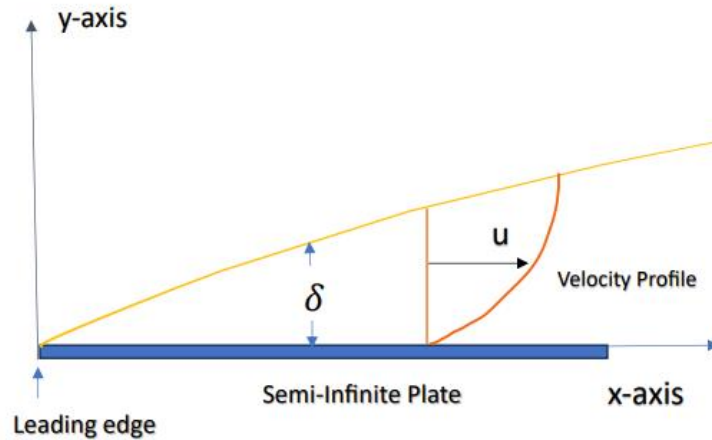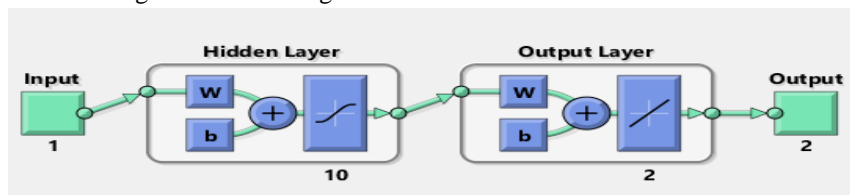**14ᵗʰ-15ᵗʰ, October 2024**
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Fig. 1. Geometry of Flow

The suggested approach is divided into two stages: generating a reference dataset in Mathematica and subsequent implementation of a neural network model in MATLAB using the "nftool".

The Blasius equation is discretized and converted into a system of first-order differential equations during the first coding phase. In Mathematica, the numerical solver command "NDSOLVE" is used to solve this system numerically. Following that, a neural network model is built in MATLAB using the "nftool" toolbox. The neural network's input layer represents the independent variable (for example, distance along the plate), whereas the output layer reflects the dependent variables (for example, velocity and shear stress). The hidden layers capture the underlying intricate interactions between the inputs and outputs. The network design and training parameters are carefully selected to optimize the model's performance and accuracy.

- The neural network is trained using a dataset derived from Mathematica numerical solution. The training phase entails modifying the network's weights and biases to reduce the difference between the predicted and target values. Once trained, the neural network can accurately forecast the velocity and shear stress profiles for any point along the semi-infinite flat plate. The proposed ANN-LMA methodology is used to determine the BE-SIP solution. For 1000 input points, the f(x) dataset values are divided as follows:
- Training uses 80% of the dataset.
- Validation is performed on 10% of the dataset.
- The testing takes up 10% of the dataset.

The proposed network's design is shown in Fig. 2.

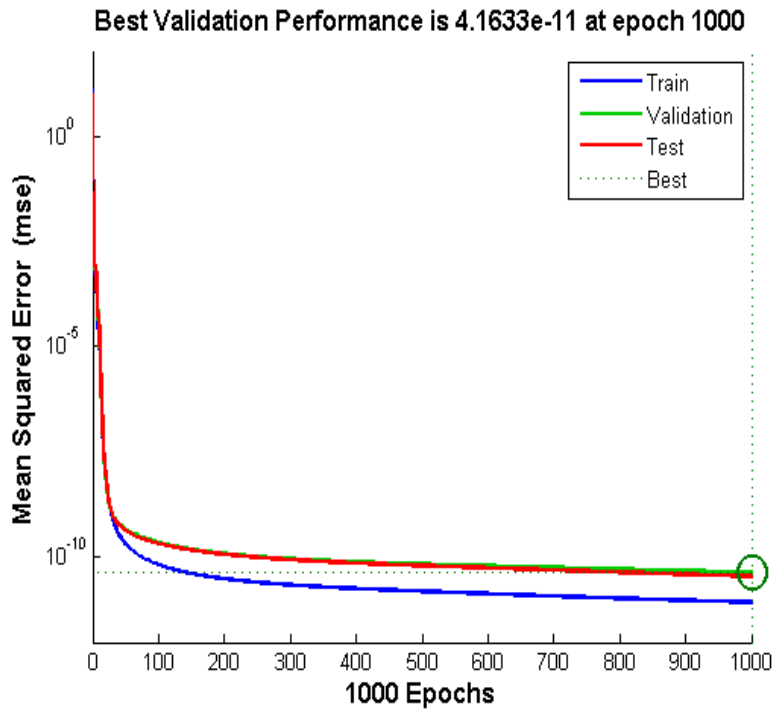*Fig. 2. Neural Networks*

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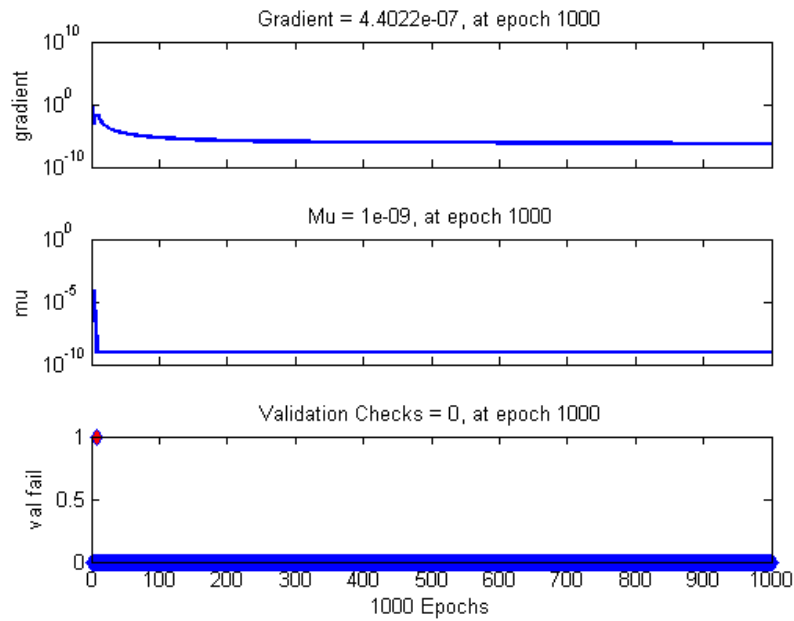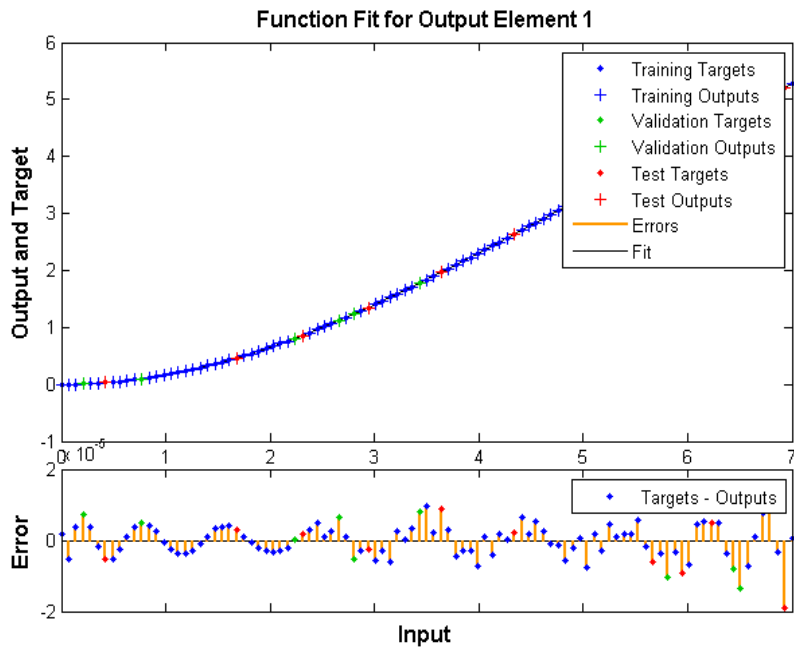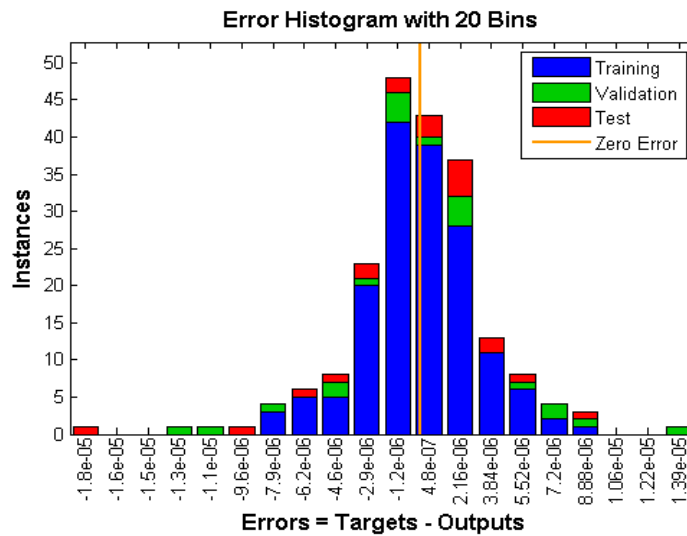**14ᵗʰ-15ᵗʰ, October 2024**
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RESULT AND DISCUSSION

For solving the BE-SIP, the developed ANN-LMA is used. The MSE resolution for validity, training, and testing using epochs, curves, time, and backpropagation regulator Mu is depicted in Fig. 3. The lowest MSE produces effective results since it illustrates the discrepancy between targeted outcomes and intended results.

The obtained MSE value is 4.1633E-11 at 1000 epoch which is very small attesting to the efficiency of the proposed strategy. MSE becomes smaller as the number of epochs increases. Fig. 4 describes the statistical evaluation of the ANN-LMA approach. Mu and gradient are hyperparameters that affect and somehow control the learning rate. Mu is 1E-9 and the gradient is 4.4022E-7 which shows the best measures. The Fitness curve is visualized in Fig. 5. The trends and patterns of the reference data set are learned by ANN efficiently, as seen in Fig. 5. The predicted values are in fair agreement with the target points. Fig. 6 displays the distribution of error for the ANN-LMA approach. Several instances falling into the bin with an error range of 10^{-7} is appreciable. Fig. 7 demonstrates the regression analysis of the proposed technique. The straight line is the line of best fit. The points lie on a straight line and are not scattered, indicating the ideal regression. Moreover, R=1 is the optimal correlation value.

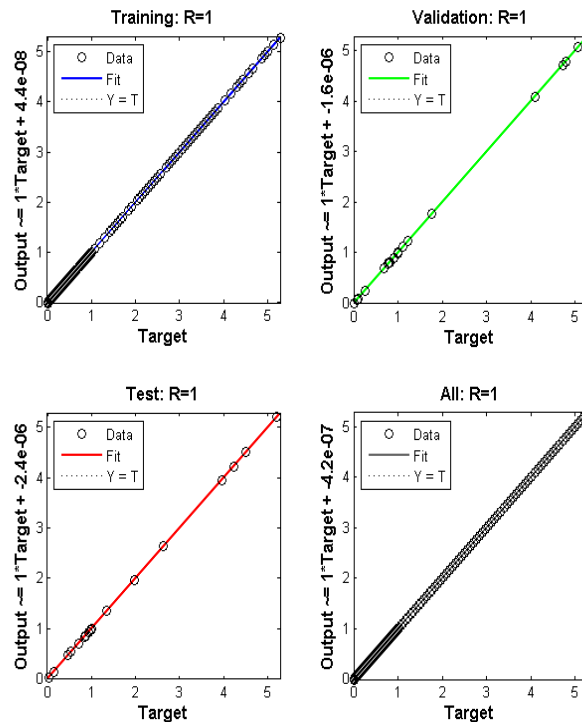*Fig. 3. MSE of ANN-LMA for BE-SIP*

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Fig. 4. Statistical evaluation of ANN-LMA for BE-SIP

Fig. 5. Fitness Curve Analysis ANN-LMA for BE-SIP

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Fig. 6. Histogram of Error of ANN-LMA for BE-SIP

Fig. 7. Regression interpretation of ANN-LMA for BE-SIP

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The network has successfully acquired the basic structures to predict the velocity profile. We evaluated the network's performance by Mean Squared error, the benchmark case in our study. Excellent convergence of the findings demonstrated the success of our technique in solving the Blasius problem. Numerous ways to solve the Blasius problem have been proposed. The key issue in this field is the accuracy and application of these approaches. We investigated the Blasius equation using a backpropagation neural network in this research.

Additionally, 'nftool' offers valuable information about the neural network's behavior. We examined how convergence behaved and how training factors such as acquisition rate and velocity affected it. These findings not only assisted us in improving our neural network approach but also assisted in comprehending the Blasius equation better.

CONCLUSION

This study implemented a novel intelligent computing technique to investigate the CFD Blasius problem efficiency. The reference dataset was generated by the Adams numerical method. ANN was trained with the reference dataset. The accuracy of the proposed strategy was validated through graphical illustration. The core outcomes of this research study are as follows

> ➢ The MSE of order 10^{-11} is obtained highlighting the accuracy of results.
> ➢ The correlation coefficient is one, optimum regression.
> ➢ Fitness curve plots confirm the trend and patterns of the flow model are learned by ANN through data effectively.

The effective execution of our suggested strategy creates opportunities for applying neural network techniques to a large number of BVPs. Additionally, the researchers can explore various network designs, improve training methods, and broaden the application to boundary layer equations with more complicated structures. In general, our study offers novel approaches for using artificial neural networks to solve differential equations and advances computational methods in fluid dynamics.

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Comparative Analysis of Power Flow Simulations in the Test 10-Bus Power System Using PowerWorld Simulator, ETAP, and PSS Software

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Abstract—Power flow analysis plays a pivotal role in under- standing and managing complex power systems. The accurate assessment of electrical parameters such as voltage, real, and reactive power is vital for both utility companies and consumers. This paper investigates the power flow analysis of the test 10- Bus power system utilizing three industry-standard software packages: PowerWorld Simulator, ETAP, and PSS. The study aims to provide insights into the performance and accuracy of these tools in simulating power flow within the network. Through comprehensive analysis and comparison of the results obtained from each software, this research contributes to enhancing the understanding of power flow dynamics and the reliability of simulation tools in real-world applications.

Keywords—**Power Flow Analysis, Voltages, PowerWorld Simulator, ETAP, PSS.**

INTRODUCTION

The comprehensive understanding and effectively management of modern power systems necessitate the thorough characterization facilitated by power flow analysis. This in- dispensable technique enables the determination of crucial electrical parameters such as voltage magnitudes, real and reactive power flows at various busbars within the system. Furthermore, power flow analysis allows for the monitoring of power losses incurred along transmission lines, thereby providing insights into the system's overall efficiency and health.

With the increasing complexity and interconnectedness of power networks, the importance of robust power flow analysis techniques cannot be overstated. These techniques serve as fundamental tools for engineers and operators to ensure grid stability, optimize power transfer, and mitigate operational risks. Moreover, they play a pivotal role in the planning and design of future expansions and upgrades to the power infrastructure.

In recent years, the availability of commercial software packages tailored for power flow studies and simulations has proliferated. Among these offerings, ETAP, PSS, and PowerWorld Simulator stand out due to their user-friendly interfaces and interactive capabilities, which streamline the analysis process and enhance accessibility for practitioners across various domains of the power industry.

This paper focuses on a comparative evaluation of power flow analysis utilizing ETAP, PSS, and PowerWorld Simulator. By leveraging these widely adopted software platforms, we aim to explore their respective strengths and limitations in accurately modelling power flow dynamics within a test power system. Additionally, we delve into the common techniques underpinning power flow analysis, including Gauss-Seidel, Newton-Raphson, and Decoupled methods, to provide a com- prehensive understanding of the computational algorithms employed in contemporary power system analysis. Through this investigation, we seek to contribute to the advancement of power system analysis methodologies and inform practitioners about the best practices for conducting power flow studies in real-world applications.

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The remaining paper is structured in this way. In section II, a brief literature review is presented, bus classification is explained in section III, description of the test 10-bus power system is analysed in section IV, simulation of the 10-bus system is given in section V, results and discussion are given in section VI and finally section VII concludes this research paper.

LITERATURE REVIEW

The power system, a complex network comprising buses, transmission lines, and loads, can be effectively represented by an equivalent circuit, as detailed in [1]. Through load flow analysis, as documented in [2]- [3], critical insights into the system's behavior are gained, encompassing key parameters such as voltage magnitude and phase angle at load buses, reactive power and phase angle of voltage at generator buses, power at slack buses, and the active and reactive power of transmission lines.

However, translating these parameters into mathematical expressions unveils their inherent non-linearity, necessitating sophisticated mathematical techniques for solution. Among the frequently employed methods are the Newton-Raphson, Gauss-Seidel, and Fast-Decoupled methods, as outlined in [4]. While hand-based calculations suffice for limited bus bar systems, as discussed in [5], the advent of modern computing has revolutionized the analysis landscape, enabling efficient
computation even for systems comprising a large number of buses, as noted in [6].

Moreover, the applications of power flow techniques extend far beyond mere analysis. In [7], [8], [9], [10], [11], and [12], various practical applications are explored, ranging from system planning and operation to stability analysis and control. This comprehensive exploration underscores the significance and versatility of power flow analysis in modern power sys- tems engineering.

BUS CLASSIFICATION

In the realm of power systems analysis, a critical concept is the "bus," which represents the point where various com- ponents such as generating units, transmission lines, or loads are interconnected. This fundamental term, as outlined in [13], serves as a pivotal node within the power network architecture. In power systems study, each bus is characterized by four essential parameters, as elucidated in [14]: Voltage Magnitude (V), Voltage Phase Angle (δ), Real Power (P), and Reactive Power (Q). These parameters encapsulate the essential electri- cal characteristics of the system at each bus, providing crucial
insights into its operational state and behavior.

Notably, while two of these parameters are explicitly iden- tified and quantified, the other two parameters remain undis- closed or "anonymous," as noted in [15]. This underscores the complexity of power systems analysis, wherein certain aspects may be inferred or estimated based on available data, while others require further investigation or measurement.

Building upon these foundational principles, buses within a power network are categorized based on the known quantities associated with them. Primarily, buses are classified into three distinct types: Swing bus, Load bus, and Generator bus. These classifications facilitate the organization and management of the power system, allowing for more efficient and effective operation and control strategies.

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Slack Bus

Slack bus is also referred as a reference bus as this bus is used to balance the network power [16]. The known parameters of this bus are voltage magnitude and phase angle while the anonymous variables are P and Q.

Generator Bus

Generator bus is also referred as a PV bus because the output power and voltage can be controlled [16]. The obvious parameters in this bus are really power and voltage magnitude while the anonymous parameters are Q and δ.

Load Bus

Load bus is also called PQ bus as the power is consumed at this bus. The obvious variables in this bus are real and reactive power while the anonymous parameters are voltage magnitude and phase angle.

DESCRIPTION OF THE TEST 10-BUS POWER SYSTEM

We consider a test 10-Bus power system for the study. Bus-1 is taken as a swing bus, bus-2 and bus-3 are PV buses while the remaining buses are loading (PQ) buses. The description of each component is given below:

Generator Parameters

There are six identical generating units in the system. The parameters of each generator i.e. power, impedance are given below:

S = 100 MVA
x_1 = 0.12 pu x_2 = 0.14 pu x_0 = 0.05 pu
10MW $\leq P_G \leq$ 30 MW
-5 MVar $\leq Q_G \leq$ 10 MVar

Transmission Lines Parameters

All the transmission lines are supposed to be made of the same conductor having the following attributes:
$z_1 = z_2 = 0.1 + j0.45$ Ω/km $z_0 = 0.3 + j1.2$ Ω/km
$b = 3 \times 10^{-6}$ mho/km Transfer Capacity = 100 MVA
The transmission line distance is given in Table 1.

TABLE I
Distance of the Transmission Lines

From Bus	To Bus	Distance(km)
Bus 1	Bus 3	68
Bus 3	Bus 6	80
Bus 6	Bus 4	56
Bus 1	Bus 4	80
Bus 4	Bus 2	74

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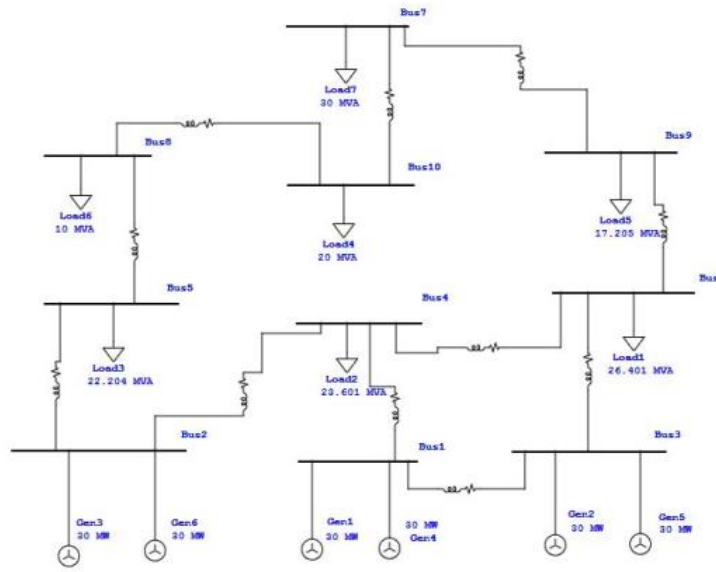**Organized by University of Wah**

Bus 2	Bus 5	48
Bus 5	Bus 8	61
Bus 6	Bus 9	45
Bus 9	Bus 7	56
Bus 7	Bus 10	48
Bus 8	Bus 10	69

Loads Parameters

The rating of the loads at each bus is presented in Table 2. The power factor of each load is 0.8 lagging.

SIMULATION OF THE TEST 10-BUS POWER SYSTEM

Simulation in ETAP

The Test 10-Bus Power System, a widely used benchmark system for power system analysis, was initially simulated using ETAP software, as illustrated in Figure 1. ETAP stands out for its comprehensive features, offering a diverse range of libraries tailored for various components crucial to power system modeling. These include Transmission Lines, Cables,

TABLE II

Rating of the loads

Location	Rating (MW)
Bus 4	20
Bus 5	20
Bus 6	24
Bus 7	30
Bus 8	10
Bus 9	16
Bus 10	20

Circuit Breakers, Motors, and Protective Relays, among others, providing users with a rich set of tools to accurately represent the intricacies of real-world power systems.

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Fig. 1. Simulation of Test 10-Bus Power System in ETAP
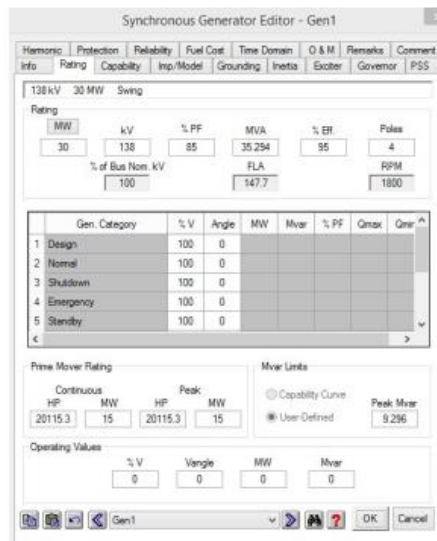
Fig. 2. Generator Parameters in ETAP

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In the context of the simulation, specific attention was directed towards configuring the generator parameters within the ETAP environment, as depicted in Figure 2. These parameters, encompassing crucial aspects such as generator ratings, control

settings, and operational constraints, play a pivotal role in determining the behaviour and performance of the generators within the simulated system. By meticulously setting these parameters in accordance with the desired specifications and operational requirements, engineers can ensure the accuracy and fidelity of the simulation results generated by ETAP.

Simulation in PSS

PSS, developed by SIEMENS, stands as another robust tool in the arsenal for power flow analysis. Available for exploration through a trial version downloadable from the official SIEMENS website, PSS offers a comprehensive plat- form for studying power system behaviour and dynamics. This software's pedigree, backed by the reputation of SIEMENS, instils confidence in its capabilities and reliability among engineers and researchers.

Figure 3 presents a snapshot of the simulation of the Test 10-Bus system within PSS, providing users with a visual representation of the system's behaviour and performance. Through this simulation, users can delve into the intricacies of power flow dynamics, gaining insights into voltage profiles, load distribution, and system stability. The ability to visualize these aspects aids in understanding complex phenomena and facilitates effective decision-making in power system planning and operation.

With its intuitive interface and powerful analysis capabilities, PSS empowers users to explore various scenarios, analyse contingencies, and optimize system performance. Whether used for educational purposes, research endeavours, or practical applications, PSS serves as a valuable tool in the study and analysis of power flow in modern electrical networks.
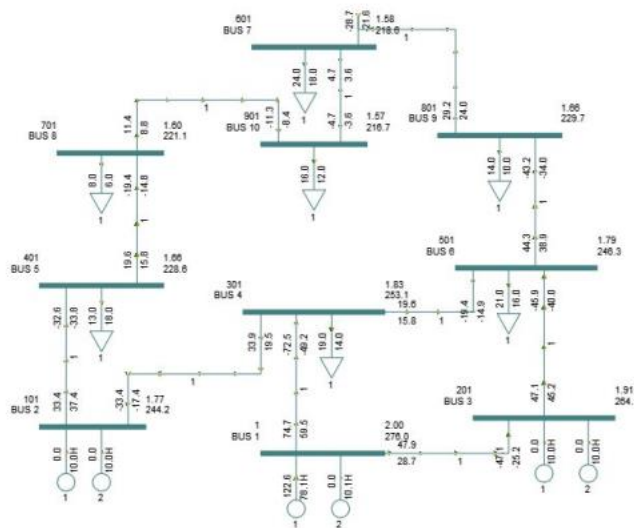

Fig. 3. Simulation of Test 10-Bus Power System in PSS

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The generator parameters in PSS are set as displayed in Fig. 4.
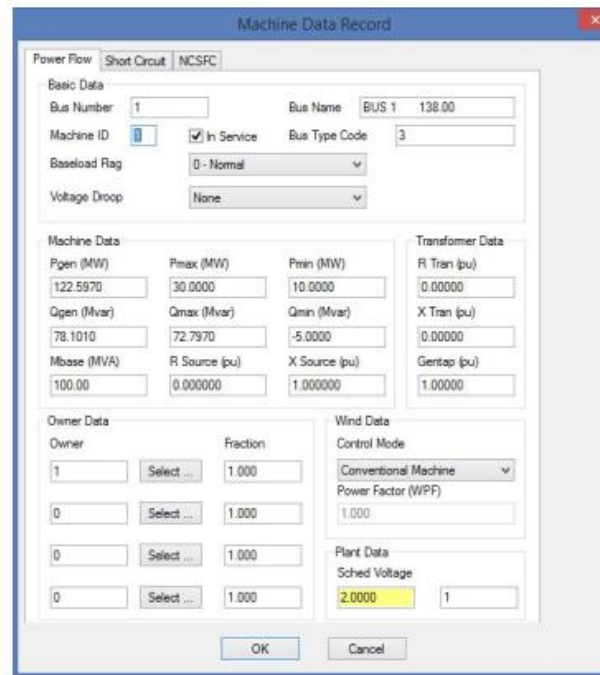

Fig. 4. Generator Parameters in PSS

Simulation in PowerWorld Simulator

PowerWorld Simulator emerges as a valuable tool for power system analysis, accessible to users as freeware via the internet. Its availability and user-friendly interface make it an attractive choice for engineers and researchers alike.

One of its notable features is the ability to visualize solved power flow cases graphically, employing animated single-line diagrams. This graphical representation enhances the under- standing of system behavior and facilitates insightful analysis. Figure 5 showcases the simulation of the Test 10-Bus system within PowerWorld Simulator, providing users with a clear visual representation of the system's operation and performance. Through this simulation, users can observe dynamic changes in system variables and identify potential issues or areas for improvement.

Furthermore, Figure 6 illustrates the configuration of generator parameters within PowerWorld Simulator. These parameters, which encompass various aspects such as generator characteristics, control settings, and operational constraints, are crucial for accurately representing the behavior of generators within the simulated system. By configuring these parameters appropriately, users can ensure the fidelity and accuracy of simulation results generated by PowerWorld Simulator, thereby facilitating meaningful analysis and informed decision-making in power system studies.

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RESULTS AND DISCUSSION

In Figure 7, we present the simulation results derived from ETAP, showcasing the outcomes of our power flow analysis. In Figures 8 and 9, we delve deeper into the comparison by employing both the Newton-Raphson and Fast-Decoupled Newton-Raphson methods. Specifically, Figure 8 illustrates the power flow analysis outcomes using the Newton-Raphson method, while Figure 9 displays the results obtained through the Fast-Decoupled Newton-Raphson method.
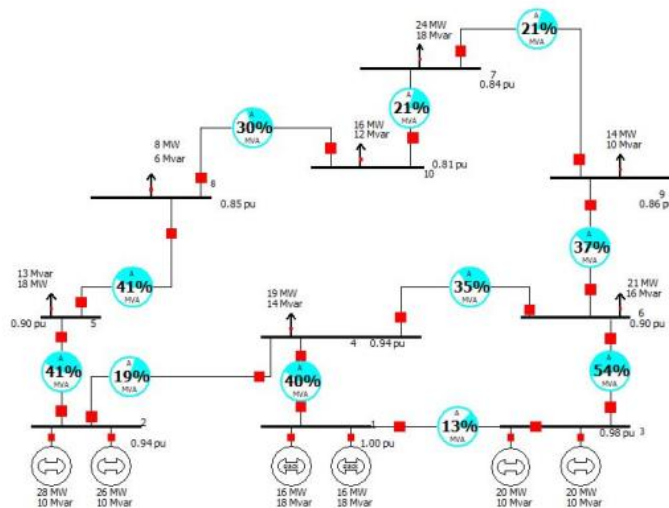
Fig. 5. Simulation of Test 10-Bus Power System in PWS
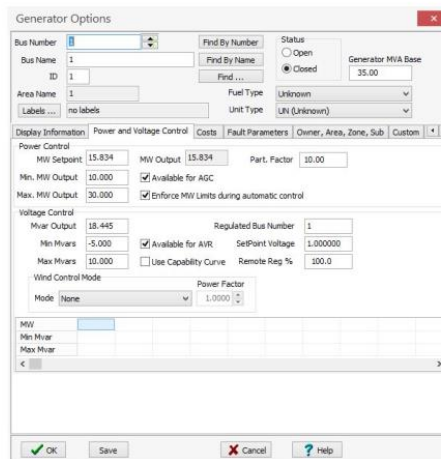
Fig. 6. Generator Parameters in PWS

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Moving forward to the results obtained from PSS, we observe a similar approach. Figures 8 and 9 display the simulation outcomes, with Figure 8 focusing on the Newton- Raphson method and Figure 9 on the Fast-Decoupled Newton- Raphson method. These figures offer a comprehensive com- parison of power flow results obtained from PSS, facilitating a detailed analysis of its performance under different solution methodologies.

Shifting our attention to PowerWorld Simulator, we con- tinue our comparative analysis. Figures 10 and 11 showcase the simulation results obtained from PowerWorld Simula- tor, with Figure 10 presenting outcomes using the Newton- Raphson method and Figure 11 demonstrating results achieved through the Fast-Decoupled Newton- Raphson method. This comprehensive evaluation provides insights into the perfor- mance of PowerWorld Simulator across different power flow solution techniques, aiding in a thorough understanding of its capabilities and limitations.
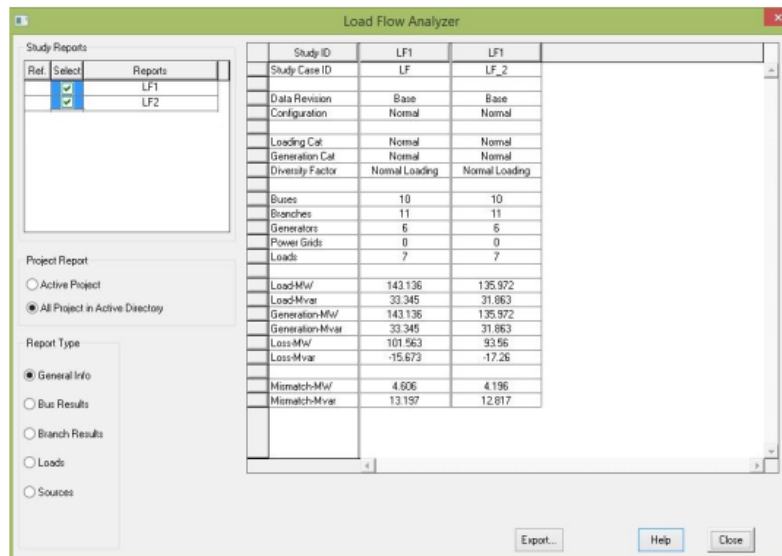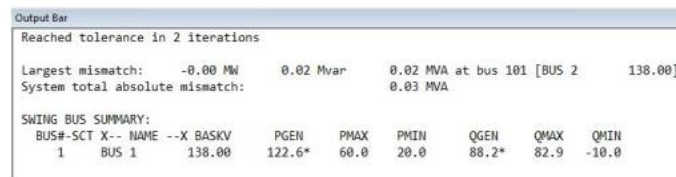

Fig. 7. ETAP Simulations Results

Fig. 8. PSS Results- Newton-Raphson Method

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```
Output Bar
Reached tolerance in 1 iterations

Largest mismatch:      -0.00 MW        0.00 Mvar      0.00 MVA at bus 101 [BUS 2      138.00]
System total absolute mismatch:                       0.01 MVA

SWING BUS SUMMARY:
    BUS#-SCT X-- NAME --X BASKV     PGEN     PMAX     PMIN     QGEN     QMAX     QMIN
       1      BUS 1      138.00    122.6*    60.0     20.0     88.2*    82.9    -10.0
```

Fig. 9. PSS Results-Fast-Decoupled Newton-Raphson Method


```
Number:  0 Max P:  54.000 at bus   2 Max Q:  34.157 at bus   10
Number:  1 Max P:   2.427 at bus   2 Max Q:  10.310 at bus   10
Number:  2 Max P:   0.028 at bus  10 Max Q:   0.079 at bus    6

Gen(s) at bus    2 at max vars
Gen(s) at bus    3 at max vars
Finished voltage control loop iteration:  1

Number:  0 Max P:   0.028 at bus  10 Max Q:  26.386 at bus    2
Number:  1 Max P:   0.345 at bus   2 Max Q:   0.223 at bus    3
Number:  2 Max P:   0.000 at bus   3 Max Q:   0.000 at bus    2

Finished voltage control loop iteration:  2

Solution Finished in   0.078 Seconds
Simulation: Successful Power Flow Solution
```

Fig. 10. PowerWorld Simulator Results-Full Newton-Raphson


```
Starting Solution using Fast Decoupled Power Flow

Number:  1 Max P:  54.000 at bus   2 Max Q:  45.631 at bus   10
Number:  2 Max P:  10.737 at bus   2 Max Q:   9.117 at bus   10
Number:  3 Max P:   1.792 at bus   2 Max Q:   1.707 at bus   10
Number:  4 Max P:   0.377 at bus   2 Max Q:   0.331 at bus   10
Number:  4 Max P:   0.066 at bus   2 Max Q:   0.057 at bus   10

Gen(s) at bus    2 at max vars
Gen(s) at bus    3 at max vars
Finished voltage control loop iteration:  1

Number:  1 Max P:  10.645 at bus   2 Max Q:   2.799 at bus    2
Number:  2 Max P:   1.276 at bus   2 Max Q:   0.622 at bus   10
Number:  3 Max P:   0.444 at bus   2 Max Q:   0.175 at bus   10
Number:  4 Max P:   0.125 at bus   2 Max Q:   0.075 at bus   10
Number:  4 Max P:   0.051 at bus   2 Max Q:   0.030 at bus   10

Finished voltage control loop iteration:  2

Solution Finished in   0.031 Seconds
Simulation: Successful Power Flow Solution
```

Fig. 11. PowerWorld Simulator Results-Fast-Decoupled Newton-Raphson

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ANALYSIS OF RESULTS

In Table 3, we present a comparative analysis of the performance of three software platforms: ETAP, PowerWorld Simulator (PWS), and PSS. Our evaluation focuses on two key metrics: the total computation time and the number of steps required to achieve the final solution.

Examining the data in the table reveals distinct differences between the software packages. For instance, when utilizing the Newton-Raphson method, ETAP, PWS, and PSS exhibit computation times of 0.09 sec, 0.078 sec, and 0.08 sec, respectively. Conversely, employing the Fast-Decoupled Newton- Raphson method yields shorter computation times, with values of 0.07 sec, 0.031 sec, and 0.04 sec for ETAP, PWS, and PSS, respectively.

Furthermore, considering the total steps taken to reach convergence, a similar pattern emerges. Under the Newton-Raphson method, ETAP requires 4 steps, while PWS and PSS accomplish the same task in only 2 steps each. With the Fast- Decoupled Newton-Raphson method, ETAP and PWS see a reduction in steps to 3 and 2, respectively, while PSS achieves convergence in just 1 step. Overall, these findings illustrate the varying performance characteristics of the software platforms under different solution methods, highlighting their respective strengths and efficiencies in power system analysis.

TABLE III

Comparison of the softwares

Comparing Parameters	ETAP	PWS	PSS
Time of Computation (Newton-Raphson)	0.09	0.078	0.08
Time of Computation (Fast-Decoupled Newton-Raphson)	0.07	0.031	0.04
Total Steps (Newton-Raphson)	4	2	2
Total Steps (Fast-Decoupled Newton-Raphson)	3	2	1

The primary aim of comparison is to determine which soft- ware is both user-friendly and efficient. Based on the results obtained, it becomes apparent that each software possesses its own set of advantages and disadvantages. While relying on a single power simulator software may seem feasible, there could be certain limitations encountered during its use. Speaking specifically about the ETAP Software, it boasts state- of-the-art libraries encompassing a wide array of power system components such as transformers, generators, transmission lines, cables, and insulators, among others. This feature makes the software particularly well-suited for industrial applications. Notably, in Pakistan, both power distribution companies (DISCOs) and the Water and Power Development Authority (WAPDA) utilize this software extensively, especially prior to the expansion of the existing power system.

In this study, we conducted simulations of a test power system using three widely utilized software platforms: PowerWorld Simulator (PWS), PSS, and ETAP. Our evaluation focused on two key benchmarks: the computational time required for analysis and the total steps needed to converge to a final solution.

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Our findings reveal distinct performance characteristics among the evaluated software packages. Specifically, Power- World Simulator demonstrated superior computational capabil- ity compared to PSS and ETAP, delivering efficient solutions within competitive timeframes. This highlights PWS as a favorable choice for practitioners seeking expedited power flow analysis without compromising accuracy or reliability.

Furthermore, in terms of the total steps required to converge to a final solution, PSS emerged as the top performer among the evaluated software platforms. Its robust algorithmic frame- work and optimization strategies facilitated swift convergence, enabling efficient resolution of power flow dynamics within the simulated system.

CONCLUSION

In conclusion, our comparative analysis underscores the importance of selecting the appropriate software tool based on specific analysis requirements and priorities. While Pow- erWorld Simulator excels in computational efficiency, PSS distinguishes itself in rapid convergence to a final solution. By understanding the strengths and limitations of each software package, practitioners can make informed decisions to opti- mize power system analysis workflows and enhance overall operational effectiveness.

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Analysis and Optimization of Protection Systems for Power System Components

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Abstract—Power systems are critical infrastructures that re- quire robust protection schemes to ensure their reliable and safe operation. In this paper, we present the design and implementation of various protection schemes for power generation, transmission, distribution, and utilization systems using SIMULINK. The proposed protection schemes are tailored to meet the specific requirements of the system, aiming to safeguard against a wide range of faults that may occur during operation. Three distinct relays—frequency check relay, differential relay, and over-current relay—are meticulously designed to protect individual components of the power system. Through simulation and analysis, we demonstrate the effectiveness and reliability of these protection schemes in ensuring the security and stability of the power system under various fault conditions. The insights and findings presented in this paper contribute to the advancement of protective relay technology, offering practical solutions for enhancing the resilience of modern power systems.

Keywords-rms—generation, transmission, distribution fault, frequency check, differential protection, over-current.

INTRODUCTION

Modern power systems comprise a complex network of interconnected components, each playing a crucial role in the generation, transmission, distribution, and utilization of electrical energy. However, these components are inherently sensitive and operate within narrow limits, rendering them susceptible to faults that could lead to disruptive or even catastrophic consequences if left unaddressed. Timely detection and isola- tion of faults are imperative to prevent operational disruptions and mitigate the risk of permanent damage to system compo- nents. In this context, this paper presents an in-depth analysis and optimization of protection systems tailored to safeguard critical components within a power system framework, as depicted in Figure 1. The system comprises an alternator, step-up and step-down transformers, transmission lines, and two distinct loads: a parallel RLC load and a resistive load. By leveraging advanced modeling techniques and simulation tools, we investigate the performance of various protection schemes in detecting and isolating faults, thereby ensuring the integrity and reliability of the power system under diverse operating conditions. The insights garnered from this study offer valuable guidance for the design and implementation of robust protection systems aimed at enhancing the resilience of modern power infrastructures.

The remaining paper is structured in this way. In section II, a brief literature review is presented, design of relays is given in section III, separate working of each relay is analyzed in section IV, simulation of the faults is discussed in section V, and finally section VI concludes this research paper.

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LITERATURE REVIEW

Power Protection is the vital component of power system [1], [2], [3]. The authors in [4] have modelled the protection scheme for the radial distribution feeder with and without distributed generation. The authors in [5], [6] and [7] have designed a protection scheme for the power system with PV energy penetration. The authors in [8] have designed protection system for the power system using MATLAB considering solar and wind generation. The authors in [9] have studied three- phase fault analysis of transmission lines using Simulink while the authors in [10] have studied the differential protection of the power transformer using voltage and current ratios. The author in [11] propose a microgrid protection scheme utilizing the active power variation coefficient of the zone, analysing impedance angle variations during internal and external faults to form a protection criterion, and validating the scheme's effectiveness through MATLAB/SIMULINK simulation. The authors in [12] investigate the impact of Special Protection Schemes (SPS) on mitigating the propagation of cascading failures and associated load loss in the Iran power grid. The authors in [13] develop a System Protection Scheme (SPS) for two 400kV/220kV interlinking transformers (ILT) in a practical utility grid. The authors in [14] examine the Double Main & Transfer (DMT) bus switching scheme used in POWERGRID India at the 220kV voltage level, highlighting concerns regarding current transformer (CT) placement and the potential for spurious current generation during routine trans- mission line maintenance, with a case study illustrating in- advertent breaker failure protection (BFP) operation triggered by spurious current, emphasizing the importance of correct isolation procedures and human factors in maintaining power transmission network reliability and stability. The authors in [15] address the frequent generator tripping contingencies experienced by the offshore Nangan-Beigan power system in Taiwan, detailing the refinement of the underfrequency load shedding (UFLS) protection scheme to mitigate the risk of complete blackouts during both normal and over 70 percent rating operations, demonstrating through comprehensive computer simulations and practical operating records its effectiveness in avoiding complete blackouts while shedding less load than the previous scheme, offering valuable insights for power engineers designing UFLS protection schemes. The authors in [16] examine the impact of various fault isolation equipment on the reliability of low voltage DC systems, core- lasting reliability indices with economic factors and proposing an objective function aimed at minimizing comprehensive costs, demonstrated through comparison of circuit breaker configurations in a building DC power supply and distribution network according to IEEE Std 493-2007 standard to obtain an optimal solution. The authors in [17] presents the application framework, theory, control, and protection system design of hybrid active power filters in LCC-HVDC projects, focusing on their role in filtering characteristic harmonics generated by converters and preventing their effects on the AC power grid, with the Fujian Guangdong DC interconnection project serving as a case study.

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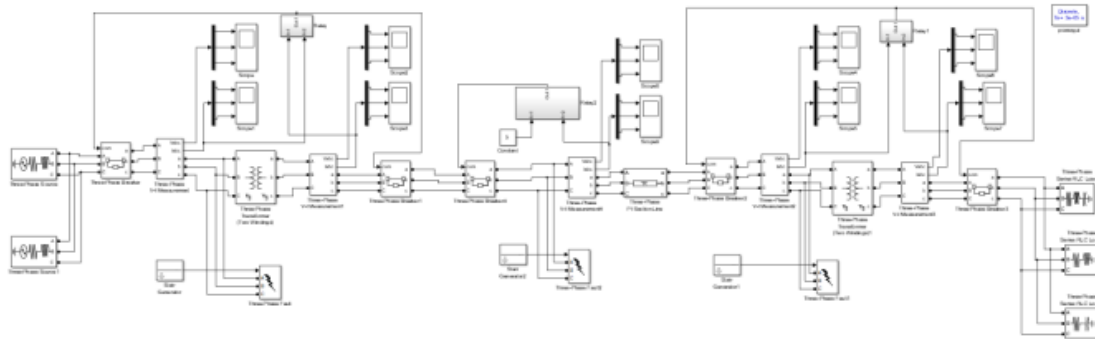**Organized by University of Wah**

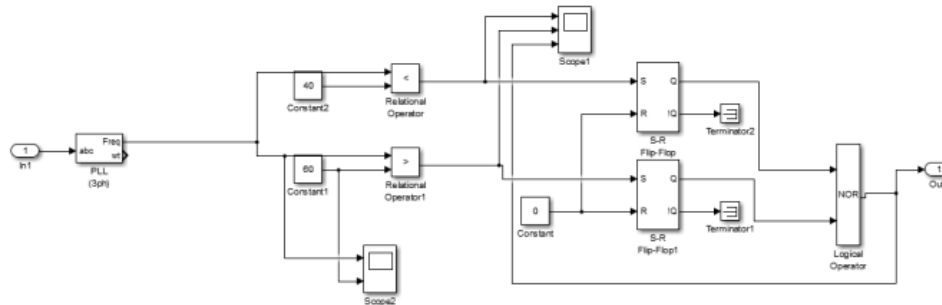Fig. 1. Unprotected Power System

Fig. 2. Frequency Relay

The alternator, transformers, transmission lines, and con- summer load represent the most critical and costly elements of this system, necessitating protection under all circumstances. Consequently, we have developed protection relays to safe- guard these components.

The generator, or alternator, is engineered to channel current and power away from itself towards the bus. However, under certain conditions, particularly during parallel operation, a generator may struggle to maintain voltage and frequency at the system level. This can occur due to malfunctioning governors attached to the generator, which fail to sustain rotor speed, thereby altering the frequency of the generated voltage and current

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waveforms. Such frequency fluctuations can have detrimental effects throughout the system, particularly on buses and transformers. Additionally, these frequency variations can adversely affect loads connected at the end of the transmission system, causing motors to draw excessive current, leading to mechanical heating and coil breakdown. To address this issue, an under/over frequency relay is incorporated into the system to continuously monitor frequency discrepancies and disconnect loads in such scenarios, as shown in Figure 2.
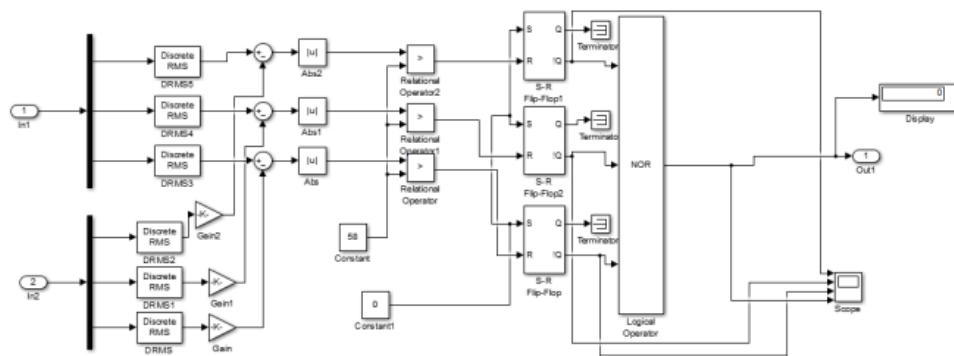
Fig. 3. Differential Relay
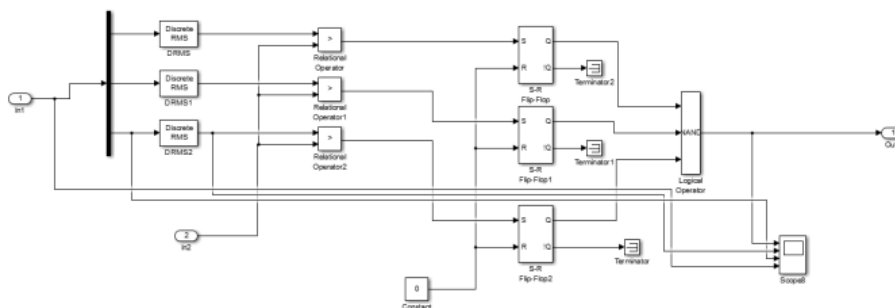
Fig. 4. Over-current relay

Transformers, like alternators, are pivotal and costly com- ponents within the power system. Their primary function is to step up the voltage at the sending end while reducing current flow, thereby minimizing I^2R losses in transmission lines and facilitating the use of lighter cables, thereby enhancing cost efficiency. Furthermore, transformers are installed at the receiving end to reduce voltage to distribution levels suitable for consumers. To protect transformers, a differential protection method is employed, monitoring current at both the primary and secondary sides of the transformer, as depicted in Fig. 3. Upon detection of a discrepancy, a trip signal is

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dispatched to the three-phase circuit breaker, interrupting the circuit to prevent damage to the transformer windings.

Transmission lines play a crucial role in delivering power from one location to another but are particularly susceptible to faults due to exposure to changing weather conditions. Contraction and expansion caused by fluctuating weather conditions exert stress on the conductor material, weakening it over time. Transmission lines bear the brunt of any faults within the system, as disruptions in any part of the system can impact them, potentially causing the entire system to cease functioning even if only one line is compromised.

DESIGN OF RELAYS

The over/under frequency relay, depicted in Fig. 2, operates by continuously monitoring the frequency generated by the generator. It collects measurements from 'm' channels of the three-phase synchronous generator and calculates the frequency from the rotor speed ω_m in radians per second, using the equation $\omega_m = 2\pi f$ to determine the operating frequency of the generator. This frequency is continually assessed and transmitted to the frequency relay, which scrutinizes these values and triggers the circuit breaker when the frequency deviates from the nominal value.
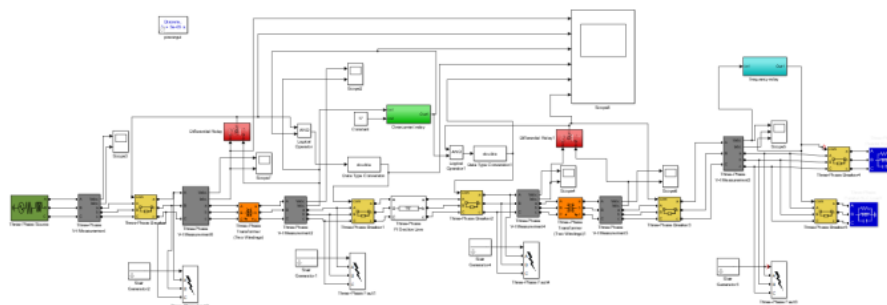

Fig. 5. Protected Power System

The differential protection relay employed for transformers obtains measurements from both the primary and secondary sides of the transformer. It functions by gathering current values from each coil of the transformer and aims to compare their magnitudes. In the case of a step-up transformer, where N1 > N2, the secondary side current is reduced by the ratio V1/V2 = N1/N2 . Consequently, as the voltage is stepped up from 3600 V to 11 kV, the currents on the secondary side decrease to 3.05 times their magnitudes on the primary side. Therefore, the incoming current values on the secondary side must be amplified by a factor of 3.05 to counteract the alterations in current caused by the transformer. Once the transformer's influence is neutralized, the difference between these values is calculated, and its absolute value is obtained to eliminate negative terms. This resulting value is then compared with the relay's pick-up value, and if it exceeds this threshold, a trigger signal is sent to the circuit breaker to open the circuit, thereby protecting the transformer. This same methodology can be applied

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to step-down transformers, where instead of amplifying the secondary side, the current is divided by the turns ratio (in this case, 11,000:440), and the process continues as previously described.

Among the three relays employed in this simulation, the over-current relay stands out as the most straightforward. Its functionality involves receiving current values from a specific point in the transmission system, notably from the transmission lines. These values are then converted into RMS values and directly compared with a preset pick-up value, illustrated in Fig. 4. Upon breach of this pick-up value, the relay promptly dispatches a triggering pulse to the circuit breaker, effectively halting the current flow through the transmission system.

SEPARATE WORKING OF EACH RELAY

Before integrating our relays into the system depicted in Figure 1, we conducted individual tests on each relay to verify its independent functionality. Subsequently, a fault was induced into the system using a three-phase fault. As illustrated in Figure 6, upon the introduction of the fault, the circuit was automatically disconnected by the circuit breaker when a fault detection signal was generated by the relay, resulting in a decrease in both current and voltage values.

Differential protection is applied separately to each transformer, with connections made on both the primary and secondary sides. Figure 11 displays voltage and current graphs in the absence of any induced faults near the step-up transformer, while Figure 12 exhibits voltage and current graphs of the step-down transformer with a fault induced. Furthermore, Figure 13 illustrates the graphs of the step-up and step-down transformers, respectively, after the introduction of the fault.

The results of the overcurrent relay, both with and without faults, are presented in Figure 11 and Figure 12, with voltage displayed in the upper half and current in the lower half. In the absence of any faults, the relay functions correctly, refraining from triggering the circuit breaker, thus resulting in the observation of smooth sine waves for both voltage and current.

Finally, we examine the operation of the frequency check relay, which identifies both under and over frequency deviations from the nominal value and interrupts the connection to the load if any such deviation occurs. Utilizing a synchronous machine, we obtained all necessary parameters of the genera- tor. In our analysis, we converted the rotor speed into per unit (p.u.) and applied a gain of 50 to align it with 50 Hz frequency. If this adjusted value falls outside the specified range, the relay activates. Figure 7 illustrates the voltage and current waveforms before encountering any frequency deviation, while Figure 8 illustrates the interruption in current flow once the system frequency deviates from the nominal frequency. The generator parameters are configured as indicated in the following figure.

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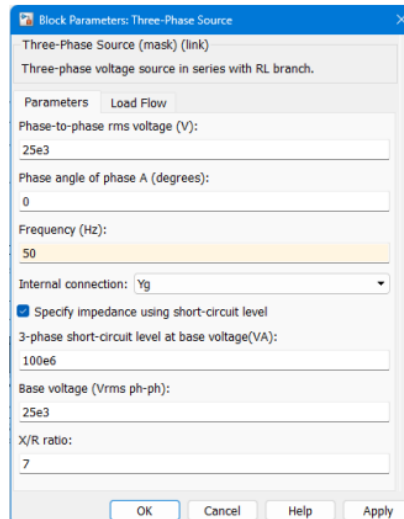**Organized by University of Wah**

Fig. 6. Generator Parameters

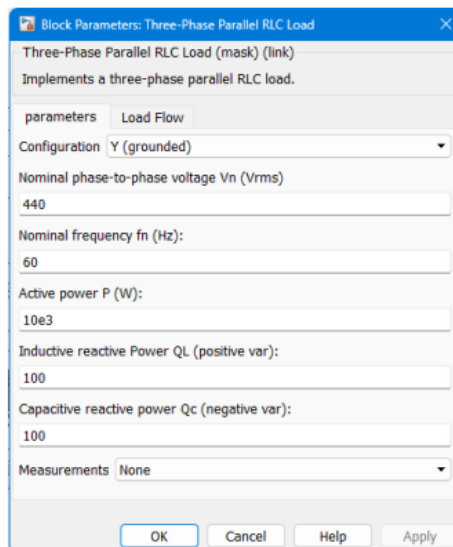The load parameters are inserted as shown in the following figure.

Fig. 7. Load Parameters

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SIMULATIONS OF THE FAULTS

Subsequently, the system underwent fault insertion at two distinct points: one at the generation side (Point A) and the other at the load side (Point B). The waveforms before fault insertion are depicted in Fig. 11. Following the fault insertion at Point A, the waveforms are illustrated in Fig. 12, while the waveforms after fault insertion at Point B are presented in Fig. 13.
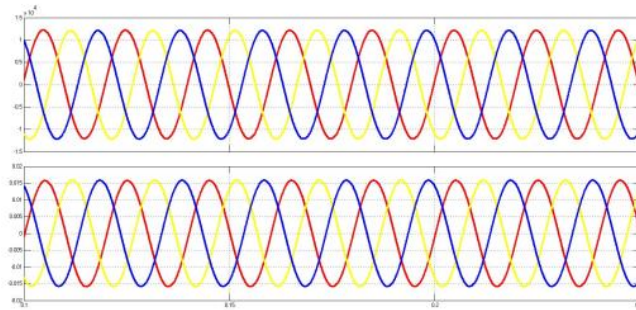

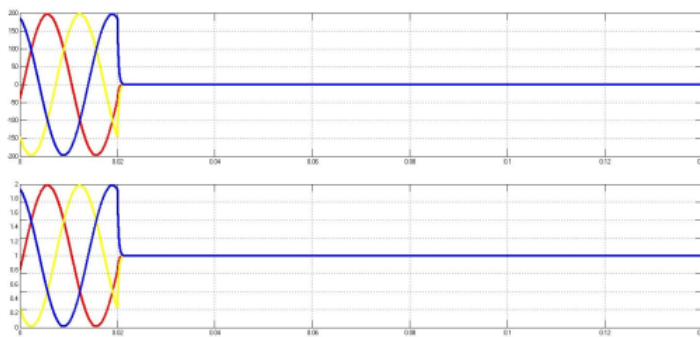Fig. 8. Simulations before fault insertion

Fig. 9. Simulations after fault insertion at point A

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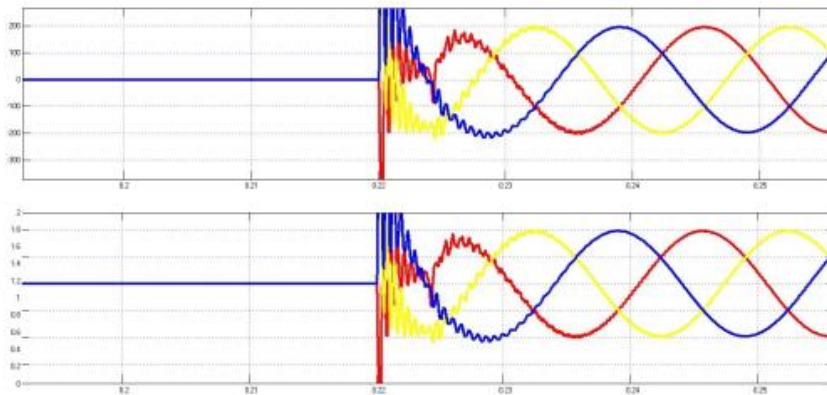**Organized by University of Wah**

Fig. 10. Simulations after fault insertion at point B

CONCLUSION

In conclusion, this paper has presented a comprehensive design and implementation of multiple relays aimed at safe- guarding diverse components of the power system. Following rigorous individual testing to ensure the independent functionality of each relay, they were seamlessly integrated into our system. With these relays in place, the detection of under and over frequency faults, over current faults in transmission lines, or internal faults in transformer windings is effectively facilitated. As a result, the system operates with enhanced safety measures, ensuring prompt detection and mitigation of faults to prevent potential disruptions and damage. This comprehensive protective framework underscores the importance of proactive measures in maintaining the reliability and resilience of power systems against a myriad of potential fault scenarios.

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Optimization of Prosumer Based Demand Side Management (DSM) by Using K-Means Clustering Algorithm

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Abstract—Prosumers both generate and consume electricity, making Prosumer-based Demand Side Management increasingly appealing due to its numerous benefits for both consumers and utility companies. This study introduces a proposed model featuring four prosumers and twelve consumers. Consumers have the flexibility to procure electricity either from the utility company or nearby prosumers based on the most competitive rates available. The K-Means Clustering algorithm is employed for optimization due to its advantageous characteristics. The pro- posed model offers a straightforward implementation through a unified network for device communication, enhancing operational efficiency for grid operators. This streamlined approach reduces complexity and cuts down on infrastructure and management costs. Positioned as a forward-thinking solution, it integrates economic incentives, environmental benefits, and operational efficiency, addressing critical challenges in energy management and sustainability. By bolstering grid resilience and sustainabil- ity, the model meets evolving consumer needs and regulatory requirements for cleaner energy solutions.

Index Terms—**Prosumer, Demand Side Management (DSM), K-Means Clustering algorithm, clean energy, smart grid.**

INTRODUCTION

One of the key objectives of a smart grid is to facilitate the generation of clean energy, like solar energy and wind energy. This goal can be achieved by encouraging consumers to gener- ate renewable energy and sell any excess power at a fair price when their production surpasses their consumption needs. In this research proposal, we aim to optimize demand side man- agement specifically tailored for prosumers—consumers who also produce energy. Our approach involves three main tasks: initially focusing on a small-scale scenario with only four prosumers to develop and test our optimization strategies, then extending our analysis to accommodate an arbitrary number of prosumers to ensure scalability and robustness, and finally designing an electricity market framework for an entire city to integrate all prosumers into a unified market for optimal energy distribution and consumption. For the optimization process, we utilize the K-Means clustering algorithm, which helps group consumers into clusters based on their energy production and consumption patterns, thereby enabling more efficient demand side management.

LITERATURE REVIEW

The research in the field of prosumer-based demand side management (DSM) and electricity markets covers a variety of innovative techniques and models. A Teaching-Learning Based Optimization (TLBO) technique aimed at improving DSM for prosumers is introduced in [1]. The TLBO method, inspired by the teaching-learning process in a classroom, optimizes energy usage, improving the efficiency and overall infrastructure of the power system.

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In [2], the authors propose a reinforcement learning-based demand response management (DRM) model that focuses on price signals to influence prosumer behaviour in a smart grid. This model considers both economic factors and the behavioural characteristics of prosumers, leading to a more realistic and effective demand response strategy. Another approach, presented in [3], utilizes Time of Use (TOU) pricing for virtual power plants (VPPs) driven by prosumers. The TOU approach adjusts electricity prices depending upon the time of day, encouraging prosumers to move their energy consumption to off-peak hours, balancing the load and optimizing VPP operations. The development of a Peer to Peer (P2P) energy trading mechanism is explored in [4]. This mechanism enables prosumers to trade surplus energy efficiently with each other, enhancing energy utilization and providing economic bene- fits through competitive pricing. Additionally, [5] introduces an online algorithm for the alternating direction method of multipliers (ADMM), used for energy sharing in VPPs. This algorithm aims to improve the computational efficiency and scalability of energy-sharing operations.

An organized framework for optimizing domestic load management utilizing photovoltaic (PV) system, battery energy storage system (BES), and electric vehicles (EVs) is proposed in [6]. This framework enhances the self-sufficiency and reliability of domestic energy systems by coordinating various energy resources. The computational performance of the distributed ADMM algorithm for slow-dynamics demand response peak shaving is evaluated and benchmarked in [7], showcasing the algorithm's effectiveness in reducing peak loads and enhancing grid stability.

A two-tier energy optimization model for renewable energy communities, accounting for regional tariffs and shared energy storage, is proposed in [8]. This model optimizes energy usage and costs within a community by leveraging both local and shared energy resources. In [9], a machine learning- based power trading algorithm (MLPTA) using the Random Forest (RF) algorithm is presented for power trading among prosumers. The MLPTA enhances decision-making in energy trading by providing accurate, data-driven predictions.

The effects of conservation voltage reduction (CVR) on electricity prices, local markets, and technical issues in distribution networks are examined in [10]. This study provides insights into how CVR influences market dynamics and technical performance in power systems. Furthermore, [11] reviews and compares various machine learning methods applied to DSM programs, highlighting the strengths and weaknesses of different approaches in optimizing DSM.

Prosumer-based electricity markets are also a crucial aspect of DSM. In [12], a model is presented for determining optimal market bids on a day-ahead market for a virtual prosumer representing a group of prosumers. This model aims to maximize economic benefits by optimizing prosumer participation in the day-ahead market. Additionally, an integrated hybrid local electricity market (LEM) combining peer-to-peer (P2P) and community-based markets is designed in [13], improving market efficiency and offering more trading opportunities for prosumers.

The Nikaido-Isoda function and Relaxation Algorithm are selected in [14] to develop a prosumer-based electricity market model. This mathematical approach helps find equilibrium solutions and optimize market outcomes for prosumers. Lastly, [15] and [16] present various schemes and models for electricity markets involving prosumer communities, focusing on enhancing market efficiency, promoting energy sharing, and optimizing economic benefits.

An IoT-based Smart Home Energy Management System (SHEMS) is proposed in [17] to optimize energy generation and consumption, enhance real-time information exchange, and improve prosumer satisfaction in smart grids with increasing eco-friendly distributed generations. The authors in [18] propose a blockchain-based platform for peer-to-peer energy trading in community microgrids, integrating smart contracts, dynamic pricing, and

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incentive-driven demand response to enhance transparency, efficiency, and community engagement in decentralized energy systems.

The authors in [19] introduce a holacracy-based self organizing energy management system for smart grids, enhancing community convenience and microgrid hosting capacity through democratic governance and local energy sharing. An economically efficient transactive energy market clearing mechanism to enhance end-user engagement and minimize penalties in smart grids is proposed in [20]. This mechanism, validated by case studies demonstrates significant monthly electricity bill savings.

.Overall, these studies contribute to the advancement of prosumer-based DSM and electricity markets by proposing innovative optimization techniques, trading mechanisms, and market models that enhance efficiency, reliability, and eco- nomic benefits for prosumers in the smart grid.

PROPOSED MODEL

In our proposed model, we focus on a system that includes twelve consumers and four prosumers. The prosumers, who are both energy producers and consumers, are denoted mathematically as pr_1, pr_2, pr_3 and pr_4. Each of these prosumers has purchased sustainable energy materials, such as PV panels or wind turbines, enabling them to generate their own electricity. Beyond meeting their own energy needs, these prosumers are also capable of supplying surplus power back to the grid or directly to other consumers.

The twelve consumers in our model are residential house- holds, numbered sequentially from H1 to H12. These consumers do not produce their own energy and thus rely entirely on the power supplied by the prosumers and the grid. The distribution of energy within this system is managed through a demand side management (DSM) framework that leverages the energy generated by the prosumers.

In this prosumer-based DSM model, the four prosumers play an important role in balancing the energy demand and supply within the community. By distributing surplus energy, the prosumers help reduce the overall energy costs for the consumers and improve the efficiency of the energy system. The interaction between prosumers and consumers, along with the flow of energy, is illustrated in Figure 1 of our study.

This model not only highlights the potential for renewable energy integration but also emphasizes the significance of prosumers in present day power systems. By effectively managing the energy production and consumption, the proposed DSM framework aims to create a more sustainable and resilient energy infrastructure.

The total electrical power sold by prosumer pr_1 is given by:
$$P_{pr}1 = P_a1 + P_a2 + P_a3 + \quad + P_an \quad (1)$$
Where P_a1, P_a2, P_a3 denotes power sold to neighbors.

Also, the power sold by prosumers pr_2 is given by:
$$P_{pr}2 = P_b1 + P_b2 + P_b3 + \quad + P_bn \quad (2)$$
Similarly, the power sold by *nth* prosumer is given by:
$$P_{pr}n = P_n1 + P_n2 + P_n3 + ... + P_nn \quad (3)$$

Next, we want to optimize the total price per unit of selling surplus power, For that, we assume that the overall price of selling power is constant i.e., the per unit price is same for all the prosumers. The cost per unit of prosumers pr_1, pr_2, pr_3 and pr_4 is denoted by C_{pr}, C_{pr}, C_{pr} and C_{pr} respectively, while the cost per unit of utility company is denoted by C_{grid}. Therefore, the objective function can be written as:

$$\left(Optimize \sum_{i=1}^{4} C_{pr_i} \right) \leq C_{grid} \quad (4)$$

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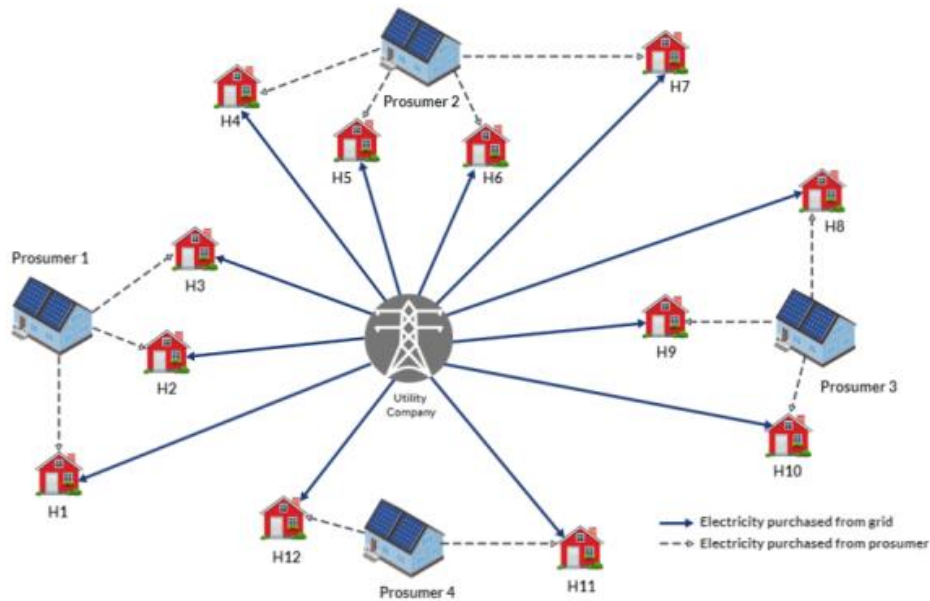**Organized by University of Wah**

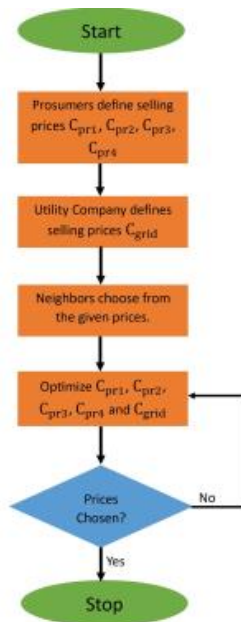Fig. 1. Proposed Model comprising of four prosumers

Fig. 2. Flowchart of Methodology

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METHODOLOGY

The flowchart of for the optimization of the proposed model is shown below. The prosumers first define selling prices as $Cpr1$, $Cpr2$, $Cpr3$ and $Cpr4$. Then the utility company defines its tariff as C_{grid}. Then the consumers choose from the given prices of prosumers and utility company. If the prices are OK then the process will proceed to the next step and terminate. On the other hand, if the prices are not good, then the K-Means Clustering algorithm will be used to optimize the given prices. This whole process is illustrated in Figure 2.

RESULTS AND DISCUSSION

In the given scenario, we have four prosumers, each with a distinct generating capacity. Specifically, the generating capacities are as follows: the first prosumer can generate 20 kW, the second prosumer 23 kW, the third prosumer 25 kW, and the fourth prosumer 24 kW. To analyze and optimize this setup, we conducted simulations on a Core i7 PC using Python as the programming language. This computational setup ensured efficient processing and accurate results. The houses are classified into clusters based upon their locations, as given in Table 1.

The simulations incorporated a specific tariff structure, which is detailed in Table 2. For the sake of simplicity, we have considered the peak hours during which the solar energy generated is maximum i.e., 12 pm to 5pm. Table 2 outlines the pricing strategy used in our model, reflecting the costs associated with both the prosumers' generated electricity and the utility company's tariffs. The structured tariff was crucial in evaluating the economic benefits and operational efficiency of the proposed demand side management model.

TABLE I

Clustering of houses

Cluster	House #
Cluster 1	H1, H2, H3
Cluster 2	H4, H5, H6, H7
Cluster 3	H8, H9, H10
Cluster 4	H11, H12

TABLE II

Tariff used in Model

Tariff	12 pm	1 pm	2 pm	3 pm	4 pm	5 pm
Cgrid (Cents/KWh)	12	13	18.5	17	15	16
Cpr1 (Cents/KWh)	10	14	13	12	10	13
Cpr2 (Cents/KWh)	13	12	12	9	10.5	14
Cpr3 (Cents/KWh)	11	10	12.5	8	12	14

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Cpr4 (Cents/KWh)	11.5	8	13	9.5	32	14.5

Figure 3 illustrates the total electricity sold by Prosumer 1 over a specified period. On the x-axis, time is represented, allowing for an analysis of electricity sales at different intervals throughout the day, week, or month. The y-axis shows the total number of units sold by Prosumer 1 to neighbouring consumers. This graphical representation provides a clear view of the distribution and fluctuations in electricity sales, highlighting peak selling periods and overall trends in energy transactions. By examining this figure, we can gain insights into the prosumer's selling patterns, such as when the highest and lowest amounts of electricity are sold. This information is essential for understanding the behaviour of the prosumer market and optimizing energy distribution strategies.
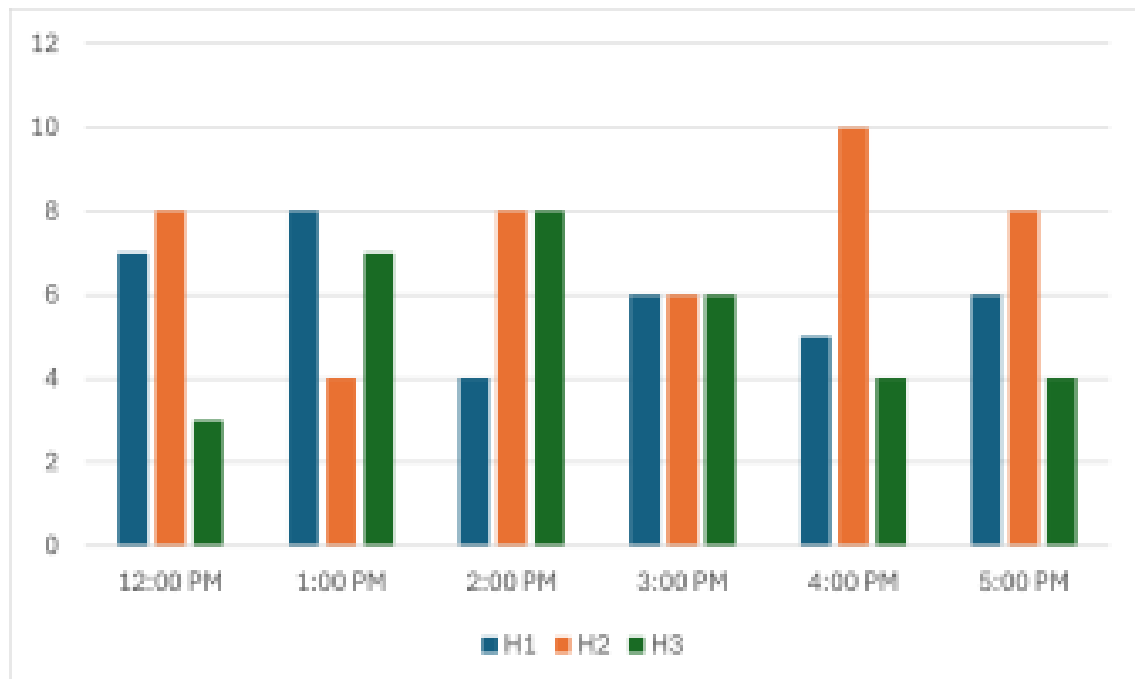

Fig. 3. Electricity sold by Prosumer 1

Similarly, the total electricity sold by Prosumers 2,3 and 4 is shown in Figure 4,5 and 6 respectively.

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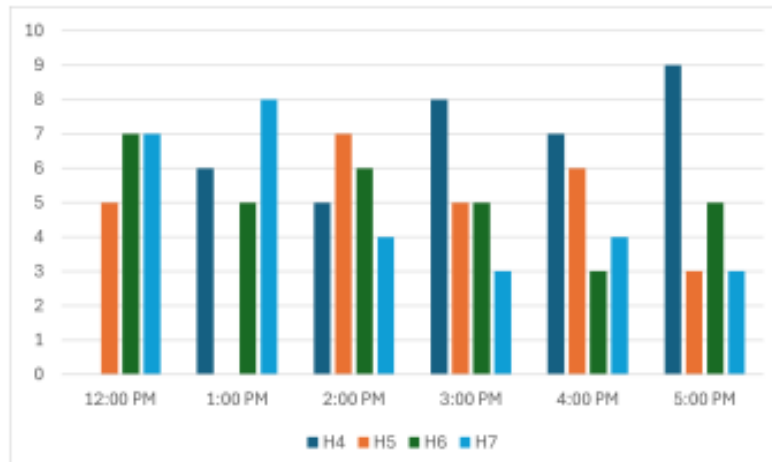**Organized by University of Wah**

Fig. 4. Electricity sold by Prosumer 2

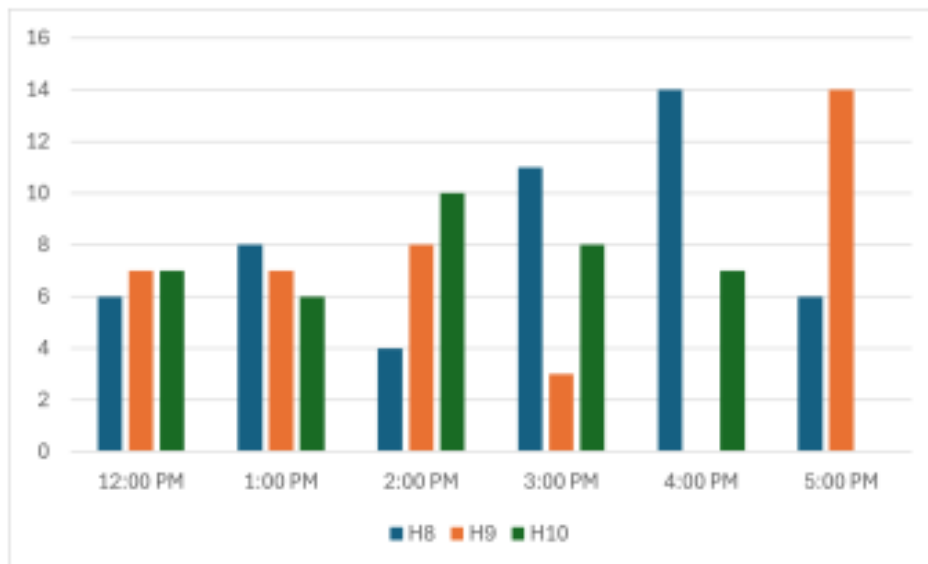Fig. 5. Electricity sold by Prosumer 3

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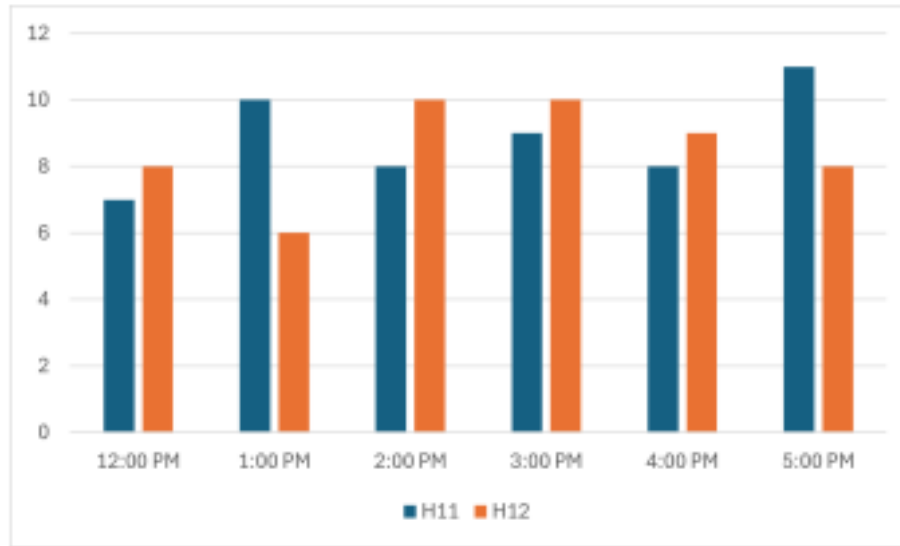**Organized by University of Wah**

Fig. 6. Electricity sold by Prosumer 4

Now, the overall comparison of all the units sold by the utility company and all four prosumers is illustrated in Figure 7. This figure clearly demonstrates that, rather than placing an excessive load on the grid, the power purchased from both the prosumers and the grid is evenly distributed. This normalization of power consumption indicates that the peak load, which typically stresses the grid, has been effectively balanced by the contributions of the prosumers. As a re- sult, prosumers significantly contribute to alleviating peak electricity consumption. This balance not only enhances grid stability but also ensures a more efficient and reliable energy distribution system. By integrating prosumers into the energy market, the dependency on the utility grid during peak times is reduced, highlighting the crucial role prosumers play in achieving a sustainable and resilient energy infrastructure.

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Fig. 7. Overall Comparison

CONCLUSION

In conclusion, the proposed model presents a comprehensive solution with significant advantages for both consumers and grid operators alike. By offering consumers the flexibility to choose their electricity supplier based on cost and environmental considerations—whether from prosumers generating renewable energy or traditional utility companies—the model empowers consumers to make informed, cost-effective decisions. This flexibility not only enhances consumer satisfaction but also contributes to peak load reduction through effective demand side management strategies. The simplicity of the model, requiring only a common network for device communication, ensures ease of implementation and operational efficiency for grid operators. This streamlined approach not only reduces complexity but also lowers costs associated with infrastructure and management. In essence, the proposed model represents a forward-thinking solution that combines economic incentives, environmental benefits, and operational efficiency. By addressing key challenges in energy management and sustainability, it stands poised to enhance the resilience and sustainability of grid systems while meeting the evolving needs of consumers and regulatory demands for cleaner energy solutions.

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A Comprehensive Review of Fin Geometries and Their Impact on Heat Exchanger Performance

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*Abstract-*Among the most widely used types of heat exchangers, finned and tube heat exchangers are essential in a wide range of industrial applications, including power plants, sewage treatment facilities, petrochemical and chemical factories, as well as cooling and heating systems for space. Enhancing the heat transfer rate while maintaining the size and weight of a heat exchanger is crucial. Various shapes and orientations of fins and tubes are utilized to improve thermal performance. The goal of this paper is to provide a comprehensive overview of the research conducted to enhance the thermal performance of heat exchangers by using different fin types, orientations, shapes, and placements. This study aims to clarify how each of these characteristics affects the enhancement of thermal efficiency and also the vibrational analysis of finned tubes under flow-induced vibration. Flow-induced vibrations can significantly impact the structural integrity and thermal performance of heat exchangers. The interaction between the fluid flow and finned tubes can lead to resonant vibrations, potentially causing mechanical failure or reduced efficiency. Understanding and mitigating these vibrations are crucial for the reliable operation of heat exchangers, especially in high-flow or turbulent conditions.

Keywords: Heat Exchanger, fins, thermal efficiency, micro channels, Plate fins, Pin fins, Perforated fins, porous fins, contact angle flat-tube and louvered finned tubes.

INTRODUCTION

A heat exchanger is a device intended to effectively transfer heat from one medium to another. To avoid mixing, the media might be in close touch with one another or divided by a solid wall. A few of their numerous applications include sewage treatment, natural gas processing, all plants, air conditioning, refrigeration, space heating, and the aerospace sector. An engine with internal combustion is the basic demonstration of a heat exchanger. Engine coolant circulates and cools down the fluid while heating incoming air as it passes through radiator coils in this engine. The fins are modifications to the surface commonly used in many types of heat exchangers to accelerate heat transmission from the solid surface to the surrounding fluid. Fins have been surfaced extensions that are frequently employed in various kinds of heat exchangers to accelerate heat transfer between a solid surface and the fluid it surrounds. Using nano fluids, researchers conducted an experimental study on the pressure drop and improved transfer of heat in dual pipes internal finned tube heat exchangers. The outcomes were compared to heat exchangers composed of basic tubes. The rate at which heat moves is 80–90% higher than with a simple tube heat exchanger, according to the results.(Basavarajappa et al., 2020)

Geometrically altered fins are frequently used, which not only raise the heat exchanger's surface area density but also raise its convective heat transfer coefficient. For these improved surface compact cores, several fin designs are possible, to name a few. They may be utilized in plate-fin & tube-fin exchangers, are easily fabricated, and may improve the thermal hydraulic performance. (Basavarajappa et al., 2020)**.**Heat exchangers are crucial to the

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waste heat recovery and natural gas and oil refining processes. Process industries are becoming more and more affected by the development of exchangers for enhanced heat transfer employing innovative technology. Fins, or extended surfaces, are fastened to one or both of the tubes sides Finned tube heat exchangers are used in cement production, power plants, waste heat recovery, and oil and gas refining. Internal fins speed up heat transmission because they expand the tube's effective heat transfer area. (Baba et al., 2018).Improvements in heat transfer efficiency can result in smaller heat exchangers, lower pressure drops, increased heat transferring efficiency of material and operational cost reductions. In industries such air separation, chemical processing, process cooling, and refrigeration, improving heat transmission is crucial. Fins and other extended surfaces play a critical role in raising the rate of heat transfer Certain improved heat transfer surface types, such as rectangular in shape, triangular in shape, trapezoidal in shape, Pins, wavy, offsetting the strip, and perforation fins, are used in situations where both convection and conduction effects are combined, depending on the application.(Basavarajappa et al., 2020)

.FINS' IMPACT ON THERMAL EFFICIENCY

When compared to a simple tube heat exchange fin give an expanded surface area, which increases the amount of heat transmission. To further enhance heat transmission and efficiently distort fluid flow, several shapes can be used. Nonetheless, a variety of fin types with varying orientations are employed to prevent a high heat transfer area unit volume In order to compare computational results with real data for four distinct heat exchanger designs, this work conducted a computerized assessment for an unbounded fin and tube-type heat exchanger. Next, the numerical model is used to study the effect of the bundle array angle of the tube on the ratio, which represents pressure drop limited heat exchanger performance. It is possible to conclude the following. Given the constraints of manufacturing, it appears beneficial from the perspective of the heat exchanger design to minimize the transverse tube pitch as much as possible, since this improves heat transfer for every pressure drop. (Basavarajappa et al., 2020) (Lindqvist et al., 2021).

Models having a laminar flow condition seem to yield data that are equivalent to those with low Reynolds turbulence. This means that these turbulence models work for all Re, and they probably work with different heat exchanger designs as well. For every single heat exchanger geometry, the numerical model and experimental results match to within 20%. Time-resolved simulations could be necessary to fully represent the flow dynamics relevant to fin-tube heat exchangers.(Lindqvist et al., 2021)When validation and verification are proven, the results ought to increase trust in the value of CFD analysis. Nonetheless, more research ought to address the evident shortcomings in prediction accuracy at tiny fin pitches and extremely low Reynolds numbers. Transient simulations will probably shed further light on this matter. Furthermore, a more detailed analysis of array angle effects is possible using the suggested technique. It is critical that the efficiency of extra correlates outside of their initial validity regime be examined in this study in order to increase trust in the design recommendations made by optimization methodologies.(Lindqvist et al., 2021)

VARIOUS STRAIGHT MICROCHANNEL DESIGNS.

The thermal efficiency of microscopic heat sinks may be enhanced using a variety of active and passive techniques to create a design where the advantages of greater heat transfer outweigh the drawbacks of higher pressure drop. One potential method for microchannel augmentation is the use of a single-phase heat transfer improvement methods. In a straighter a microchannel heat sink, several authors investigated the effects of different shapes, such as trapezoidal in shape, triangular in shape and rectangular forms, and using computer analysis to ascertain the

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effect of channels number on cross-sectional area. The triangular microchannel had the highest thermal resistance, whereas the rectangle had the lowest Additionally, adding more channels lowers the resistance to heat, but at the expense of a large pressure decrease. The highest performance was shown by a rectangular small channel with a dimension ratio that ranged from 8.904 to 11. 442..(Hajialibabaei & Saghir, 2022)This review summarizes the theoretical and practical studies on warmth sinks with microchannel designs that are wavy or straight. A number of effective characteristics are associated with microchannel thermal performance.Two sections describe how the general efficiency of microchannels may be enhanced by using different designs as both active and passive strategies. Different kinds of nanofluids are also evaluated as cooling agents for both microchannels. The next section discusses how lithium-ion batteries employ microscopic channels to regulate heat:(Hajialibabaei & Saghir, 2022)
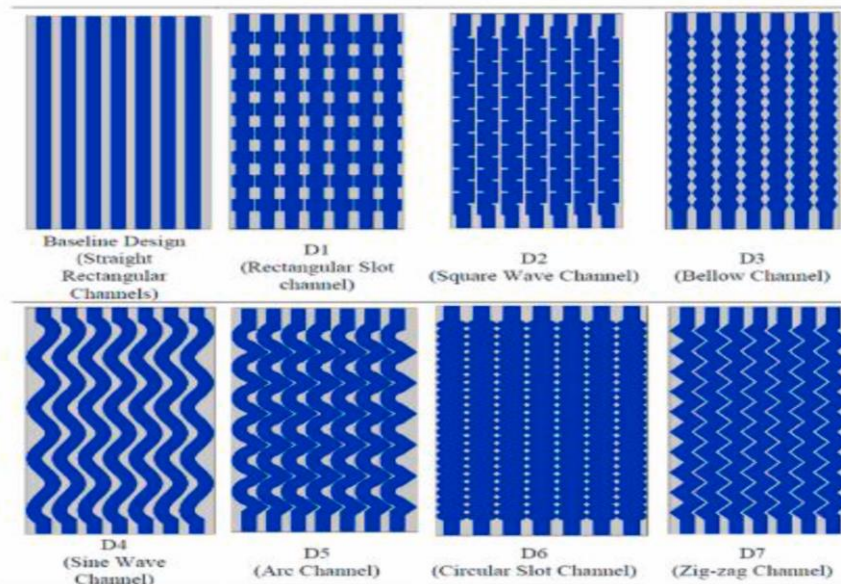

Figure 1: **Different Channel Design.**

PLATE FINS, PIN FINS, PERFORATED FINS AND POROUS FINS.
The researchers place the highest attention on developing the ideal fin profile in order to meet industry demand for lightweight and cheap cost. Additionally, a large number of research on several common fins—such as permeable, perforated and constructal, and so on—as well as their corresponding conclusions are compiled in this study. Porous fins promote heat transfer because they have greater surface area for convective than hard fin of the same size and mass. This supports its application when weight is a significant obstacle. Compared to solid fins, perforations fins have a significantly higher surface area that comes into contact with the fluid. Consequently, increasing the fin effectiveness and the rate of heat transfer may also be achieved by using perforated fins rather than solid ones. Fins with more holes might be utilized to investigate how improved heat transport is affected by perforation. On the other hand, compared to solid fins, perforated fins exhibit lower pressure drop and increased friction. Using perforations with various geometry has an impact on how heat is transferred through fins. Fins with varying holes allow for the analysis of variations in the Reynolds number, Nusselt number, as well as pressure

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drop; these may then be compared to fins without perforations. A fin with fewer holes transfers heat more effectively.(Maji & Choubey, 2020)
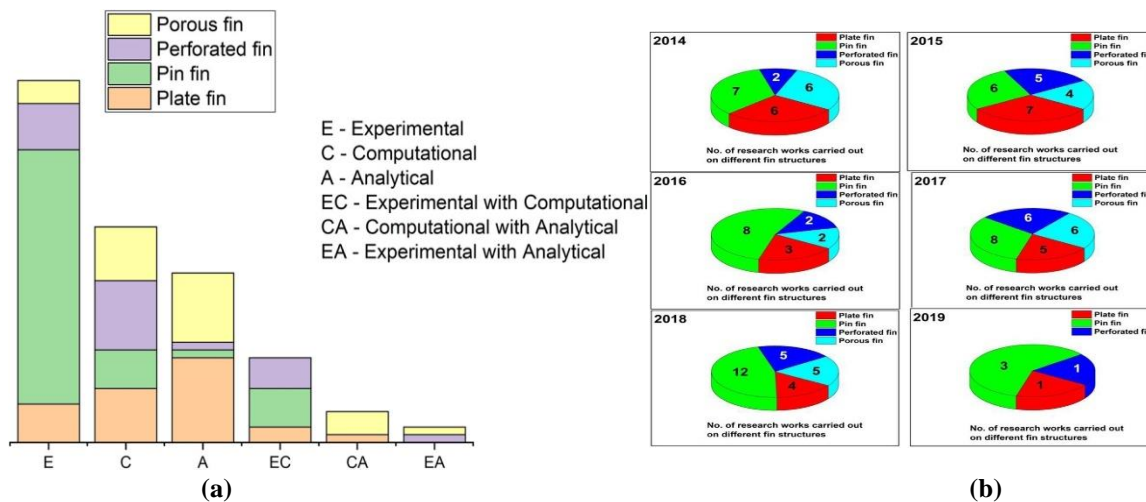

(a)

(b)

Figure 2.(a) shows the experimentation done on different types of fins . (b) Shows how much research done on fins**.**

WAVY AND OFFSET STRIPS IN FIN TUBE HEAT EXCHANGER
Two passive methods that are commonly utilized in tiny heat exchangers are the use of offsets and wavy strip channels. How to enhance the offset strip plate-fin and wavy heat exchangers' performance. By examining the effects of changes in wave-and-lance length, the study examined the thermal-hydraulic efficiency of the 3-dimensional layout of both offset and rippling strip channels. (Lumsden & Weaver, n.d.).The channel types that are offset and wavy, with longer wave-lengths along the direction of flow, are associated with higher heat transfer. The pressure decrease within the offsets strip channels is shown to be independent of the lance length change. Therefore, it can be concluded that during the channel's initialization phase, modest wave-and-lance lengths improve heat transfer. Using the wave-and-lance length variations can be an efficient way to increase the thermal efficiency of plate-fin heat exchangers. Furthermore,
The current study's findings are important for improving the plate-fin heat exchangers localized thermal performance and preventing hot patches from acting as chemical reactors.(KhoshvaghtAliabadi&Hormozi,2013)(Hajialibabaei & Saghir, 2022; Maji & Choubey, 2020)

A FLAT-TUBE AND LOUVERED FINNED TUBES
All significant flow characteristics with heat transfer via louvered fins may be quickly and affordably investigated by numerical studies of louvered fins. This was illustrated in **Leu et al**. (2001)'s numerical work. Three-dimensional simulations were conducted to examine the thermal and fluid dynamic characteristics of heat transfer systems with oval and cylindrical tubes, utilizing louvered fins. They looked at how the heat exchanger's length, pitch, angle, and axis ratio affected its efficiency. For a given louver length and point, they discovered that an

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increase in pivot proportion led to a decrease in both pressure fall and intensity move viability. Furthermore, they discovered that the decrease in louver pitch and length was correlated with an increase in the intensity move coefficient and tension drop variable. Although the pressure drop increases with increasing flow angle, an ideal angle may be identified in relationship to the thermal transfer coefficient. . (Zhang and Tafti (2003)).
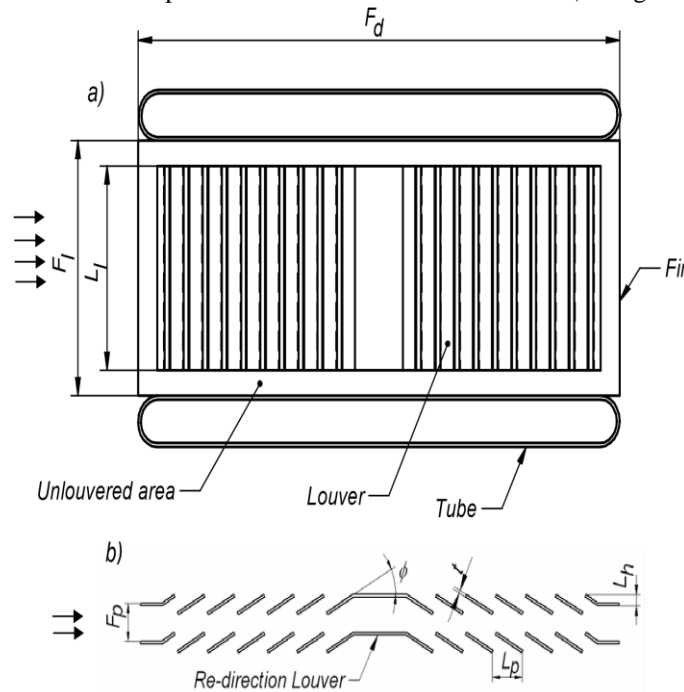

Figure 3:Louver fin angle

.THE EFFECT ON THE CONTACT ANGLE ON HYDROPHOBIC MICROPIN FINS.
Experimental studies assessing the flow resistance characteristics in microscopic pin fins with different cross section shapes and angles of contact of θ = 99.5°, 119.5º, & 151.5º, respectively, yielded a number of conclusions..(Guan et al., 2016)Small pin balances hydrophobic surfaces delay the stream's separation and advancement in wake zones and greatly reduce stream resistance.With earlier separation of flow and excessive drag in wake zones, The small pin balances cause an even greater resistance reduction. For round micropin balances, the value of the changing coefficients pressure drop increases with the contact point as it rises from 83° to 119.5° and then decreases as it rises from 119.5° to 151.5°. The coefficient of pressure drop for curvy and valuable stone micropin blades increases as the contact point rises from 83° to 151.5°.For elliptical micropin fins, the actual value of changing coefficient pressure drop always declines as the flow rate increases; whereas, for diamonds and circular micropin fins, the value initially decreases and subsequently becomes constantAt a fixed contact angle, the value of the variable coefficient of friction factors reduces as it grows Re for ellipse micropin fins, whereas for diamond and round micropin fins, it first lowers and then almost approaches a constant value. With a fixed angle of θ=151.5, the least values changing coefficient of friction factor in diamonds and round small pin fins are 50.81% & 58.68%, respectively. At the same flow rate, the round micropin fins have the most pressure

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loss while the elliptical testing section has the least. The shifting coefficients of drag related to diamond micropin fins reaches its greatest value when the contact between them degree is increased to 151.5°, yet the elliptical testing section stays the smallestThe ellipse micropin fins have a higher coefficient of friction coefficient at low Ré than the round and diamond micropin fins when their contact position is 99.5°..(Guan et al., 2016; Khoshvaght-Aliabadi et al., 2014)

CONCLUSION

In this article, we concluded about the significance of heat exchanger, particularly fins and tube heat exchangers, in industrial settings, emphasizing the need to improve thermal performance by utilizing various fin types and designs.it discusses the impact of different fin shapes, microchannel designs, and geometrical alternations on heat transfer efficiency and pressure drop. Additionally, the document provides detailed geometric characteristics of finned tube and plate-finned surface type, listing parameters like tube dimensions, fine dimensions, materials, number of fins, and area ratio, to optimize heat exchanger performance. Overall, it underscores the importance of design consideration in enhancing thermal efficiency and references various heat transfer enhancement techniques for different applications.

Additionally, it delves into the influence of different microchannel designs and fins shapes on heat transfer efficiency and pressure. In this we also determine the significance of geometrical alterations in improving the heat transfer efficiency of plate fins. Furthermore, the impact of contact angles on hydrophobic micro pin fins in reducing flow resistance is discussed. Furthermore, this article provides us the geometric characteristics which includes details such as dimensions of tube fins, material used, no of fins, Specific value for parameters like fine diameter, tube diameter fin spacing and enhancement technique using different types if surfaces and heat exchange

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Techno-Economic Analysis for Biodiesel Production through Wheat Straw Pyrolysis

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Abstract— Limited domestic resources, high fuel imports and finite access to modern fuel resulting in economic burden has led to increase in energy poverty in Pakistan. Moreover, waste management is the burning issue in the context of agricultural residue which is burned by farmers causing soil deterioration and air pollution. These significant and interconnected issues of the Pakistan that have far-reaching economic, environmental, and social implications. The primary goal of sustainable fuel production is to reduce the environmental and social harm associated with traditional fossil fuel extraction and production methods. Bio-crude is a liquid biofuel produced by thermochemical conversion of wide variety of biomass. Fast pyrolysis considered as an efficient and the most economical technique of valorization is used for the production of bio-crude from wheat straw. Catalytic upgrading methods like hydro-processing are then employed to upgrade biocrude to a variety of fuels including diesel and gasoline. In present work, techno-economic and environmental assessment is made for the process. Moreover, a complete process route is developed with detailed economic analysis to determine its feasibility. The process was also subjected to an economic study, and the results indicate that the project is fiscally feasible. With a 3.9 - year payback period and a positive present worth value, this project is the best investment. With pyrolysis being the most inexpensive route towards biofuels, the developed process can serve as a solution towards energy crisis issues of Pakistan.

Keywords— Pyrolysis; Wheat Straw; Bio-diesel, Circular Economy; Energy Crisis; Fuels

INTRODUCTION

The utilization of renewable energy sources, particularly biodiesel, for power generation, has garnered significant attention on a global scale. In the context of Pakistan, this approach holds promise in alleviating the current and anticipated energy challenges the nation faces (Pinheiro Pires et al., 2019a). Pakistan has a severe economic crisis stemming from a persistent disparity between energy demand and supply (Okopi et al., 2023). The power and gas supply shortage has already resulted in the stagnation of numerous industrial sectors, including textiles, small and medium enterprises, and local transportation. There is a prevalent concern in today's world regarding the depletion of fossil fuels, coupled with the relentless escalation of energy costs, which are projected to peak by 2050. The diminishing fossil fuel reserves within Pakistan have necessitated the annual importation of approximately 8.1 million tons at a cost of around US$ 9.4 billion (Awan et al., 2022). Therefore, the sustainable maintenance of renewable energy resources, such as biodiesel, is imperative to attain a

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sustainable energy mix and ensure energy security. In light of this imperative, the extensive integration of various biodiesel sources holds the potential to effectively address the energy shortfall and ensure energy security in Pakistan. In this context, the advancements in biodiesel related research within Pakistan are evaluated and presented, emphasizing strategies to fulfil the objectives outlined by the government. This comprehensive study deliberates on biodiesel as a renewable energy source, aiming to mitigate energy crises, foster a pollution-free environment, drive economic growth, and notably increase farmers' income.

Bio-DIESEL :

Biodiesel, a renewable and biodegradable fuel, is obtained from various natural sources, including vegetable oils (e.g. canola and soybean etc.), animal fats, recycled cooking grease, and lignocellulosic biomass like wheat straw. Biodiesel can either be used in its pure form, or blended with fossil fuel derived diesel in varying concentrations, such as B20 (20% bio-diesel, 80% conventional diesel), to power diesel engines(Danso-Boateng & Achaw, 2022). The benefits of biodiesel are significant, including a substantial reduction in GHG emissions compared to conventional fossil-derived fuels, which helps combat climate change. It also decreases dependence on finite fossil fuel sources, fostering energy security. Biodiesel has superior lubricating properties that can enhance engine performance and longevity. Moreover, the use of biodiesel supports local agriculture and economies, providing farmers with additional revenue streams and promoting rural development. Biodiesel production from waste materials, such as used cooking oil and wheat straw, contributes to waste reduction and promotes a circular economy. Overall, biodiesel represents a versatile and environmentally friendly substitute to traditional fossil-based diesel, with multiple production routes and numerous environmental and economic benefits.

Global Market of Bio-Diesel)

The United States remains at the forefront of biodiesel production, generating approximately 2.5 billion gallons of biodiesel in 2022. The country's biodiesel industry relies heavily on agricultural outputs such as soybean oil, animal fats, and recycled cooking oil, with considerable production facilities in states like Iowa, Texas, and Illinois. With an annual production of around 1.3 billion gallons (about 4.9 billion liters) in 2022, Brazil is another significant contributor to the biodiesel market (Hargreaves, 2017). The country's biodiesel production predominantly relies on soybean oil, benefiting from its extensive farming. In 2022, the European Union collectively produced about 3.2 billion gallons (approximately 12 billion liters) of biodiesel, with leading countries in biodiesel production including Germany, France, and Spain. The EU's biodiesel production is sustained by rapeseed oil, used cooking oil, and animal fats, driven by renewable energy directives and environmental policies.

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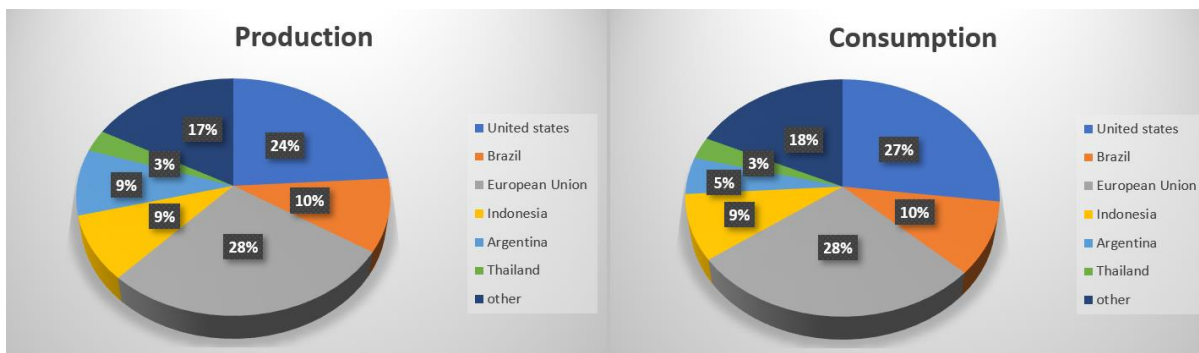**Organized by University of Wah**

Figure 10 Production and Consumption of Bio-diesel in the world.

Production, Consumption and Import of Crude Oil in Pakistan:

Pakistan's domestic crude oil production remains relatively modest compared to its consumption needs. As of 2022, the country's crude oil production stood at approximately 88,000 barrels per day (bpd). The oil fields are predominantly situated in the southern and central regions, encompassing the Sindh and Punjab provinces. Despite continuous exploration and development endeavours, domestic production only satisfies a small fraction of the national demand. Pakistan's consumption of crude oil surpasses its production significantly. In 2022, the country consumed about 450,000 barrels per day (bpd) of crude oil. Various sectors drive this substantial consumption, including transportation, power generation, and industrial uses. Notably, the transportation sector emerges as a significant consumer of oil products, primarily relying on diesel and gasoline as the principal fuels. Due to the notable disparity between production and consumption, Pakistan relies heavily on imports to fulfil its crude oil requirements. In 2022, the country imported approximately 362k BPD of crude oil to bridge the gap between domestic production and demand (Hargreaves, 2017). Pakistan sources its crude oil imports from various international suppliers, including critical sources from Middle Eastern countries such as Saudi Arabia, the UAE, and Kuwait. These imports are critical in meeting the country's energy needs and ensuring a consistent supply of refined petroleum products.

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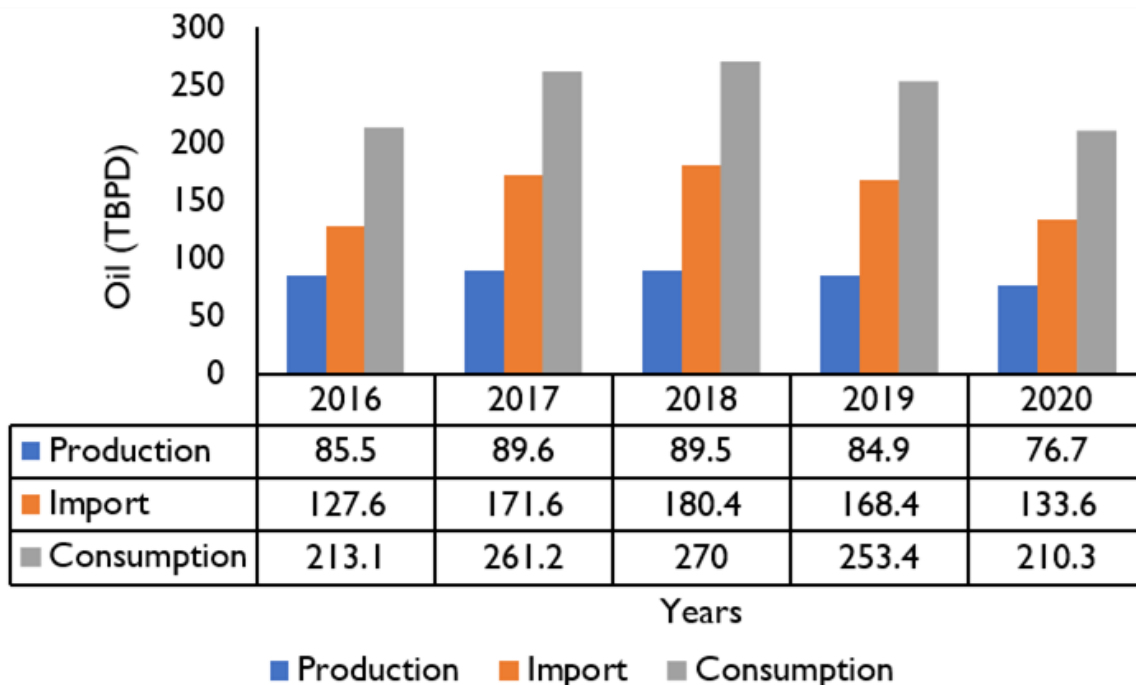| Years	2016	2017	2018	2019	2020
■ Production	85.5	89.6	89.5	84.9	76.7
■ Import	127.6	171.6	180.4	168.4	133.6
■ Consumption	213.1	261.2	270	253.4	210.3

Figure 11 Production, Consumption and Import of Crude oil in Pakistan.

Current Bio-Diesel Market:

The current biodiesel market in Pakistan is at a nascent stage of development, with a noticeable shift towards adopting renewable energy and a focus on environmental sustainability. Although biodiesel production and consumption levels are currently modest compared to traditional fossil fuels, this sector has a growing interest and influx of investments. Government-led initiatives promoting renewable energy, including mandates for biodiesel blending and tax incentives, are significant market expansion drivers. Nonetheless, challenges persist, such as limited infrastructure, technological constraints, and competition from conventional fuels(Wang et al., 2023). As awareness of the environmental advantages of biodiesel expands and technological advancements enhance production efficiency, the biodiesel market in Pakistan is poised for substantial growth, presenting opportunities for investment, innovation, and the advancement of sustainable energy.

Applications of Bio-Diesel:

Biodiesel exhibits diverse applications across multiple sectors due to its renewable nature and environmental advantages(Hobbie et al., 2022). The primary applications of biodiesel encompass:(Elhenawy et al., 2024; Green & Perry, 2008a)

- Biodiesel is a widely used fuel for diesel engines in various modes of transportation, including cars, trucks, buses, and other vehicles.
- Biodiesel is commonly used in farm equipment and machinery, such as tractors and harvesters, supporting a sustainable agricultural cycle by enabling farmers to utilize biofuel produced from their crops.

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- Biodiesel is employed in marine vessels, including boats and ships. It offers an eco-friendly alternative to traditional marine fuels and contributes to reducing water pollution and greenhouse gas emissions.
- Biodiesel is employed in diesel generators to produce electricity, particularly in remote or off-grid locations. This thereby mitigates dependence on fossil fuels and fosters the utilization of renewable energy sources.
- Biodiesel can be utilized in residential and commercial heating systems as a substitute for heating oil, requiring minimal or no modifications to existing oil furnaces and boilers.
- Although still in the experimental phase, biodiesel is being subjected to trials as a potential sustainable aviation fuel (SAF) to aid in curbing the aviation industry's carbon footprint.
- Biodiesel is applied in various industrial settings, including as a solvent for cleaning and degreasing and in the production of lubricants and other chemicals.
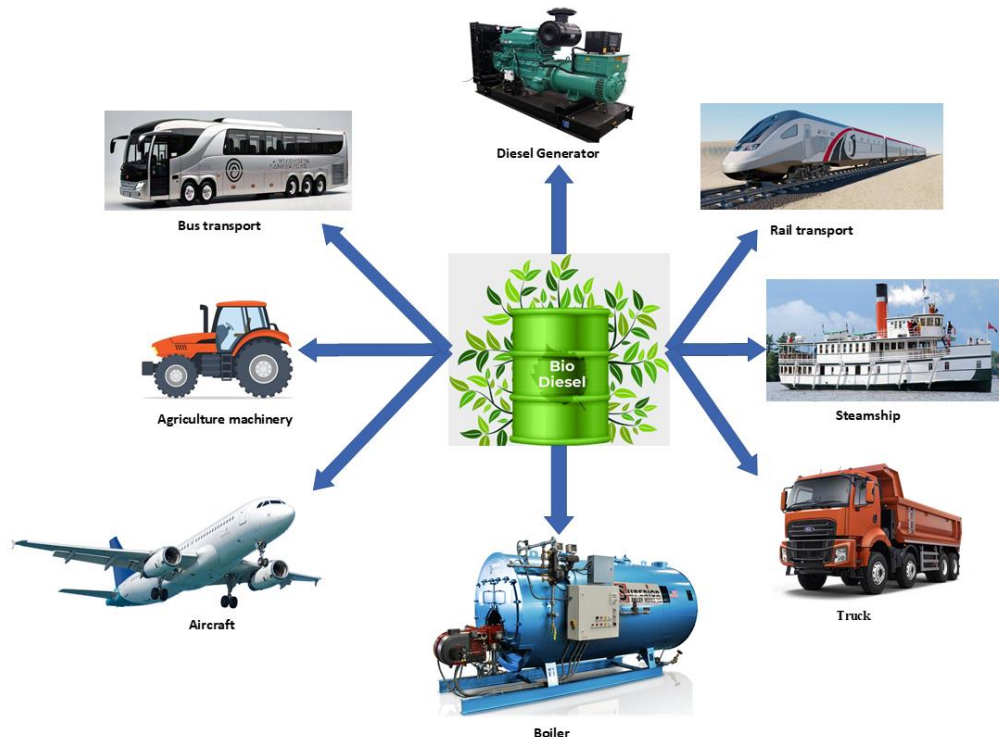

Figure 12 Applications of Bio-diesel.

Wheat Straw Availability:

Wheat straw, the fibrous byproduct remaining after wheat grain harvest, is primarily composed of cellulose, hemicellulose, and lignin. This agricultural residue holds significant potential for sustainable energy production, particularly in the form of biodiesel. Its significance in biodiesel production lies in its role as a lignocellulosic biomass, which can be converted into biodiesel through thermochemical processes e.g. pyrolysis and gasification, followed by upgrading methods such as Fischer-Tropsch synthesis. It is estimated that Pakistan produces around 25 million metric ton of wheat straw on yearly basis, and the major provinces for this production includes Punjab,

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Sindh, Khyber Pakhtunkhwa and Balochistan(Auersvald et al., 2019). About 50% of this straw is consumed by animals for food, and around 20% is utilized in activities like mulching, bedding, and composting. A small proportion goes to industrial uses like production of paper and other related products. But it is alarming that around 30% of straw is left unutilized and is mostly burnt or lacking proper handling facilitie(Pinheiro Pires et al., 2019b)s. This has a negative impact on the environment and the wastage of good organic matter that can be of great benefit to human beings.("Biomass to Biofuels: Strategies for Global Industries," 2010)

Table 4 Availability of Raw Material in Pakistan.

Total wheat straw production = 25 million tons per annum	
Animal Fodder	50%
Pulp & Paper Industry	5%
Domestic use	2%
Export	5%
As a fuel	10%
Available wheat straw	28%

Utilizing wheat straw for biodiesel production offers various environmental and economic benefits:

- It helps reduce waste by providing a productive use for agricultural residues that might otherwise be burned or left to decompose, which can contribute to greenhouse gas emissions.
- The use of wheat straw as a feedstock for biodiesel can reduce the reliance on food crops like soybean or canola, thus avoiding the food-versus-fuel conflict and enhancing food security.
- Converting wheat straw into biodiesel contributes to a circular economy by turning agricultural waste into valuable energy resources, supporting rural economies, and creating new revenue streams for farmers.
- Biodiesel produced from lignocellulosic biomass like wheat straw has a lower carbon footprint compared to fossil fuels, thus contributing to climate change mitigation.

Table 5 Physio-Chemical Properties of Wheat Straw.

Properties	% Content
Cellulose	33.19
Hemi-cellulose	25.20
Lignin	15.27
Carbon	48.93
Hydrogen	6.52
Nitrogen	1.11

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Oxygen	42.56
HHV (MJ/Kg)	18.01
Moisture Content	6.5
Ash Content	5.45
Fixed Carbon	13.35

Routes to Bio-Diesel:

Converting wheat straw into biodiesel can be achieved through two major thermochemical processes:

- Pyrolysis
- Hydrothermal Liquefaction (HTL)

Pyrolysis is a thermal decomposition process of biomass material in the presence of heat and absence of oxygen to produce bio-oil/bio-crude, syngas and char(Bridgwater, 2000). This process normally occurs at the temperature of about 400-600°C and can be classified as slow, fast and flash pyrolysis.(Ansari et al., 2019) Fast pyrolysis is preferable for bio-oil production because of higher liquid yield and higher yield of bio-oil compared to slow pyrolysis which yields more char and flash pyrolysis which may produce unstable bio-oil at 450-500°C and high heating rates(Kataria et al., 2022). On the other hand, hydrothermal liquefaction (HTL) utilizes H_2O at high temperatures (250-374°C) and pressures (4-22 MPa) to convert biomass into bio-crude oil which has higher energy density and similar to conventional fossil fuels(Han et al., 2019). HTL typically produces better quality of bio-oil and is capable of processing wet biomass directly, which offers feedstock flexibility and superior product quality on one hand, but it is complex and pricey due to the need for high pressure equipment on the other hand(Bridgwater, 2000). As for the two methods, fast pyrolysis is more commercialize on a large scale because of its lower operational intensity and cost, thus considered suitable for the conversion of wheat straw to biodiesel.(Johannes et al., 2024)

Table 6 Difference between Pyrolysis and Hydrothermal Liquefaction.

Parameter	Pyrolysis	Hydrothermal Liquefaction
Feedstock	dry	Wet
Particle Size	1 – 20 mm	< 1mm
Temperature	~500 °C	200 – 350 °C
Pressure	1 bar	50 – 200 bar
Oil Yield (wt%)	80	20 – 60
Present Status	Commercialised	Underdeveloped
Bio-oil viscosity mPa.s	13 – 70	67000
Relative capital cost	low	high

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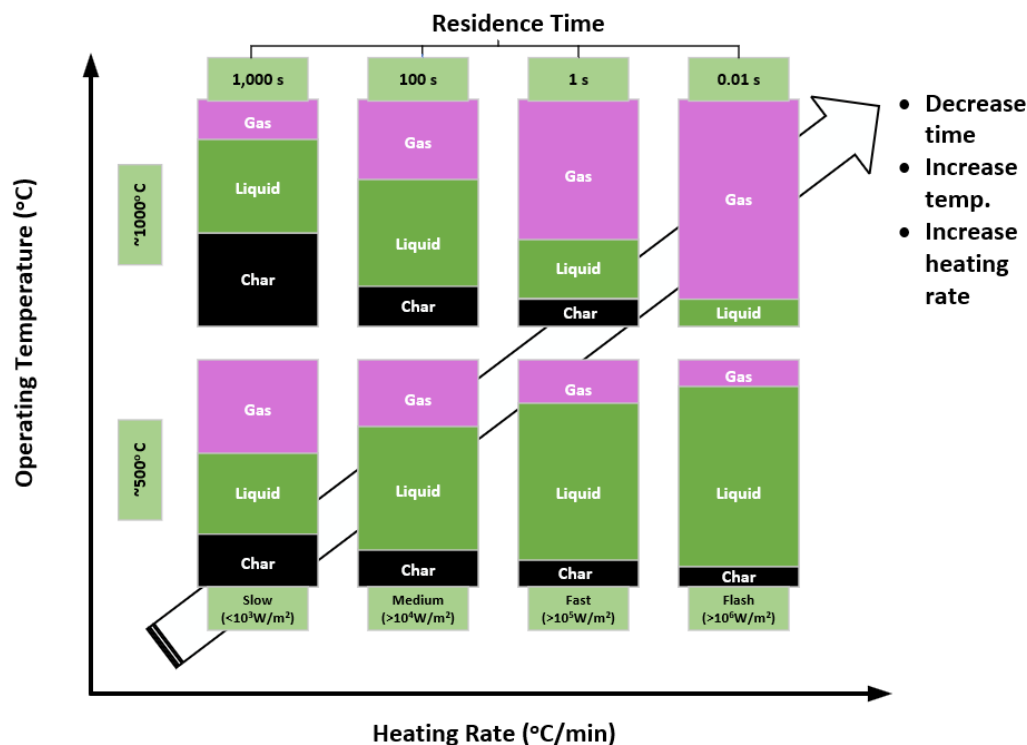**Organized by University of Wah**

Figure 13 Types of Pyrolysis Processes.

Process Description:

The process of producing biodiesel from wheat straw via pyrolysis involves several vital stages: pretreatment, pyrolysis, upgrading of bio-oil through hydrotreating and hydrocracking, separation of diesel and gasoline fractions through distillation, and final storage(Green & Perry, 2008b). Each stage is crucial for efficiently converting wheat straw into high-quality biodiesel. Pretreatment begins with size reduction, where wheat straw is mechanically processed through shredding or milling. This reduces the particle size, enhancing heat transfer and increasing the efficiency of the pyrolysis process(Han et al., 2019). Additionally, impurities such as stones, metals, and other contaminants are removed to prevent pyrolysis equipment damage and to enhance the quality of the resulting bio-crude. The pyrolysis process is conducted at temperatures between 500°C in an O_2-free atmosphere to prevent combustion. The heating rate is rapid, ensuring quick decomposition of the biomass(Jin et al., 2022). The resulting products include bio-oil, syngas, and char. Bio-oil, the primary product, is a complex mix of organic compounds, while syngas and char are indispensable byproducts. Bio-oil serves as the feedstock for further upgrading into biodiesel. (Theristis et al., 2018)Hydrotreating involves adding hydrogen to remove oxygen from the bio-oil, using catalysts under high pressure and moderate temperatures("Heat Transfer," 2013). Following hydrotreating, hydrocracking further breaks down the large hydrocarbon molecules into smaller, more desirable ones, such as diesel and gasoline fractions(Han et al., 2019). This process occurs under high pressure and temperature in the presence of catalysts, resulting in a mixture of hydrocarbons suitable for use as fuels(Peng et al., 2013). The upgraded bio-oil undergoes distillation to separate the mixture on the basis of the boiling points of its constituents(Meier et al., 2013). The mix is heated during distillation, causing the different hydrocarbons to

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vaporize at their respective boiling points. These vapours are then condensed into liquid form and collected in separate fractions. Diesel and gasoline are two primary fractions obtained, each with distinct properties and uses.(Chen et al., 2018)
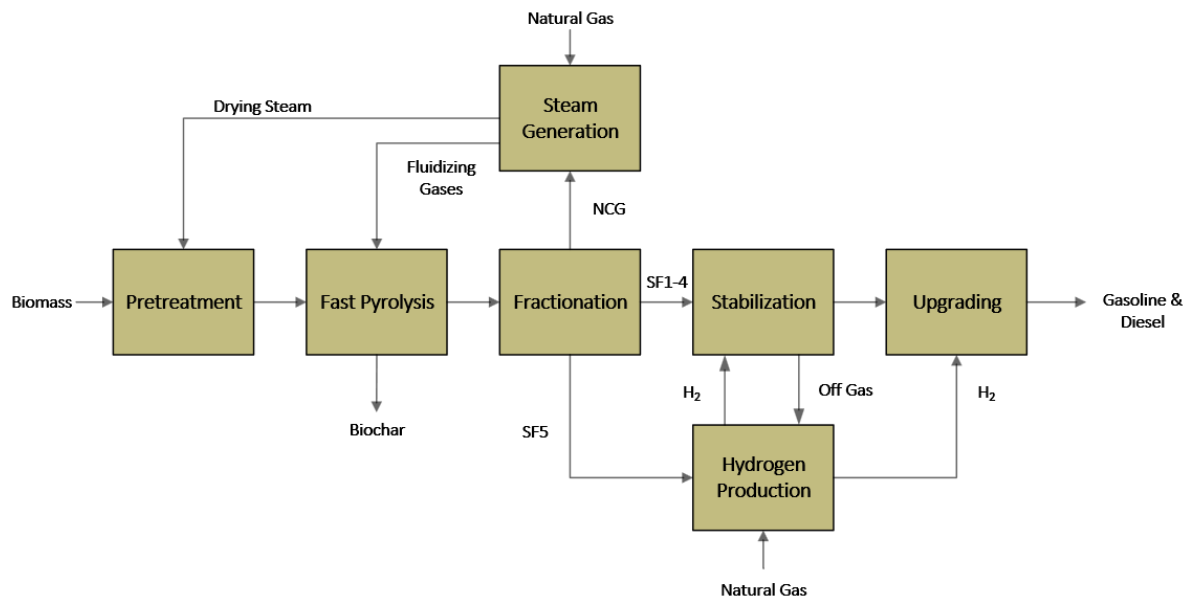

Figure 14 : BFD proposed for the Process.

Plant Specifications:
- Plant Capacity = 2000 tons/day of Biodiesel
- Raw Material Supplied = 23870 tons/day of Wheat Straw
- Bio-oil Yield = 42%
- Bio-oil Production rate = 10025.4 tons/day
- Plant commences operation in 4-7 years
- Plant life is 20 – 22 yrs
- Plant operation is 300 days/yr

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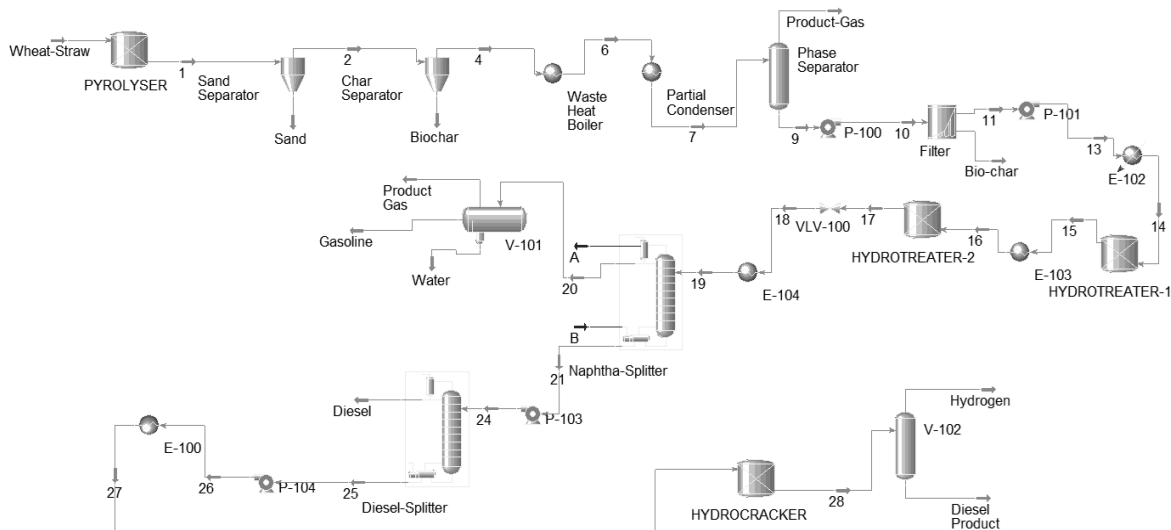**Organized by University of Wah**

Figure 15 Simulated Flowsheet of Proposed Plant.

Conventional VS Wheat Straw Derived Diesel:

Biodiesel derived from pyrolysis of wheat straw is a viable substitute for regular diesel as it has similar energy density, cetane number, viscosity, density and distillation characteristics. (J. Xu et al., 2020)For instance, this other diesel has lower levels of sulfur and aromatic hydrocarbons, resulting in lower sulfur oxides and particulate emissions(M et al., 2022). Interestingly(Wu et al., 2020), these similarities suggest that the diesel produced from pyrolysis of wheat straw can easily be used in the existing diesel engines and dissemination channels, (Haarlemmer et al., 2016)thus making it easier to substitute the current unsustainable fuel.(Ferreira et al., 2023; D. Xu et al., 2023)

Table 7 Conventional VS Bio-diesel Properties.

Property	Fossil Fuel Diesel	Biodiesel
Gasoline / Diesel Equivalent	1 gallon = 1.12 GGE	1 gallon = 1.05 GGE
	1 gallon = 1.00 DGE	1 gallon = 0.93 DGE
LHV	128,488 Btu/gal	119,550 Btu/gal
Cetane Number	40 – 56	48 – 65
Flash Point	165°F	212° to 338°F
Cloud Point	-3	-3 to 15
Pour Point	-13	-5 to 10
Specific Gravity	0.843	0.88

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Economic Analysis:

The economic feasibility of producing diesel from wheat straw pyrolysis is evident from the economic analysis of the process and the benefits of using the produced diesel over the conventional diesel. It also efficiently employs an agricultural waste product which is available in large quantities and hence cuts down the costs of feedstock(Inayat et al., 2022). The investment and maintenance costs of pyrolysis plants especially the fast pyrolysis are relatively low compared to the other advanced biofuel technologies making them financially feasible. In addition, byproducts like biochar and syngas can be sold to create more income streams for the business. The reduction in the sulfur content and the ability of pyrolysis derived diesel to emit fewer pollutants can reduce costs by avoiding penalties and meeting set regulations. Therefore, the economic and environmental impacts and the fact that few changes to the infrastructure make this process crucial to the progress of energy security and sustainability.

Capital Investment:

Before commencing operations, an industrial plant requires substantial financial resources to procure and install essential equipment and machinery. Furthermore, acquiring land and service facilities, as well as complete plant construction with all necessary pipe controls and services, is imperative. Moreover, it is crucial to have funds available to cover the plant's operational expenses. The capital required for procuring the essential manufacturing and plant facilities is represented as fixed capital investment, whilst the funds essential for the plant's operation are called working capital investment.

Fixed Capital Investment:

The capital needed to supply fixed plant facilities is called fixed capital investment. It is categorized in to two sub classifications,

- Direct Cost
- Indirect Cost

Table 8: Calculations on the basis of Purchased Equipment cost.

Item	% of Purchased Cost	%	cost ($)
Purchased Equipment		100	206602695
Installation	25 – 55	40	82641078
Instrumentation and control	6 – 30	18	37188485
Piping	40 – 80	60	123961617
Electricity	10 – 15	13	25825337
Building	15	15	30990404
Land	4 – 8	7	12396162
Service facility	30 – 80	56	113631482
Yard Improvement	10 – 20	14.5	30990404
Insulation Cost	8 – 9	9	17561229
TOTAL			681788894

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Table 9: Indirect Cost on the basis of Direct cost.

Item	% of Direct Cost	%	Cost ($)
Engineering and supervision	25	25	170447223.4
Contractor fees	2 – 8	5	34089444.68
Construction expenses	10	10	68178889.35
Contingencies	8	8	54543111.48
TOTAL			327258668.9

Direct Cost = $ 681788894

Indirect Cost = $ 327258668.9

$$FCI = Fixed\ Capital\ Investment = DC + IDC = \$1009047562$$

Working Capital Investment:

The capital that is essential for the operation of the plant is known as working capital investment.

WCI = Working Capital Investment = 15% of FCI = $ 151357134

$$Total\ Capital\ Investment = FCI + WCI = \$ 1160404697$$

Variable Costs:

The variable cost of a plant includes costs that fluctuate with the output of the plant. These costs include the cost of the materials used in the production process, wages and salaries of employees, and energy costs, which can fluctuate depending on the amount of products or services produced.

Raw Material Cost:

Table 10: Raw Material Cost.

Item	$ per kg	Flowrate (kg/yr)	Total $/yr
Wheat Straw	0.1	8712547080	871254708
Hydrogen	2	143716560	287433120
TOTAL			1158687828

Utilities Cost:

Table 11: Utilities Cost.

Item	$ per kg	Flowrate (kg/yr)	Total $/yr
Steam	0	8500000000	170000000
Cooling Water	0	200000000000	3600000
TOTAL			173600000

Catalyst Cost:

Table 12: Catalyst Cost.

Catalyst cost ($/kg)	7.5
catalyst weight(kg)	5043
Total catalyst cost ($/yr)	37822.5

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Miscellaneous Cost:

Table 13: Miscellaneous Cost.

Maintenance cost	7% of FCI	70633329.37
Miscellaneous material	10% of maintenance cost	7063332.937

Fixed Operating Cost:

Other costs that are related to operating costs and are also known as 'fixed costs' or 'overhead costs' are costs that stay unvarying regardless of the level of production. These costs do not alter according to the level of activity of the facility for a particular period of time. Examples include rental or lease expenses for facilities, salary for permanent employees, insurance charges, and depreciation of equipment(Inayat et al., 2022). Fixed operating costs provide stability in the financial projections since they are predictable; however, they also contribute to the firm's obligations that have to be met regardless of low production or sales.

Table 14: Fixed Operating Cost.

Item	% of FCI	Cost ($)
Maintenance cost	7	70633329
Operating cost of labour	10	100904756
Laboratory cost	20	201809512
Supervision cost	15	151357134
Plant overhead	50	504523781
Capital Charges	10	100904756
Insurance	1	10090476
Local Taxes	2	20180951
Royalties	1	10090476
TOTAL		1170495172

Total Production Cost:
Direct Production Cost:

Direct Production Cost= Variable Cost + Fixed Operating Cost
DPC = $ 2509884156

Overhead Charges = 30% DPC
Overhead Charges = 752965246.7

Manufacturing Cost = Overhead + DPC
Manufacturing Cost = 3262849403

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General Expenses:

Table 15: General Expenses.

Item	% of Manufacturing Cost	Cost ($)
Administration	2	65256988.05
Distribution and marketing	2	65256988.05
Research and development	5	163142470.1
Total		293656446.2

Total Production Cost = Manufacturing Cost + General Expenses
Total Production Cost = $ 3556505849

Profitability Analysis:
Total Income and Gross Profit:
Evaluating the profitability of a plant requires a careful analysis of the plant's financial status using measures like the total income and the gross profit. Total income refers to the money that the plant makes through its operation and is inclusive of all sales of products or services. Gross profit on the other hand is derived by subtracting the cost of sales which include direct cost such as raw materials and direct labour from the total revenue. This calculation gives a clue of the degree to which the plant is able to convert its sales into profit once the costs of production have been factored in. These metrics can be used by analysts to assess the efficiency of the plant, the success of the pricing strategy, and the overall profitability. The analysis provided here is quite useful in understanding the financial health of the plant and its competitiveness in the market.

Table 16: Profitability Analysis.

PRODUCTION COST		
Total Production rate	3650000000	Kg/yr
Production cost	0.974385164	$/kg
PRODUCT SELLING PRICE		
Price of bio-diesel in Market	2.085	$/kg
Selling price of the product	1.2	$/kg
PROFIT PER YEAR		
Selling price - production cost	0.225614836	$/kg
profit per year	823494151.2	$/yr
TOTAL INCOME		
Selling price	1.2	$/kg
Total production rate	3650000000	Kg/yr
Total Income	4380000000	$/yr
GROSS PROFIT ATTAINED		
Total Income - Total Production Cost	823494151.2	$/yr

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Depreciation and Payback:

Depreciation is an accounting term that describes a method of diffusing the cost of a physical item over the passage of its useful life. The term "depreciation" refers to the amount of an asset's worth that has been used up. It allows companies to acquire assets over time and create income from them. If depreciation is not taken into account, it could significantly affect a company's profitability. For tax and accounting reasons, long-term investments might also be written off as expenses.

Table 17: Depreciation and Payback.

DEPRECIATION			
Machinery and equipment	20% of FCI	201809512.5	$/yr
Building	4% of Building cost	1239616.17	$/yr
Total Depreciation	Machinery and equipment + Building	203049128.6	$/yr
TAXES			
Let the tax rate is 40%			
Taxes	0.4×Gross Profit	329397660.5	$/yr
NET PROFIT			
Net Profit before Taxation	Gross profit – Depreciation	620445022.6	$/yr
Net Profit	Net Profit before Taxation – Taxes	291047362.1	$/yr
ANNUAL RATE OF RETURN			
Rate Of Return	net profit/tci *100	25.08153948	%
PAYBACK PERIOD			
Payback Period	1/rate of return	3.986996097	yrs

Cumulative Cash Flow:

The net cash flow calculations made for the pyrolysis plant that converts wheat straw into diesel reveals that payback period is 3. 9 years. On the horizontal axis of the graph, the time is represented in years. The values below this axis are negative, which indicates the initial investment phase and early years of operation, where the total cash flow may be negative due to capital expenditure and operating costs being higher than revenues. On the other hand negative values on the horizontal axis refer to subsequent years where the cumulative cash flow becomes positive since the amount of money that is generated from the sale of diesel is greater than the ongoing expenses. The vertical axis depicts the cumulative cash flow in monetary units, using negative values for the investment and the startup phase and positive values for the profitable phase. This paper is a financial tool of great importance as it presents the plant's performance and its path to profitability to help the potential investors and stakeholders in making sound decisions.

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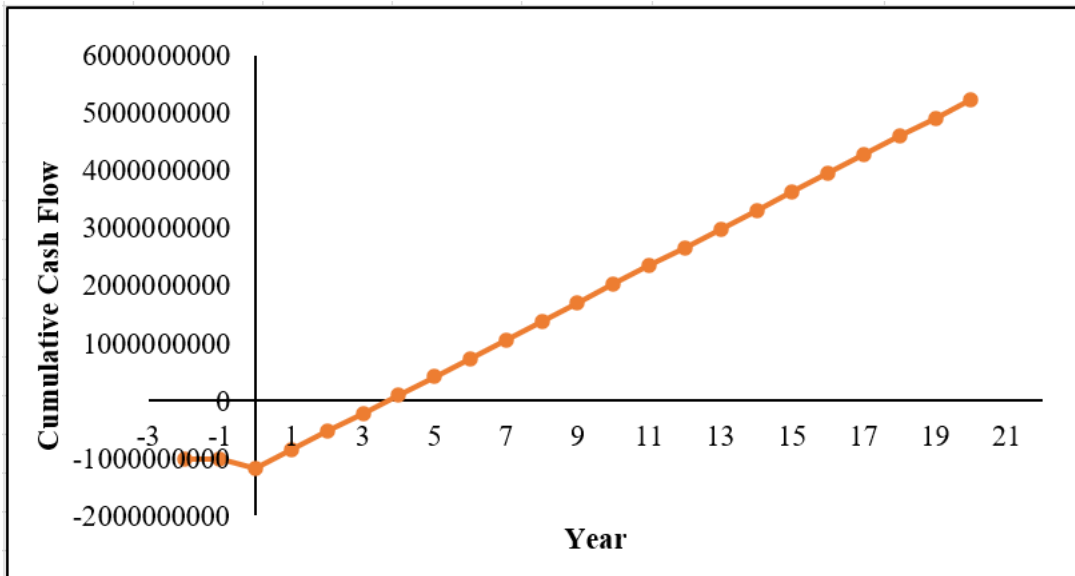**Organized by University of Wah**

Figure 16: Cumulative Cash Flow Diagram.

Net Present Worth:

Minimum Acceptable Rate of Return (MARR) = 15%

Internal Rate of Return = i %

$$NPV = \frac{Net\ Profit\ ((1 + i)^n - 1)}{i(1 + i)^n} - TCI = 0$$

By performing iterations,

   IRR = 24.45%

   NPV = $ 29973061

   IRR > MARR

<div align="center">24.45% > 15%</div>

The net present value (NPV) and internal rate of return (IRR) are critical fiscal measures when assessing the economic viability of the pyrolysis plant. The project's IRR of 24.45% indicates that the expected returns surpass the cost of capital, signifying its financial attractiveness. NPV, which accounts for the time value of money and initial investment by omitting future cash flows to current value, reflects the project's cost-effectiveness today. A positive NPV indicates that the project produces added profit than its costs, further bolstering its potential as a sustainable and profitable venture in converting wheat straw into diesel. These metrics affirm the plant's capacity to yield substantial returns throughout its operational lifespan, positioning it as an enticing investment opportunity in the renewable energy sector.

Environmental Assessment:

The primary objective of this assessment is to analyze the potential environmental impacts linked to biodiesel production from wheat straw pyrolysis(S. Ali et al., 2021). By methodically evaluating the environmental problems, this assessment contributes to making well-informed decisions that balance economic development and environmental protection.(Belinskaya et al., 2021)

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Air Quality:

The production of biodiesel from wheat straw using pyrolysis and hydroprocessing plays a substantial role in reducing GHG emissions when contrasted to typical fossil fuels(M et al., 2022). This in turn positively impacts efforts to combat climate change by lowering the lifecycle emissions of biodiesel. Moreover, biodiesel contains minimal sulfur content, stemming in lower emissions of sulfur dioxide (SO_2)(Igba et al., 2015), a key donor to air pollution and acid rain when used as a fuel. Conversely, it is imperative to note that the pyrolysis process can release volatile organic compounds (VOCs), carbon monoxide (CO), nitrogen oxides (NOx), and particulate matter (PM), all of which can have adverse effects on air quality if not properly managed(Aprovitola et al., 2021). Similarly, hydro-processing, particularly when reliant on hydrogen produced from non-renewable sources, can result in emissions of CO_2 and other pollutants. Additionally, the process itself may emit small amounts of VOCs and NOx, necessitating the use of effective emission control technologies. (Luo et al., 2020)

Water Quality:

On the water quality front, one notable advantage of the pyrolysis process is the production of biochar, which can be used to improve soil structure and water retention, thereby reducing the need for chemical fertilizers that contribute to water contamination through agricultural runoff. This can have a positive impact on both soil and water quality by reducing the potential for nutrient leaching into water bodies(Y. Xu et al., 2014). However, it's worth mentioning that both the pyrolysis and hydroprocessing processes are water-intensive, requiring substantial amounts of water for cooling and hydrogen production, which can deplete local water resources. Furthermore, hydroprocessing may generate wastewater containing contaminants such as residual hydrocarbons, catalysts, and other chemicals, posing the risk of significant water pollution if not properly treated.

Soil Quality:

Concerning soil quality, the use of biochar, a by-product of the pyrolysis technique, offers numerous benefits. Biochar can appreciably enhance soil potency, nutrient retention, and soil organic carbon content, ultimately leading to better crop yields and reducing the dependency on chemical fertilizers(Eschenbacher et al., 2020). Additionally, biochar helps sequester carbon in the soil, contributing to the reduction of atmospheric CO_2 levels and assisting in mitigating climate change. (Ndlovu et al., 2022)Nonetheless, it's important to note the potential negative effects on soil quality, such as soil contamination if bio-oil or residual chemicals from the production process are not properly managed(Pennington, 2015). Also, the transportation and storage of these materials pose risks that must be carefully managed. Moreover, an overreliance on agricultural residues like wheat straw for biofuel production can lead to soil degradation over time if not appropriately compensated with other organic inputs.(F. Ali, 2023)

Sustainable Development Goals:

The process of producing biodiesel from wheat straw pyrolysis is closely linked to a few Sustainable Development Goals (SDGs). These include SDG 1 (No Poverty), SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 13 (Climate Action). This project has the potential to make a difference in various ways – it could help reduce poverty by creating employment opportunities and generating income, contribute to the renewable energy sector, foster technological and industrial innovation, and play a role in combating climate change by lowering greenhouse gas emissions.

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CONCLUSION:

In conclusion, using wheat straw to produce biodiesel through pyrolysis offers a promising solution to Pakistan's escalating energy requirements and waste management issues. Circulating fluidized beds and multi-tubular reactors are employed for wheat straw pyrolysis and bio-oil upgrading. An in-depth technical evaluation and economic analysis of the pyrolysis plant have been conducted. The initial assessment indicates high feasibility, reasonable conversion rates, and yields. The economic analysis reveals that the total capital investment needed for a pyrolysis plant is estimated at $1.1 billion, with an annual production cost of approximately $3.5 billion and potential revenue generation of $800 million per year. The anticipated net profit from the plant is $291 million annually, with a 25.08% rate of return and an estimated payback period of 3.9 years. By addressing both agricultural waste management and Pakistan's energy crisis, wheat straw pyrolysis holds the potential to solve two significant challenges. With an annual production of 25 million tons of wheat straw in Pakistan, primarily burnt in rural areas, converting this abundant resource into biodiesel presents an opportunity to mitigate waste management issues and address the country's energy shortages, particularly for electricity generation. This initiative tackles environmental concerns related to straw burning. It contributes to sustainable energy production, fostering energy security and effective waste utilization in line with Pakistan's objectives for renewable energy development and environmental sustainability.

FUTURE ASPECTS:

The potential for biodiesel production from wheat straw pyrolysis in Pakistan is substantial and presents various promising aspects from an academic perspective:

- Investment in research and development can potentially enhance pyrolysis technologies, leading to increased bio-oil yield and improved quality. Innovations in catalytic pyrolysis and reactor designs promise to enhance the efficiency and economic viability of the entire process.
- Pakistan's significant wheat production produces abundant wheat straw, a readily available feedstock. Utilizing this agricultural residue for biodiesel production can reduce waste and create a sustainable energy source.
- Developing a biodiesel industry could introduce new economic opportunities, particularly in rural areas. This can stimulate local economies, create jobs, and reduce dependence on imported fossil fuels, thus contributing to energy security.
- Biodiesel production from wheat straw has the potential to contribute to reducing greenhouse gas emissions and environmental pollution. This provides a cleaner alternative to conventional fossil fuels and aligns with Pakistan's commitments to international climate agreements.
- Government incentives and policies promoting renewable energy and using waste biomass are essential for driving investment in biodiesel production. Supportive frameworks, including subsidies, tax breaks, and research grants, can expedite industry growth.
- Establishing integrated biorefineries for producing biodiesel and other valuable by-products such as biochar, syngas, and chemicals could significantly enhance process economics and sustainability. This approach maximizes the value derived from wheat straw.
- Collaborating with international research institutions and industries promises to bring advanced technologies and best practices to Pakistan, thereby facilitating the development of a robust biodiesel sector.

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- Increasing awareness about the benefits of biodiesel and educating farmers and stakeholders about the potential of wheat straw as a feedstock is critical in driving acceptance and participation in the biodiesel supply chain.

-

Acknowledgment *(Heading 5)*

All praise to Allah, the Greatest, the Knower of all knowledge and the Master of all universe. The path to this study was not smooth. It contains the fruit of many sleepless nights and doubtful moments, for this, before anybody else, we would like to thank our Parents for just being there, becoming a source of moral support and the driving force in these testing times.

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