BOOK OF ABSTRACTS

1st International Conference on Recent Advances in Green Biotechnology and Climate Resilience

(RAGBCR-2025)

September 15-16, 2025

Organized by

Department of Environmental Sciences & Department of Biotechnology, Shaheed Benazir Bhutto University, Sheringal, Dir (U), KP, Pakistan

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1st International Conference on Recent Advances in Green Biotechnology and Climate Resilience (RAGBCR-2025)
September 15-16, 2025
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MESSAGE

It is my proud privilege and honor to welcome you all to the 1st International Conference on "Recent Advances in Green Biotechnology and Climate Resilience (RAGBCR-2025). The objective of this conference is to provide a unique opportunity for Researchers, Scientists, and Professionals from around the world to come together and share their innovative ideas, experiences, and cutting-edge research in RAGBCR-2025 being held at Shaheed BB University Sheringal Dir Upper, Khyber Pakhtunkhwa, Pakistan. The RAGBCR-2025 will be an important network opportunity for faculty members, researchers, and students. RAGBCR-2025 is the result of the endless efforts of the organizing committee. The committee worked hard to organize the conference including local arrangements, inviting papers, and evaluation/screening of submitted papers. Therefore, I congratulate them on hosting such a wonderful event. I am also thankful to the reviewers for sparing valuable time for the review process and selection of top-quality papers for publication at the conference. I am hopeful that the contribution of the local and foreign scholars and researchers at this forum will strengthen the academia, industry, and R&D organizations' future and ongoing endeavors. I am confident that this collection of quality papers and invited talks will provide you an insight into recent trends and research directions in emerging Environmental Science and Biotechnology areas.

May this conference be a complete success for everyone

Prof. Dr. Muhammad Shahab
Patron in Chief
RAGBCR-2025

PREFACE

The 1st International Conference on "Recent Advances in Green Biotechnology and Climate Resilience (RAGBCR-2025) will be held on 15-16 September 2025 at Shaheed Benazir Bhutto University Sheringal Dir Upper, Khyber Pakhtunkhwa, Pakistan. It has been co-organized by the Department of Biotechnology and Department of Environmental Science, Shaheed Benazir Bhutto University Sheringal Dir Upper, Khyber Pakhtunkhwa, Pakistan. Green Biotechnology and Sustainable Development Goals and Climate Resilience and Sustainable Development Goals and were selected as the themes of the conference. The conference attracted 170 abstracts to be presented in the conference with more than 100 participants with different affiliations including researchers, academicians, and nascent students. From these abstracts, 120 abstracts are then shortlisted to be published in this proceeding. The papers presented here are organized into ten sub-themes namely: (i) Green Biotechnology (ii) Climate Resilience. The abstracts offered in this proceeding are expected to stimulate new perceptions in talking to promote science and technology culture in Pakistan. The main objective of the conference is to provide a dedicated platform for researchers, young, inspired scientists, and academicians to share the knowledge that is still yet to be revealed in the field of environmental science and biotechnology at this 2-day event scheduled for September 15-16, 2025. The conference will comprise keynote addresses, oral presentations, and poster presentations. The event will bring together a unique mix of experts, researchers, graduate and undergraduate students, as well as decision-makers both from academia and industry across the country to exchange their knowledge, expertise, and research innovations to build an excellent "Environmental Science and Biotechnology" conference. We hope that you will find this 1st International Conference on "Recent Advances in Green Biotechnology and Climate Resilience (RAGBCR-2025) perceptively inspiring and that the RAGBCR-2025 is a prestigious event organized with a motivation to provide an international platform for scientists and scholars around the world to share their research findings in the various research fields.

Dr. Muhammad Asif Nawaz
Conference Chair

Dr. Allah Ditta
Conference Co-Chair

ACKNOWLEDGMENT

It is our pleasure to welcome you to the 1st International Conference on "*Recent Advances in Green Biotechnology and Climate Resilience*" (RAGBCR-2025). We thank the authors for giving the content of the program in the form of posters and oral presentations. We are also grateful to the keynote speakers from academia and research centers. These valuable speeches will guide us to a superior appreciation of the fields of Environmental Science and Biotechnology. We also thank our sponsors including the Higher Education Commission (HEC), Islamabad, Pakistan Scientific and Technological Information Center (PASTIC), and Shaheed Benazir Bhutto University, Sheringal, Dir Upper, Khyber Pakhtunkhwa, Pakistan, without their support, it would not be possible to hold this international conference. We are thankful to all organizers, who worked hard day and night to make this event successful.

Dr. Allah Ditta
Conference Chair

Dr. Muhammad Asif Nawaz
Conference Co-Chair

ABOUT PASTIC

Pakistan Scientific & Technological Information Centre (PASTIC) is a subsidiary organization of Pakistan Science Foundation (PSF), under the umbrella of Ministry of Science and Technology (MoST). PASTIC is a specialized premier organization in the field of S&T information handling and dissemination responsible for catering to information needs of R&D and industrial community across the country. The PASTIC National Centre is housed at Quaid-e-Azam University Campus, Islamabad having a network of 6 Sub-Centres at Karachi, Lahore, Peshawar, Quetta, Faisalabad and Muzaffarabad.

To begin with PASTIC supported research community across the country when S&T research infrastructure in Pakistan was at a nascent stage and provided facilities including supply of scientific and technical documents, abstracts and indexes, bibliographies, translations, patent information and patent indexes, science reference library service, technological information transfer service, dissemination of computer-based information services, reprographic and publication services.
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- Capacity/skill development of researchers, information professionals, innovators & entrepreneurs
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- Database of Books published by Pakistani authors
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Organize STEM and IT Expo for promotion of local R&D, SMEs, technologies/products/services, as well as empowering youth and general public on new and faster ways of delivering and accessing information.

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A state-of-the-art Traditional Library facilitating the researcher through following services: Reference & Referral Services; Reader Service; Internet Service, Journal Listings; Photocopying & Scanning Services.

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Organize Seminars/Workshops /Trainings/ for capacity building of:

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- Women Entrepreneurs on E-marketing & E-business skills
- Library Professionals on Library automation & digitization
- Journal Publisher/Editors on E-Journal management & publishing
- Researchers and Innovators on Intellectual Property Rights, Media Information Literacy

CONFERENCE PROGRAM

Venue: Main Library, Shaheed BB University Sheringal, Dir (U), Khyber Pakhtunkhwa, Pakistan

Time	**Day I 15th September 2025 (Main Library)**
08:00 – 09:00	Registration
	Inauguration ceremony
09:00 – 09:05	Recitation of the Holy Quran
09:05 – 09:10	Conference Overview/Welcome Speech: Dr. Muhammad Asif Nawaz/Conference Chair
09:10 – 09:15	Conference Overview/Welcome Speech: Dr. Allah Ditta/Conference Co-Chair
09:15 – 09:25	Opening Remarks, Vice Chancellor: Prof. Dr. Muhammad Shahab, SBBU, Sheringal
09:25 – 09:35	Opening Remarks, Pro-Vice-Chancellor: Dr. Syed Abdul Khaliq Jan, SBBU, Sheringal
09:35 – 09:45	Address by Prof. Dr. M. Akram Shaikh (DG PASTIC)
09:45 – 10:15	Keynote Address 1: Prof. Dr. Sardar Khan
10:15 – 10:30	**Morning tea**
Day I: 15th September 2025	
	Venue: Main Library Hall
10:30 – 11:00	Keynote Address 2: Prof. Dr. Iqbal Munir
11:00 – 11:30	Keynote Address 3: Prof. Dr. Sabir Hussain
11:30 – 12:00	Keynote Address 4: Prof. Dr. Raham Sher Khan
12:00 – 12:30	Keynote Address 5: Prof. Dr. Bilal
12:30 – 13:00	Keynote Address 6: Prof. Dr. Ayaz Ahmad
	Venue: Hall I
10:30 – 11:00	Paper 1: Sadeeq Ullah UoP
11:00 – 11:30	Paper 2: Nisar Ahmad UoSwat
11:30 – 12:00	Paper 3: Dr. Karim Gul, AWKUM
12:00 – 12:30	Paper 4: Muhammad Jawad Darwish
12:30 – 13:00	Paper 5: Ms. Samreen Ali
13:00 – 14:00	**Lunch and Prayer Break**
	Main Library Hall
14:00 – 14:30	Keynote Address 7: Prof. Dr. Muhammad Arif
14:30 – 15:00	Keynote Address 8: Prof. Dr. Irum Gul
15:00 – 15:30	Keynote Address 9: Prof. Dr. Fazal Akbar

15:30 – 16:00	Keynote Address 10: Dr. Muhammad Imtiaz
16:00 – 16:30	Paper 12: Dr. Ihtesham ul Haq
16:30 – 17:00	Paper 13: Dr. Shandana Khan
	Hall I
14:00 – 14:30	Paper 6: Ibrahim Khan
14:30 – 15:00	Paper 7: Tila Muhammad
15:00 – 15:30	Paper 8: Arsalan Khan
15:30 – 16:00	Paper 9: Majeed Ullah
16:00 – 16:30	Paper 10: Muhammad Amjad Yusuf
16:30 – 17:00	Paper 11: Dr. Fazal Hadi, UoM
	Day II: 16th September 2025
Venue	**Main Library**
08:00 – 09:00	**Registration**
09:00 – 09:15	International Speaker: Prof. Dr. Qaisar Mahmood
09:15 – 09:30	International Speaker: Prof. Dr. Gianluca Viscusi
09:30 – 09:45	International Speaker: Prof. Dr. R. Usha
09:45 – 10:00	International Speaker: Prof. Dr. Heng Yin
	Hall I
09:00 – 09:15	Paper 14: Dr. Adnan Ahmad
09:15 – 09:30	Paper 15: Dr. Zul Kamal
09:30 – 09:45	Paper 16: Dr. Ayesha Aman Ullah
10:00 – 10:30	**Morning tea**
10:30 – 11:00	International Speaker: Prof. Dr. Sajid Mehmood
11:00 – 11:30	International Speaker: Prof. Dr. Yuan Yuan
11:30 – 12:00	International Speaker: Prof. Dr. Azamal Husen
12:00 – 12:30	International Speaker: Prof. Dr. A.V.L.K. Udalamaththa
12:30 – 13:00	International Speaker: Prof. Engr. Leila Mercado Borbon-Laya
10:30 – 13:00	Poster competition (Hall I)
13:00 – 14:00	**Award and Closing Ceremony**
14:00 – 15:00	**Farewell Lunch and prayer break**

NATIONAL INVITED SPEAKERS

Azeem Khalid
Department of Environmental Sciences, PMAS, Arid Agriculture University, Rawalpindi, Pakistan

Sardar Khan
Department of Environmental Science, University of Peshawar, Peshawar, Pakistan; Key Lab of Urban Environment and Health, Institute of Urban Environment, Chinese Academy of Sciences, Xiamen 361021, China

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Institute of Biotechnology and Genetic Engineering, the University of Agriculture Peshawar-Pakistan

Ayaz Ahmad
Department of Biotechnology, Abdul Wali Khan University Mardan, Khyber Pakhtunkhwa, Pakistan

Sabir Hussain
Department of Environmental Sciences, Government College University Faisalabad, Pakistan

Iftikhar Ahmad
Department of Environmental Sciences, COMSATS University Islamabad, Vehari Campus, Vehari-61100, Pakistan

Muhammad Imtiaz
Soil & Environmental Biotechnology Division, NIBGE, Faisalabad, Pakistan

Muhammad Bilal
Department of Environmental Sciences, COMSATS University Islamabad, Abbottabad Campus, Abbottabad, KPK, Pakistan

Raham Sher Khan
Department of Biotechnology, Abdul Wali Khan University Mardan, Pakistan

INTERNATIONAL INVITED SPEAKERS

Gianluca Viscusi, Giuliana Gorrasi
Department of Industrial Engineering, University of Salerno, Italy

JV Asmone, RAAS Fernando, MDS De Silva, AVLK Udalamaththa
Spectrum Institute of Science and Technology, Colombo, Sri Lanka

Qaisar Mahmood (TI)
Department of Biology, College of Science, University of Bahrain, Sakhir, Bahrain

Ibrahim Khan, Sajjad Asaf, In-Jung Lee
College of Agriculture and Applied Biosciences, Kyungpook National University, South Korea

Engr. Leila Mercado Borbon-Laya
Senior Manager, Prime Integrated Waste Solutions Inc.
Former Vice President for Technology, Watermatic Philippines Corporation

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Moaz Hosen Pramanik
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Ayman El Sabagh
Department of Field Crops, Faculty oof Agriculture, Siirt Universty, Turkey

Jannati Akter, Rimon Hossain, Durjay Mondal, Rubel Mia, Bushra Islam, Mst. Jannatun Nayem, Md. Mominur Rahman, Jannati Akter, Debasrita Das, Md. Shakibul Islam, Mohamad Sohidul Islam
Department of Agronomy, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh

ABSTRACTS

Sustainable and efficient approaches for water security: design, functionalization and applications

Gianluca Viscusi and Giuliana Gorrasi

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The increase in population growth, industrialization and climate change will lead to an increase in scarcity of water in the next few decades. The pressing issue of water scarcity, exacerbated by the growing population, necessitates immediate action [1]. The key to addressing these concerns is treating polluted water by removing contaminants. Various physical, chemical, and biological techniques and integrated systems are widely utilized in wastewater treatment for safe disposal or reuse [2, 3]. The traditional wastewater treatment methods have some efficiencies and show several drawbacks such as energy consumption, toxic by-products, and large areas for the treatments. These drawbacks prompt the researchers to look for more efficient technologies for contaminants removal from wastewater [4]. Adsorption is one of the most efficient physicochemical methods since it is cost-effective, flexible, and versatile [5]. Since the synthesis and regeneration of synthetic adsorbent is still cost-prohibitive, this work focuses on the design, modification and testing of sustainable, low-cost cost and green solutions as a win-win strategy to improve waste management and achieve environmental protection aiming to remove several classes of contaminants (drugs, oil, dyes) through the application of efficient and sustainable solutions.

Bioengineered Solutions for Microplastic Degradation Across Terrestrial and Aquatic Ecosystems

R Usha[1*], Shamina. S[1] and Parimala. Gnana Soundari A[2]

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Microplastic pollution has emerged as a critical environmental threat, affecting terrestrial and aquatic ecosystems, food security, and human health. Traditional remediation methods, including physical separation and chemical degradation, remain inadequate due to high costs, incomplete removal, and potential secondary pollution. Bioremediation, an eco-friendly and sustainable alternative, offers significant promise in mitigating microplastic contamination. This review explores potential strategies for the bioremediation of microplastic polluted soils and aquatic environments. Microbial degradation using bacteria, Pseudomonas, Bacillus, Rhodococcus and fungi Aspergillus, Fusarium and Penicillium capable of secreting plastic degrading enzymes such as laccases, cutinases, and PET hydrolases is highlighted. The role of algae and plant microbe interactions in enhancing plastic breakdown and reducing toxicity is also reviewed. Innovative approaches such as biofilm mediated degradation, genetically engineered microbes with enhanced enzymatic activity, and consortia-based bioremediation

systems explored. In aquatic systems, floating bioreactors and enzyme immobilization technologies show potential for large-scale application, while in soils, biochar-amended microbial inoculants can enhance plastic adsorption and degradation. Integrating bioremediation with circular bioeconomy practices, such as converting degraded polymers into value-added bioproducts, further strengthens its societal relevance. Bacterial enzymes and nanomaterial-enabled strategies, with nano-enabled technologies demonstrating substantial potential to enhance microplastic removal efficiency. The integration of microbial enzymatic, and bio-based approaches underscores bioremediation role as a sustainable frontier in combating the pervasive challenge of microplastic pollution. Overall, bioremediation provides a sustainable, low cost, and scalable strategy to address the global challenge of microplastic pollution and holds promise for restoring ecosystem health and resilience. Through this review, it is hoped to obtain comprehensive insights into the future potential of sustainable bioremediation technology in addressing the issue of microplastic contamination in both terrestrial and aquatic environments.

Keywords: Microplastic, Bioremediation, Soil, Aquatic system, Microbial degradation, Sustainable remediation, Bioreactor, Biochar and enzymes immobilization.

Carbohydrate-Binding Modules Enhance H_2O_2 Tolerance by Promoting Lytic Polysaccharide Monooxygenase Active Site H_2O_2 Consumption

Wa Gao[1] Tang Li[1], Haichuan Zhou[1], Jiu Ju[1], Heng Yin[1,2]

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Lytic polysaccharide monooxygenases (LPMOs) oxidatively depolymerize recalcitrant polysaccharides, which is important for biomass conversion. The catalytic domains of many LPMOs are linked to carbohydrate-binding modules (CBMs) through flexible linkers, but the function of these CBMs in LPMO catalysis is not well understood. In this study, we utilized MtLPMO9L and MtLPMO9G derived from Myceliophthora thermophila to investigate the impact of CBMs on LPMO activity, with particular emphasis on their influence on H2O2 tolerance. Using truncated forms of MtLPMO9G generated by removing the CBM, we found reduced substrate binding affinity and enzymatic activity. Conversely, when the CBM was fused to the C terminus of the single-domain MtLPMO9L to create MtLPMO9L-CBM, we observed a substantial improvement in substrate binding affinity, enzymatic activity, and notably, H2O2 tolerance. Furthermore, molecular dynamics simulations confirmed that the CBM fusion enhances the proximity of the active site to the substrate, thereby promoting multilocal cleavage and impacting the exposure of the copper active site to H2O2. Importantly, the fusion of CBM resulted in more efficient

consumption of H2O2 by LPMO, leading to improved enzymatic activity and reduced auto-oxidative damage of the copper active center.

Pharmacological and Anticancer Potential of Black Ginger (*Kaempferia parviflora*)

Indah Hairunisa, Mohd Fadzelly Abu Bakar, and Muhammad Da

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Kaempferia parviflora (KP), also known as Black ginger or Kra-chi-dum in Thailand, is a Zingiberaceae plant native to Thailand and Malaysia. This plant is commonly used by the community as a spice in cooking and healthy drinks for disease prevention and treatment. According to researches, KP extracts have broad bioactivities against infectious diseases caused by viruses and bacteria, as well as diseases related to metabolic disorders such as obesity, diabetes, aging, and gastrointestinal disorders. KP is also effective as an anticancer agent. This review article focuses on KP's anticancer activity and possible mechanisms of action. Furthermore, the botanical aspect and content of active compounds are investigated in this article. Considering KP's high potential as a medicinal plant, the potential interactions of KP with synthetic drugs and its potential formulation are investigated. According to the findings of this review, KP has anticancer and antimetastatic activity, and the active ingredient responsible for this activity is methoxyflavone.

Biochar-amended nutrient film technique flow system effectively alleviated chromium stress in guar (*Cyamopsis tetragonoloba*) plants

Sajid Mehmood

[1]Center for Eco-Environment Restoration of Hainan Province, School of Ecology, Hainan University, Haikou 570228, China; [2]School of Topical Agriculture and Foresty, Hainan University, Haikou 570228, China

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Heavy metal contamination, such as chromium (Cr), poses global threats to soil, water, and human health. Biochar is an effective adsorbent for mitigating heavy metal toxicity, remediating polluted environments, and promoting plant growth under stress. This study evaluated the effects of *Allium sativum* peel biochar, produced via concentrated sulfuric acid carbonization (CSGPB) and high-temperature carbonization (HTGPB), on *Cyamopsis tetragonoloba* under Cr-stress in a Nutrient Film Technique (NFT) hydroponic system. The results showed that combining two biochar treatments showed better results in mitigating the growth of guar plants under Cr-stress. Increasing the pH and EC values of water reduced the mobility and plant availability of the heavy metal chromium, resulting in an 87.78 % reduction of Cr in guar, along with enhanced antioxidant enzyme activities, alleviation of oxidative stress, improved nutrient absorption, primary metabolite synthesis, and soluble sugar and protein levels,

and significant growth promotion with a 123.8 % increase in biomass. This study underscores the potential of biochar (CSGPB-HTGPB) as a high-performance adsorbent for remediating Cr-contaminated water in flow-through systems, offering a theoretical basis for addressing heavy metal pollution.

Selenium-Containing Nano-Micelles Delay the Cellular Senescence of BMSCs Under Oxidative Environment and Maintain Their Regenerative Capacity

Yuan Yuan

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The cellular senescence and functional decline of stem cells are primary contributors to the reduced regenerative capacity and weakened disease resistance in aged tissues. Among the various factors involved, oxidative stress resulting from the accumulation of reactive oxygen species (ROS) is a key driver of stem cell senescence. In an oxidative environment, cells continuously generate ROS, which accelerates cellular senescence and leads to functional deterioration. To intervene in the cellular senescence process of stem cells under such conditions, we selected bone marrow mesenchymal stem cells (BMSCs) as the model system and developed ROS-responsive selenium (Se)-containing nano-micelles capable of efficiently scavenging intracellular ROS. The optimal formulation was determined by modulating the selenium content. Analysis of cellular senescence markers and regenerative capacity reveals that nano-micelles containing 8% Se (Wt %), at a concentration of 15 μg/mL, can significantly modulate ROS levels in BMSCs under oxidative stress, thereby effectively delaying cellular senescence and preserving the osteogenic differentiation potential of BMSCs. These findings offer a promising strategy for mitigating stem cell senescence.

Keywords: selenium-containing nano-micelles; reactive oxygen species; bone marrow mesenchymal stem cells; cellular senescence

Nano Driven Strategies in Green Biotechnology for Sustainable Climate Solutions

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The accelerating impacts of climate change, including rising temperatures, unpredictable rainfall, soil degradation, and increased incidence of pests and

diseases, demand innovative solutions for sustainable agriculture and ecosystem resilience. Green biotechnology, integrating environmentally friendly practices with advanced nanotechnology, offers a transformative pathway to address these multifaceted challenges. This review explores recent advancements in nano-enabled strategies that enhance plant productivity, improve stress tolerance, and promote environmental sustainability. Nanomaterials, owing to their unique physicochemical properties, enable precise delivery of nutrients, agrochemicals, and genetic materials, thereby improving resource efficiency and minimizing ecological risks. Nano-fertilizers and nano-pesticides have demonstrated superior performance over conventional inputs, ensuring controlled release, reduced losses, and lower environmental contamination. Similarly, nanotechnology-assisted plant breeding and genetic modification facilitate the development of climate-resilient crops capable of withstanding drought, salinity, and extreme weather conditions. Additionally, nanomaterials play a significant role in soil and water remediation, restoring contaminated agricultural lands and safeguarding water resources for long-term food security. The integration of nanosensors with green biotechnology provides real-time monitoring of plant health, soil fertility, and environmental conditions, enabling data-driven precision farming practices. This review emphasizes the potential of nano-enabled green biotechnology to balance productivity with ecological preservation while addressing pressing climate-related constraints. It also discusses safety concerns, regulatory frameworks, and future prospects for large-scale application, paving the way toward a resilient and sustainable agricultural future.

Keywords: Nano-enabled biotechnology; Climate resilience; Sustainable agriculture; Nano-fertilizers and nano-pesticides; Environmental remediation; Precision farming technologies

Synergistic Role of Green Nanotechnology in Strengthening Phytoremediation Efficiency for Heavy Metal Stress-Review

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Heavy metal (HM) contamination of soil persists as a global threat to food safety and environmental health. Nano-phytoremediation, the integration of nanotechnology with phytoremediation, has emerged as a cutting-edge approach for the remediation of contaminated soils, water, and sediments. Conventional phytoremediation often faces limitations such as low efficiency, slow metal uptake, and poor tolerance of plants to high pollutant loads. Recent studies of this nano-phytoremediation highlight successful applications in detoxifying heavy metals like Cd, Pb, Cr, As, organic pollutants, and emerging contaminants such as pharmaceuticals and dyes. Green-synthesized nanomaterials produced via plant and microbes will offer a low-toxicity, low-energy alternative to conventional nanoparticles for enhancing phytoremediation. Recent studies

demonstrate that plant and microbe mediated metallic and metal-oxide nanoparticles (such as nZVI, ZnO, and Ag), along with nano-biochar and zeolite nanocomposites, can immobilize heavy metals through adsorption, complexation and surface precipitation, facilitate valence state reduction, enhance plant tolerance and uptake by regulating ROS homeostasis, root exudation, and nutrient transporter activity. Controlled "simulated" soil systems enable rigorous evaluation of dosage, aging, and soil chemistry effects on nanoparticle transformation and HM speciation, while quantifying plant responses. This review highlights the role of green biotechnology in achieving synergistic role of green nanotechnology in strengthening phytoremediation efficiency for heavy metal stress. Overall, the review provides a comprehensive analysis of current progress, challenges, and future directions for leveraging green biotechnology as a transformative pathway toward heavy metal stress tolerance.

Exogenous mannitol enhanced growth, physiology, yield and biochemical attributes of wheat (*Triticum aestivum* L.) by alleviating NaCl-Induced salt stress

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Soil salinity is a critical threat to global agriculture, with rising climate variability accelerating salinization and reducing cultivable land, thus endangering food security. This study investigates the efficacy of exogenous mannitol (MN) application in mitigating the negative consequences of NaCl-induced salinity in wheat (*Triticum aestivum* L.). Three concentrations of mannitol (0, 50, and 100 ppm) were evaluated under three salinity levels (0, 50, and 100 mM NaCl) using a completely randomized design (CRD) at HSTU, Bangladesh. Results showed that 100 ppm mannitol (MN_2) significantly enhanced growth parameters including plant height, leaf number, root length, leaf area, and biomass accumulation (fresh and dry weight of leaves, culm, and roots) under salt stress. Physiological improvements were observed through elevated levels of chlorophyll a, chlorophyll b, total chlorophyll, carotenoids, and improved water status (RWC, WSD, WRC, and WUC). Yield attributes such as 1000-grain weight (36.65 g), grain yield (2.86 g plant^{-1}), stover yield, biological yield, and harvest index (40.36%) were notably improved. Mannitol also mitigated oxidative and ionic stress by enhancing nutrient uptake (K^+, Ca^{2+}, N^+), reducing Na^+ accumulation, and increasing protein content and membrane stability. The ameliorative effects of mannitol were concentration-dependent, with 100 ppm proving most effective across parameters. In contrast, salinity

without mannitol significantly suppressed growth, yield, and quality traits. These findings suggest that mannitol application, particularly at 100 ppm, can enhance wheat salt tolerance, providing a viable, affordable method for enhancing crop production in soils impacted by salt.

Keywords: Wheat, Salinity stress, Mannitol, Growth, Yield, Nutrient uptake, Osmotic adjustment.

Plant Growth-Promoting Endophytic Bacteria (PGPEB) enhanced growth, physiology, yield and biochemical attributes of wheat (*Triticum aestivum* L.) by alleviating NaCl-induced salt stress

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A pot experiment was carried out at the Agronomy shade house, Department of Agronomy, Hajee Mohammad Danesh Science and Technology University, Dinajpur -5200 from December 2023 through June 2024 to determine the role and application of PGPR in combating the salt stress of wheat (BWMRI Gom 1). The experiment comprised five treatments viz. i) S_0B_0 (0 mM NaCl + 0 PGPR) ii), $S_{150}B_0$ (150 mM NaCl + 0 PGPR), iii) $S_{150}B_1$ (150 mM NaCl + PGPR-_*Serratia sp*. Strain HSTU-BF_1R_2), iv) $S_{150}B_2$ (150 mM NaCl + PGPR-*Serratia sp*. Strain HSTU-BF_3R_4), v) $S_{150}B_1$+B_2 (150 mM NaCl + *Serratia sp*. Strain HSTU-BF_1R_2+ *Serratia sp*. Strain HSTU-BF_3R_4). The experiment was laid out in Completely Randomized Design (CRD) with three replications. Salinity stress markedly reduced wheat growth, physiological traits, yield components, and nutrient status, whereas PGPEB application effectively alleviated these adverse effects. The combined inoculation (S150B1+B2) consistently produced the highest values across morphological parameters, including plant height (51.73 and 55.59 cm at 60 DAS and FH), number of leaves (6.00 and 8.67), flag leaf area (1026.0 mm²), flag leaf length (140.07 mm), width (8.75 mm), ratio (15.17), fresh and dry leaf weights (1.88 g and 0.48 g), fresh and dry culm weights (2.05 g and 0.38 g), root length (7.48 cm), root fresh weight (0.28 g), and root dry weight (0.18 g). Photosynthetic pigments (Chl a, Chl b, total Chl, carotenoid) and water status (RWC, WRC, CMS) were also highest under S150B1+B2, while canopy temperature was lowest. Yield attributes improved significantly, with maximum spike length (13.11 cm), spike weight (0.50 g), grains spike^{-1} (13.00), 1000-grain weight (3.18 g), grain yield (0.35 g plant^{-1}), biological yield (0.61 g plant^{-1}), and harvest index (51.01%). Nutrient analysis revealed the highest K (30.62 mg g^{-1} DW), Ca (0.80 mg g^{-1} DW), and protein (11.90 mg g^{-1} DW) in the dual-inoculated plants. Antioxidant

enzyme activity was also significantly affected by treatments. Under control conditions, CAT (0.49), POD (0.21), and APX (0.09 U mg^{-1} protein) were lowest, while salinity stress alone (S150B0) caused the highest CAT (1.05), POD (0.65), and APX (0.17), indicating oxidative stress. Inoculation with PGPEB under salinity reduced enzyme activities, with the lowest CAT (0.52), POD (0.11), and APX (0.11) recorded in S150B1+B2, followed by single-strain treatments. These findings demonstrate that PGPEB, particularly the dual inoculation (S150B1+B2), not only enhanced growth, physiological traits, yield performance, and nutrient accumulation but also mitigated oxidative stress by regulating ROS levels, thereby improving the overall resilience of wheat under salinity stress.

Keywords: Salt stress, Plant growth-promoting endophytic bacteria (PGPEB), *Serratia* sp. (HSTU-BF_1R_2 and HSTU-BF_3R_4), Growth, Physiological traits, Nutrient status, Antioxidants enzymes, yield, wheat (cv BWMRI Gom 1).

Endophytic fungi derived from seaweeds for sustainable production of pharmaceuticals

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Endophytes are micro-symbionts living within other higher organisms contributing to beneficial properties for survival. These endophytes could either be fungi or bacteria. Seaweeds, on the other hand, have reported to be carrying a plethora of bioactive compounds, which have produced medicinal drugs. Marine microbiome had not been explored well enough in comparison to terrestrial microbiome. Hypothesizing, the endophytes of seaweeds would have the potential to possess novel compounds with pharmaceutical properties, several research have been carried out globally. This research has reported antibacterial, antifungal, antiviral, antitumor and antioxidant activities. Citrinal, Nigerasperones, Chrysin, and Asperversin, along with many more novel secondary metabolite structures have been reported to exert these beneficial properties. As Sri Lanka is an Island nation, and a biodiversity hotspot, the aim of the ongoing project is to isolate fungal endophytes from marine seaweeds from three different coastal locations, and investigate their anti-bacterial effects against four pathogenic bacterial species. Of the collected 5 seaweeds from the different coastal areas (Galle, Colombo and Negombo) 12 species have been isolated. Currently, ethyl acetate extraction of secondary metabolites of the 12 isolates is being carried out. The positive results in terms of anti-bacterial effects of the secondary metabolites of fungal endophytes and chemical characterization of the extracted metabolites, may pave the pathway to sustainable production of novel antibiotics using available natural resources.

Use of AI for Environmental Conservation

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Artificial Intelligence (AI) has emerged as a transformative tool for addressing complex environmental challenges by enabling data-driven insights, predictive modeling, and optimized decision-making. With its ability to process large-scale environmental datasets from satellites, sensors, and monitoring systems, AI facilitates accurate climate forecasting, air and water quality assessment, and early warning systems for natural disasters. Machine learning algorithms are increasingly being applied to optimize energy consumption, enhance renewable energy integration, and improve waste management and recycling processes. Moreover, AI-driven solutions contribute to biodiversity monitoring, precision agriculture, and pollution control, thereby supporting sustainable development goals. Despite its potential, challenges remain, including data privacy, high energy demands of AI systems, and limited adoption in developing regions. Nonetheless, the integration of AI into environmental management frameworks offers a promising pathway toward mitigating climate change, promoting resource efficiency, and advancing global sustainability.

Genome-Wide Characterization, Expression Analysis, and Molecular Docking of Tomato Calmodulin (SlCaM) Proteins in Response to Cadmium (Cd) Stress

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Calcium ions (Ca^{2+}) are essential for plant development and adaptation to environmental challenges, particularly heavy metal (HM) stress. This study aimed to explore the calcium-mediated stress response in Solanum lycopersicum by identifying and characterizing the calmodulin gene family (SlCalMs), a key sub-family of calcium-binding proteins (CBPs), to understand their roles in cadmium (Cd) stress tolerance. A genome-wide identification of SlCalMs was conducted using Oryza sativa sequences as a reference. Bioinformatics analyses included BLASTP searches, sequence alignment, phylogenetics, assessment of physicochemical properties, gene structure and motif analysis, chromosomal mapping, and duplication events. Gene expression was assessed under Cd stress using RNA-seq and validated by qRT-PCR. Molecular docking simulations evaluated Cd-binding affinities, and protein–protein interaction networks and gene ontology (GO) enrichment were used to explore biological functions. Eight distinct SlCalM groups were identified, varying in gene size, exon number, and isoelectric point. Conserved motifs, exon-intron patterns, and stress-responsive cis-elements were identified. Chromosomal analysis revealed segmental duplications. Under Cd stress, several SlCalMs showed differential expression; notably, Solyc04g077830 was significantly downregulated and showed strong

Cd-binding affinity in silico, suggesting a role in Cd sequestration. GO and interaction network analyses confirmed their involvement in Ca^{2+} signaling, metal ion binding, and stress-related pathways. This study provides comprehensive insight into the structure, evolution, and functional roles of SlCalMs in tomato. Their involvement in Ca^{2+} signaling and Cd stress response highlights their potential for improving heavy metal tolerance, offering valuable targets for future genetic or biotechnological interventions in crop improvement.

Keywords: Tomato, Cd stress, SlCalMs, Genome-wide analysis, Differential gene expression

Entering the New Age of Waste Management – How the Philippines is starting its journey towards sustainability infrastructures

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The Philippines, with a total current population of 116 million people generates an approximately 46,400 metric tons of municipal waste daily. The waste in general is collected with a portion recovered through small-scale (barangay or municipal level) Materials Recovery Facilities, and then dumped in Sanitary Landfills. While there are Philippine laws in effect, the implementation is not perfect and a large portion of the waste ends up in open dumpsite which pollutes the water body. The high value materials in the Municipal Solid Waste include recyclables (PET and glass bottles), papers, ferrous materials, and mixed plastic waste. In the most urban areas in the Philippines which includes the Metro cities, recyclables and mixed plastic waste can vary from 50-60% of the total weight of the received waste. This large percentage if not recovered will end up in Sanitary landfills or open dumpsite – a lost opportunity for the economy and for sustainability. Since early 2000, the cement plants in the Philippines have started using alternative fuels in the form of Refuse Derived Fuels (RDFs) to replace coal. However, because the segregation and recovery of the waste using the small-scale MRFs has not covered more than 40% of the produced, getting stable quantity of feed is a challenge towards using RDFs. In 2024, the build and operation of private large scale Materials Recovery Facilities (MRFs) with a capacity of 1000-3000 tons per day has started in the Visayas and North Luzon. This is a big step toward securing the feed to produce RDFs. These facilities aim to recover mixed plastics and then process it through pre-shredding, sieving, air separation, drying, and fine screening – to have a final output in size, moisture content, and calorific value required for RDFs of cement plants. The combined capacity of the existing large private MRFS and small-scale MRFs is less than 50% of the generated waste, which still gives a lot of opportunities for other private companies to enter the waste sector. Using RDFs as an alternative to coal can decrease greenhouse gases, reduce water body pollution, and reduce the land needed for landfill. It also reverses the chain - using fossil fuel to make plastic by turning the plastic into fuel again. It is still a long, difficult process for

a developing country like the Philippines to mature in waste management and waste-to-fuel process but the wheels are already in motion. Leila Mercado Borbon-Laya is a Registered Chemical Engineer by profession and has more than 18 years of experience in the industry – particularly in the engineering design, testing & commissioning, and project management of Water and Wastewater Treatment facilities. She has devised several water and wastewater treatment systems, including the treatment of Palladium wastewater which received an Excellence award at the 2010 Ibiden TPM convention in Ogaki, Japan. Leila has received President's Award from Manila Water in 2015, 2017, and 2018. She has worked on different projects across Asia and the Middle East.

Green Biotechnology for Climate Resilience: Engineering Low-Viscosity Oils in Brassica juncea for Sustainable Biofuels

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Climate change remains the most pressing global challenge of the 21st century, with transport and fossil-fuel-driven machinery contributing nearly 25% of total energy related greenhouse gas emissions worldwide. Rising temperatures, unpredictable weather extremes, and resource depletion underscore the urgent need for sustainable and renewable energy alternatives. Among the many approaches, green biotechnology provides powerful tools to engineer crops for biofuel production, thereby reducing reliance on fossil fuels and mitigating environmental impacts. *Brassica juncea* oil represents a promising biofuel feedstock; however, its practical use is constrained by high viscosity, low volatility, and poor performance under cold conditions. To address these limitations, our research focused on metabolic engineering of *B. juncea* by introducing the *Euonymus alatus* diacylglycerol acetyltransferase (*EaDacT)* gene, responsible for synthesizing low-viscosity acetyl triacylglycerols (acTAGs). Through an optimized Agrobacterium-mediated transformation approach, transgenic plants were developed, and subsequent strategies involving DGAT/PDAT gene silencing combined with *EaDacT* overexpression successfully yielded seed oils enriched with acTAGs and reduced viscosity. This work exemplifies how recent advances in green biotechnology can contribute to climate resilience by developing renewable, plant-based energy solutions, reducing greenhouse gas emissions, and providing sustainable alternatives to fossil fuels for transport and machinery.

Antibiotics Residues and Resistance Genes in Agroecosystem: Sustainable Approaches for Mitigation and Management

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The widespread use of ABs in livestock farming has led to the accumulation of ABs residues and ARGs in agricultural soil, which poses severe threats to environment and public health. TCs, SAs, MCs, FQs and β-L are widely used in veterinary medicine and are excreted in feces, serving as major vectors for ARGs such as tetA, tetG, ermB, sul1, qnrS and blaTEM. The genes tetG and tetAP predominantly contribute to TCs resistance by encoding efflux pump mechanisms. In contrast, sul1 and sul2 showed strong correlations with soil salinity which promote the persistence of ARGs in environment. Manure application can increase ARGs abundance over a period of decades, with ermB reaching 7.29×10^9 copies/g in manure and qnrS persisting in soil fertilized for 30 years. These ARGs can further disseminated through HGT and amplified by integrase genes. Innovative material such as BCs NPs, MOFs and COFs have proven their ability to mitigate these risks. BCs adsorbs 39% of OTC uptake in lettuce and suppress ARGs by altering microbial communities. NPs such as Ag, ZnO and Fe based NPs degrade ABs through photocatalysis (94.9%) and disrupt bacterial membranes (inhibiting HGT). MOFs such as MIL-100(F) achieved 96.6% degradation of levofloxacin while COFs (TpBD-$(CF_3)_2$ showed exceptional adsorption efficiency (3387%, recovery rate) for sulphapyridine and capacities ranged from 68.8-196.7 mg g^{-1} for FQs. Despite these advances, challenges remain including material stability, environmental impacts, and scalability. Future efforts should focus on optimizing feedstocks for BCs, eco-friendly NPs synthesis and MOFs/COFs composites with enhanced light absorption properties. Integrating these materials with sustainable practices and enforcing manure management regulations are critical to reduce the ARGs proliferation. Addressing this crisis requires interdisciplinary cooperation to safeguard agroecosystems.

Synthesis and characterization of bio-based UV curable polyurethane coatings from algal biomass residue

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Polyurethanes (PUs) are commonly used chemicals in various industries and are conventionally produced by the reaction of polyols and diisocyanates. However, synthetic petroleum-based polymers are non-biodegradable and resulting in issues like waste disposal, risks to aquatic and terrestrial ecosystems. In this study, a novel microalgal protein-based ultraviolet (UV) curing polyurethane acrylate (PUA) was prepared with hexanediol diacrylate (20% HDDA) precursor, amino acid oligomers, and photoinitiator (Irgacure 184).

Experimental conditions for the synthesis of precursors were studied and their chemical structures were confirmed by FT-IR, ^{1}HNMR, ^{13}CNMR, and differential scanning calorimetry (DSC). The absorption peak at 1695 cm^{-1} confirmed the formation of a urethane bond. For instance, the obtained polyurethane acrylate coating (PUA) possessed a glass transition temperature (T_g) of 122 ℃, tensile strength, modulus of 19.1 MPa, 465 MPa, and lower elongation break (6%). While using reactive diluents, the coating compositions showed significant enhancement of mechanical, physical, and chemical resistance properties. In general, this work offered a simple bio-scheme of reactions to prepare a sustainable microalgal-based PU coating that could be applied in the coating industry with improved properties.

Isolation, biochemical characterization, and antimicrobial activities of EPS-producing bacterial endophytes from Moringa oleifera

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Bacterial endophytes are a key part of the plant microbiome that influence developmental processes via different mechanisms. One of the known mechanisms is the production of exopolysaccharides (EPS) that are responsible for the response towards stresses and plant-bacterial interactions. In the current experiment, we isolated 42 strains of bacterial endophytes from the sterilized parts of Moringa oleifera plant and screened them to produce EPS. Out of the 42, only three isolates; KR-27, KL-4, and KS-7 produced a significant number of EPS. All these isolates showed in vitro antagonistic activities against phytopathogenic fungi and bacteria. These antagonistic endophytic isolates, KR-27, KL-4, and KS-7 were identified as *Serratia marcescens*, *Klebsiella aerogenes*, and *Lelliottia amnigena*, respectively based on 16 s RNA gene ribotyping. The selected bacterial strains were screened out for phytohormones and secondary metabolites production and all the identified strains produced significant amount of various phytohormones such as indole acetic acid (IAA), gibberellic acid (GA3), and salicylic acid (SA). In addition, the identified strains produced antioxidant compounds like siderophores, phenolics, and flavonoids. The phosphate solubilization ability of all the strains was ascertained and found highest for KR-27 (30.46±0.82 µg/mL), followed by KS-7 (18.30±0.54 µg/mL) and KL-4 (17.36±0.68 µg/mL). Unlike previous research, which primarily focused on the nutritional and medicinal properties of M. oleifera, this research uncovers the new aspect by exploring the biotechnologically important bacterial flora of this miracle tree. In conclusion we isolated three novel bacterial endophytic strains with the ability to produce bioactive compounds for plant and antimicrobial activity against phytopathogens for the first time which can replace the synthetic fertilizers and pesticides in future sustainable agriculture practices.

Keywords; *Moringa oleifera;* Endophytic bacteria; Exopolysaccharides; Bioactive compounds; Antimicrobial activity

Prebiotic potential of oligosaccharides from cress seed mucilage

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Probiotics, beneficial microorganisms known for their positive impact on human health, require specific nutrients to thrive and exert their health-promoting effects. Oligosaccharides, a class of dietary carbohydrates, have gained attention as potential prebiotics, selectively nourishing beneficial gut microbiota. The current study aimed to isolate ethanol-precipitated oligosaccharides from cress seed mucilage and evaluate their in vitro prebiotic effects on human probiotics. Mucilage was extracted by immersing cress seeds in autoclaved distilled water overnight, and polysaccharides were precipitated in 75% ethanol. The ethanol-precipitated polysaccharides were digested to produce bioactive oligosaccharides using *Pichia pastoris* fermentation. The fermented product was fractionated using size-exclusion chromatography. Ethanol-precipitated polysaccharides (EPP) substantially supported the growth of *P. pastoris*, with the cell count rising from 4.98 ± 0.13 log CFU/mL at 0 hours to 8.76 ± 0.17 log CFU/mL after 6 hours, followed by a decline over 72 hours. The biochemical contents of fractions were analyzed. Results revealed that DF73 contained the highest carbohydrate content (3.14246 mg/mL). EPP contained the highest unsaturated uronic acid (5.54436 ± 0.35138 µg/g) and hexose (6.54849 ± 0.30852 µg/g) contents. DF58 exhibited the highest uronic acid concentration (7.98201 ± 0.73763 µg/g), while DF72 had the highest pentose content (4.54738 ± 0.11939 µg/g). The prebiotic effect of the selected carbohydrate-rich fractions was determined on probiotics, including *Bacillus clausi* and *Bifidobacterium bifidum*. DF73 displayed the strongest acidifying effect with a pH drop to 4.74333 ± 0.27538 after 24 hours. DF48 showed a potent acidifying effect on *B. clausii* with a pH of 4.34 ± 0.04 at 24 hours. In terms of bacterial proliferation, DF73 supported significant growth of *B. bifidum* from (2.88649 ± 0.13948) to (9.96 ± 0.26) log10 CFU/mL at 48 hours) and *B. clausii* from (2.8595 ± 0.13948) to (9.75598 ± 0.4967) log10 CFU/mL at 48 hours). DF72 and DF73 demonstrated the highest prebiotic scores and indices, with DF73 exhibiting a prebiotic score of (5.66789 ± 0.12713) for *B. bifidum* and (5.47309 ± 0.237) for *B. clausii*. These findings revealed the potential of cress seed-derived polysaccharides, particularly fractions DF72 and DF73, as effective prebiotics for the growth of beneficial gut microbiota and highlighted the importance of improving functional foods to promote gut health.

Nanotechnology in Agriculture: Synthesis, Characterization and Dissecting the Role of Cu and Mn Nano Sulfides in Plant Performance

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Copper (Cu), manganese (Mn), and sulfur (S) are important nutrients for plant health and cannot be absorbed by the plants effectively from the corresponding salts. Copper sulfide (CuS) and manganese sulfide (MnS) nanoparticles (NPs) are more effective and economical than Cu and Mn slats due to their nano-sizes. This review article critically summarizes the methods of CuS and MnS NPs synthesis, characterization, and their effect on plant growth, stress resilience, plant health, and their possible uptake mechanism and translocation. It has been proved that CuS and MnS NPs trigger antioxidant activities in plants and antimicrobial activities against pathogenic fungi and bacteria. Although CuS and MnS NPs are encouraging elicitors in agricultural applications, they have their effect at molecular and cellular level, soil microbiota, fate in the soil, and safety assessments need further investigation.

Microbial Biotechnology for Wastewater Treatment: Current Scenario and Future Perspective

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Wastewater management has been considered as a major environmental issue due to rapid industrialization, increasing population, and limitations of traditional treatment approaches. To address the issue, microbial biotechnology has emerged as an environmentally safe and sustainable solution for wastewater treatment. It employs the usage of a variety of microorganisms to facilitate the degradation of pollutants and reduce the energy demands in comparison to traditionally used methods. Meanwhile, advancements in microbial biotechnology like usage of consortia, its integration with nanotechnology in form of nanomaterial-assisted biodegradation, and enzyme-immobilized nanoparticles, and use of other molecular tools, further enhanced the adaptability and efficacy of these processes. The unique properties of nanomaterials, like a large surface area to volume ratio, extraordinary catalytic and adsorption potential, make them the best candidate for the degradation of organic and inorganic pollutants, and removal of heavy metals. Microbe-mediated biosynthesis of nanoparticles offers an eco-friendly and cost-effective alternative, contributing to the sustainability of these technologies for wastewater remediation. However, the toxicity of nanoparticles, their environmental hazards, legislative barriers, and limited scalability still exist. So, the future directions should be focused on the synthesis of biodegradable nanomaterials, the improvement of green synthesis technologies, and the integration of artificial intelligence to monitor and optimize the processes in real time. Overcoming these challenges is essential for the large-scale deployment of bio-nanotechnology, paving the way for next-generation wastewater treatment systems that are both efficient and environmentally responsible.

Climate-resilient hybrid wheat: A sustainable pathway for food security in Pakistan

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Wheat is a critical staple crop in Pakistan, occupying 37% of the total cropping area. However, a significant yield gap persists compared to global averages, primarily due to water scarcity and a lack of high-yielding, resilient varieties. From 2016 to 2019, a collaborative study with the Beijing Engineering Research Centre for Hybrid Wheat (BERCHW) was conducted. A series of field trials were established in Pakistan to evaluate advanced Chinese two-line hybrid wheat lines. The trials included row tests (evaluating up to 417 hybrids), plot tests (up to 30 hybrids), small-area demonstrations, and variety trials. The hybrids were assessed for key agronomic traits including grain yield, biological yield, phenology, plant height, and grains per spike under local management practices, including limited irrigation. The hybrid wheat lines demonstrated significant potential for superior performance. Results consistently showed higher grain yields compared to local check varieties across multiple seasons and trial types. Notably, the hybrids exhibited remarkable resilience, performing well under water-saving conditions and showing a 26% yield increase in saline soil trials in China, a trait highly valuable for Pakistan. Despite challenges like lodging in one season due to unusual weather, the overall performance was promising, with some demonstrations indicating yield increases of over 35%. It is concluded that hybrid wheat presents a viable and transformative strategy for ensuring food security in Pakistan. Its demonstrated ability to produce significantly higher yields under efficient water use and stress conditions can help bridge the national yield gap. Widespread evaluation and adoption of this technology across Pakistan's diverse agro-ecological zones are strongly recommended to boost domestic production and reduce dependence on imports.

Keywords: Hybrid Wheat, Food Security, Water Efficiency, Yield Gap, Climate Resilience, Pakistan.

Genetic diversity of Gemini viruses infecting diverse plant species in Khyber Pakhtunkhwa, Pakistan

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Geminiviridaea is one of the most important family of plant-infecting viruses that has been classified into fourteen recognized genera. Amongst these, *Begomovirus* is the largest and economically most important genus. Viruses of the genus are further categorized into monopartite (single genomic component or DNA-A) and bipartite (two genomic components called DNA-A and DNA-B) begomoviruses. These viruses infect a wide range of plant species in tropical and sub-tropical regions of the world. Different plants such as *Amaranthus*

retroflexus, Cannabis sativa, Capsicum annum, Glycine max, Mentha longifolia, Parthenium hysterophorus that showed symptoms indicative of begomovirus infection were sampled in several districts of Khyber Pakhtunkhwa. Begomoviruses, mastreviruses and their associated alphasatellite and/or betasatellite present in these samples were amplified by RCA and PCR, cloned, and sequenced. The phylogenetic and biogeographic analyses of virus components were performed by various bioinformatics tools. Complete genome sequences of begomoviruses and satellites obtained in this study showed the highest sequence identity with chili leaf curl virus, tomato leaf curl virus, tomato leaf curl New Delhi virus, chili leaf curl betasatellite, parthenium leaf curl alphasatellites and papaya leaf curl betasatellite. *Tomato leaf curl virus* and *Tomato leaf curl New Delhi virus* were the prominent viruses, whereas, *Papaya leaf curl betasatellite* and *Parthenium leaf curl alphasatellite* were the prominent betasatellites and alphasatellite, respectively in the region. The existence of these viruses/ satellites in numerous diverse important plant hosts might be a sign that future epidemics are possible in the area and is an alarming signal for future food security in the region. The study also provides an understanding of the origin and evolution of both monopartite and bipartite begomoviruses and highlights the need for further research on developing management strategies.

Key words: geminiviruses, begomoviruses, satellite, KP, Pakistan, diversity

Heavy Metal Stress Management in Plants through Bio-Organic Amendments

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Bio-organic amendments including plant growth-promoting rhizobacteria (PGPR), compost, biogas slurry, and biochar application may have the potential to significantly improve plant growth and modulate metal toxicity and their translocations to plants. The purpose of this study was to see how inoculating PGPR with organic amendments reduces physiological stress in crop plants by regulating metal uptake and the antioxidant defense system. PGPR was

equipped with aminocyclopropane-1-carboxylate deaminase (ACC deaminase), exopolysaccharide (EPS), and indole acetic acid (IAA). PGPR was applied alone and combined with BGS to crop plants in a pot experiment subjected to metal concentrations in soil. Integrated use of PGPR and organic amendments significantly ($P < 0.05$) increased plant biomass (up to 44%), relative water contents (up to 15%), photosynthetic rate (up to 20%), and stomatal conductance (up to 11%) of crop plants under normal and metal stress conditions, respectively. Possibly, metal-induced production of reactive oxygen species resulted in increased electrolyte leakage and malondialdehyde contents, which led to a reduction in growth and physiology, however, such negative effects were ameliorated by the regulation of antioxidants. Lipid peroxidation is repaired by the crop plants through enhanced activities of ascorbate peroxidase and catalase antioxidants; however, the combination of PGPR and organic amendments modulate these parameters to mitigate metal stress on crop plants.

Keywords: Antioxidants; *Bacillus* sp.; Biogas residues; Bioremediation; Heavy metals; Phytotoxicity

Studying Salt-Induced Shifts in Gene Expression Patterns of Glucosinolate Transporters and Glucosinolate Accumulation in Two Contrasting Brassica Species

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Brassica crops are well known for the accumulation of glucosinolates—secondary metabolites crucial for plants' adaptation to various stresses. Glucosinolates also functioning as defence compounds pose challenges to food quality due to their goitrogenic properties. Their disruption leaves plants susceptible to insect pests and diseases. Hence, a targeted reduction in seed glucosinolate content is of paramount importance to increase food acceptance. *GLUCOSINOLATE TRANSPORTERS* (*GTRs*) present a promising avenue for selectively reducing glucosinolate concentrations in seeds while preserving biosynthesis elsewhere. In this study, 54 putative GTR protein sequences found in *Brassica* were retrieved, employing Arabidopsis GTR1 and GTR2 templates. Comprehensive bioinformatics analyses, encompassing gene structure organization, domain analysis, motif assessments, promoter analysis, and cis-regulatory elements, affirmed the existence of transporter domains and stress-related regulatory elements. Phylogenetic analysis revealed patterns of conservation and divergence across species. Glucosinolates have been shown to increase under stress conditions, indicating a potential role in stress response. To elucidate the role of GTRs in glucosinolate transportation under NaCl stress in two distinct *Brassica* species, *B. juncea* and *B. napus*, plants were subjected to 0, 100, or 200 mM NaCl. Based on the literature, key *GTR* genes were chosen and their expression across various plant parts was assessed. Both species displayed divergent trends in their biochemical profiles as well as glucosinolate

contents under elevated salt stress conditions. Statistical modelling identified significant contributors to glucosinolate variations, guiding the development of targeted breeding strategies for low-glucosinolate varieties. Notably, *GTR2A2* exhibited pronounced expressions in stems, contributing approximately 52% to glucosinolate content variance, while *GTR2B1/C2* displayed significant expression in flowers. Additionally, *GTR2A1* and *GTR1A2/B1* demonstrated noteworthy expression in roots. This study enhances our understanding of glucosinolate regulation under stress conditions, offering avenues to improve *Brassica* crop quality and resilience.

Enhanced Resilience to Salt Stress: An Integrated Approach Addressing Physiochemical Attributes of Wheat (Triticum aestivum L.)

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Salinity stress exerts a deleterious impact on crop growth, presenting a formidable challenge to sustainable agriculture, because of the prevalence of salt-affected arable land globally. The present investigation focused on mitigating the adverse effects of salinity on Triticum aestivum L. and employed integrated physical, chemical, and biological amendments, which were denoted as treatments T1 to T8. The findings unveiled higher pH, EC, and Na^+ concentrations in the topsoil compared to the subsoil within the selected saline field. In comparison to the control treatment (T1), the combined application of gypsum, farmyard manure, and ridges (T8) demonstrated a significant enhancement in agronomic traits, chlorophyll contents, and total protein in wheat. Notably, T8 exhibited the lowest Na^+ concentration and the highest levels of K^+, Mg^{2+}, Ca^{2+}, and Mg^{2+} compared to all other treatments. Furthermore, the amalgamation of two reclamation approaches (T5, T6, and T7) surpassed single amendments (T2, T3, and T4) in terms of both agronomic traits and ionic analysis. Treatment T8 displayed the lowest phytochemical contents (i.e., antioxidant activity) in wheat, as indicated by total phenolic and flavonoid content, ferric and molybdate ion reduction, DPPH, and hydroxyl scavengers. These parameters exhibited a positive association in descending order, with 80.6%, 86.9%, 82.2%, 73%, 86%, and 84.5% in T1 and 71.4%, 81.2%, 73.4%, 68.1%, 79.3%, and 78.5% in T8, respectively. The observed alterations resulting from the combinations of amendments present promising targets, rendering them prospective in enabling wheat plants to successfully acclimatize to saline soil conditions. Therefore, the GQD-0.1Fe-20N-TiO2-300 proves to be a potential photocatalyst for onward usage in binary and multi-solute systems.

Oral Presentations

Green-synthesized nanomaterials synergized with traditional medicinal extracts: a sustainable strategy to combat antimicrobial resistance (AMR)

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The escalating global crisis of Antimicrobial Resistance (AMR) and Multidrug Resistance (MDR) necessitates the urgent development of innovative, eco-friendly, and sustainable therapeutic strategies. With conventional antibiotic pipelines in decline, alternative approaches are critically needed. This study converges three cutting edge domains, green nanotechnology, traditional medicinal knowledge, and advanced drug delivery biotechnology to propose a climate-resilient solution to AMR. We report the facile biosynthesis of carbon dots (CDs) and metallic nanoparticles (silver, zinc oxide) using phytochemical rich extracts of medicinal plants indigenous to the Hindukush ranges of Pakistan and Traditional Chinese Medicines (TCMs). These plants were selected based on their ethnopharmacological use against infectious diseases. The green synthesis process aligns with sustainability principles by minimizing toxic by-products and reducing the carbon footprint compared to conventional chemical synthesis. The nanomaterials were extensively characterized (UV-Vis, FTIR, XRD, TEM, and DLS), confirming nanoscale dimensions, stable morphology, and bioactive phytoconstituent capping. These nanoparticles demonstrated potent antimicrobial activity against MDR clinical isolates, including MRSA, ESBL-producing *E. coli*, and *Klebsiella pneumoniae*, alongside antifungal activity. A novel aspect of this research is the functionalization of CDs as smart nanocarriers, enhancing the bioavailability and targeted delivery of active phytochemicals, thereby merging traditional medicine with modern biotechnology. Remarkably, synergistic effects were observed when green synthesized nanomaterials were combined with plant extracts, yielding significantly lower Minimum Inhibitory Concentrations (MICs) than either component alone. This not only improved efficacy but also reduced dosage requirements, minimizing toxicity and delaying resistance emergence. Overall, this work underscores the transformative potential of integrating green biotechnology with indigenous ethnopharmacology to develop effective, sustainable, and climate-resilient nanotherapeutics, offering a promising frontier in the global fight against AMR.

Keywords: Antimicrobial resistance, green nanotechnology, carbon dots, metallic nanoparticles, traditional medicine, drug delivery, climate resilience.

Green biotechnological insights into Salvia hians: a climate-resilient approach for antibiofilm and antimicrobial applications

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The global rise of antimicrobial resistance (AMR) and biofilm associated infections is one of the most pressing public health challenges of the 21st century, demanding sustainable and eco-friendly alternatives to synthetic antibiotics. In this context, green biotechnology and traditional ethnomedicine offer promising avenues for developing climate resilient antimicrobial strategies. This study explores the antimicrobial and antibiofilm potential of *Salvia hians*, a medicinal plant indigenous to the Hindukush region and long valued in local ethnopharmacology for its infection-healing properties. Aqueous and decoction extracts of *S. hians* were prepared and subjected to phytochemical analysis, confirming the presence of flavonoids, terpenoids, and phenolic compounds. The extracts were tested against clinically relevant multidrug-resistant (MDR) pathogens, including *Staphylococcus aureus* (MRSA) and *Escherichia coli*, using agar diffusion, broth microdilution, and biofilm disruption assays. Microscopic and spectrophotometric analyses further elucidated the inhibitory and eradication effects on pre-formed biofilms. Results revealed that *S. hians* extracts significantly inhibited bacterial growth and biofilm formation in a dose-dependent manner. Decoction extracts, in particular, exhibited stronger efficacy, suggesting enhanced extraction of bioactive metabolites under heat-assisted preparation. Sub-inhibitory concentrations disrupted established biofilms by more than 60%, underscoring the extracts' dual action of growth suppression and biofilm eradication. These findings highlight *Salvia hians* as a sustainable phytobiotechnological resource, offering an eco-friendly strategy to address AMR and persistent biofilm infections. By integrating indigenous knowledge with modern green biotechnology, this work contributes to climate resilient therapeutic innovations and supports the global agenda of sustainable health solutions.

Keywords: *Salvia hians*, antimicrobial resistance, biofilm inhibition, MRSA, *E. coli*, green biotechnology, climate resilience.

Agricultural Waste Transformation: Industrial Xylanase Production from *Bacillus* Strains

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Lignocellulosic agricultural waste has become a useful and economic source for production of many commercially important products due to the presence of a wide variety of components. Xylan is a complex carbohydrate polymer which is

composed of D-xylose units linked through β-1,4 linkage. Current study is an effort to produce xylanase from newly isolated microbial strain *Bacillus*. 30 strains were isolated from different areas (soil, water and air) of the Upper Dir. Out of 30, 13 were found to be Bacillus upon morphological, biochemical and microscopic characteristics. The production of xylanase was optimized using various physical and chemical parameters. 5 different reported media were used, and new medium was designed. The components of new media were also varied by incorporating agro-waste and wheat bran was found to be best induced at 3% concentration. Other salts were optimized as well. A high yield of xylanase was obtained at 40ºC, pH 7.0, and after 18 hours of fermentation. Thus, xylanase produced in current study can be further employed for biodegradation of lignocellulosic biomass which can be useful in circular bioeconomy.

Impact of Zingibain (Plant Enzyme) on Growth and Gut Health of Broilers Fed High Animal Protein Diets

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The purpose of this study was to examine the impact of phyto-protease produced from ginger on blood biochemical indicators, gastrointestinal health, litter quality, and nutrient retention. A total of 250-day-old broiler chicks (ROSS 308) were obtained from a hatchery, with similar weight, age, breed, and sex. These chicks were divided into five treatment groups: T1, T2, T3, T4, and T5. Each group consisted of five replicates (10 chicks per replicate). T1 served as the control group, while T2 and T3 had diets with 4% and 6% animal protein concentrate (APC), respectively. T4 had the same diet as T2 but included ginger-derived protease (GPZ) at 0.02%, and T5 had the same diet as T3 with GPZ at 0.02%. During the starter phase (days 1-21), the supplementation of phyto-protease improved body weight gain (BWG) and feed conversion ratio (FCR). The inclusion of APC in the broiler diet adversely affected BWG and FCR. However, the addition of phyto-protease enzyme to diets containing 4% and 6% APC resulted in better BWG and FCR. In the finisher phase, supplementation with phyto-protease continued to improve BWG and FCR. The inclusion of phyto-protease resulted in a significant ($p<0.05$) improvement in the weight of lymphoid organs and carcass yield. Salmonella and Escherichia coli (E. coli) counts were lowest in groups supplemented with phyto-protease and highest in groups fed APC. Conversely, Lactobacillus counts increased with the supplementation of phyto-protease compared to other groups. Supplementation with phyto-protease significantly affected nutrient digestibility (ND) and apparent metabolizable energy (AME) in broilers fed with APC. The digestibility of dry matter (DM), crude protein (CP), and ether extract (EE) was lower in the group fed with APC alone. Phyto-protease supplementation

significantly increased ND and AME. Dietary supplementation with ginger-derived phyto-protease enzyme could be a viable approach to enhance production performance and nutrient digestibility in broiler diets that use higher levels of animal protein sources with deficient protein and amino acid levels.

Keywords: Growth efficiency, animal protein source, nutrient digestibility, gut microbiome, and amino acids.

Policy pathways for integrating green biotechnology into Pakistan's healthcare system: a climate-resilient public health perspective

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Pakistan faces the dual challenge of climate change vulnerability and an overburdened healthcare system struggling with infectious diseases, antimicrobial resistance (AMR), and resource limitations. While global advances in green biotechnology are reshaping sustainable healthcare models, their adoption in Pakistan remains fragmented due to policy gaps, weak regulatory frameworks, and limited public–private collaboration. This paper highlights policy pathways for integrating green biotechnology into Pakistan's healthcare settings as a means of enhancing climate resilience and public health security. Priority strategies include strengthening governance through clear biosafety and bioethics regulations, incorporating biotechnology and climate-health innovations into medical and pharmacy curricula, incentivizing public–private partnerships to support eco-friendly diagnostics, vaccines, and medical devices, and promoting sustainable healthcare infrastructure through solar powered facilities, biodegradable medical waste management, and green procurement policies. At the community level, preventive health programs can be expanded by deploying climate smart biotechnological solutions such as biosensors for water quality monitoring and bioengineered approaches for vector control. By linking One Health principles with national priorities, these measures can reduce the ecological footprint of healthcare, enhance resilience against infectious diseases, and align Pakistan's health system with the UN Sustainable Development Goals (SDGs). The integration of green biotechnology into healthcare policy thus represents both a scientific necessity and a political imperative for ensuring equitable, climate resilient, and sustainable healthcare for Pakistan's population

Keywords: Pakistan health policy, green biotechnology, antimicrobial resistance, climate resilience, One Health, sustainable healthcare, public private partnerships, biosafety regulations.

Assessing the impacts of traditional hunting practices on Demoiselle crane (*Anthropoids virgo*) population in district Bannu, Khyber Pakhtunkhwa

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The crane is a migrant bird species with long legs, a long neck, and a long bill. They often wade in shallow waters, usually in rivers, wetlands, lakes, and paddy fields. At landscape level, floral vegetation structure, and trophic level, they significantly alter ecosystem functions. In spite of human intervention, the population of these bird species is declining at an alarming rate. In order to understand what types of threats these marvelous birds face due to anthropogenic activities, this study assessed the impacts of traditional hunting practices on the demoiselle crane (anthropoids virgo) population in district Bannu, Khyber Pakhtunkhwa, Pakistan. Total 5 samples of Demoiselle crane were collected from hunters and brought to the laboratory to check the occurrence of bacterial and other parasitic diseases. Neither E. coli bacteria nor other harmful bacteria inside were detected in the intestine and blood of the Demoiselle crane bird. In addition, it was founded that Demoiselle care were hunted in Gambila, Kwashi, Baran Dame, and Kurram River site. Moreover, the perceptions of hunters revealed that, approximately 33.0% used Gambila site, 27.0% Kwashi site, 21.0% Baran Dame site and 19.0% Kurram River site for Demoiselle crane hunting. However, the choice of hunting sites depends on the occupancy of local tribes in a particular area, i.e., Gambila (33%), Wazirs Kwashi (27.0%), and Banochi Kurram River (19%) and Baran Dame (21.0%) respectively. The perceptions of the respondents revealed also demonstrated that Demoiselle cranes in Bannu district face numerous threats, including uncontrolled hunting (67.0%), shortages of aquatic habitat due to water diversion and abstraction for agriculture (15.0%), pollution of water (10.0%) and habitat degradation (8.0%) as a result of land conversion (i.e., agriculture fields). Likewise, demoiselle cranes have been hunted extensively by calling and weapon hunting (each; 80.0%), bait and lure (70.0%), net trapping (70.0%), and battni and snaring (each; 60.0%). In the calling method, hunters used tamed crane 80.0%, netting 15.0%, and guns 5.0% to attract Demoiselle cranes. In gun hunting, 80.0% use weapons, 15.0% attract tame birds for hunting, and 5.0% capture birds with nets. A decline of population trend was observed in the study area due to hunting (70.0%), illegal trade (30.0%), pet birds (25.0%), and habitat degradation (30.0%). In addition, illegal trade in Demoiselle cranes has contributed significantly to the population decline because they have been trapped them to sold in the market and kept as pets in homes. The literacy rate and profession of the respondents in the study area varied. Overall, the outcomes indicate that unrestrained hunting activities, driven by socio-cultural and economic factors, have contributed to a decline in the species' population, highlighting the need for urgent conservation measures. This research

emphasizes the imperative of adopting a holistic approach to conserve the Demoiselle Crane population in District Bannu.

Prevalence of gastrointestinal parasites in wild and domestic birds; investigating the three unexplored regions of district Dir (Upper) Khyber Pakhtunkhwa Pakistan

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The class Aves is a diverse group of vertebrates having a worldwide distribution. More than 20000 species have been reported globally. Birds are prone to many types of gastrointestinal (GI) parasites and some of them can cause substantial effect to their population. The current study provides an insight on the prevalence and diversity of avian GI parasites in district Dir (Upper) Khyber Pakhtunkhwa Pakistan. A total of 400 birds representing 05 Orders, 16 families and 22 species were sampled from three different sampling sites, Gandigar, Sheringal and Ushiri during September 2021 till September 2023. The qualitative examination of fecal samples taken from these birds was done using "Direct smear, Sedimentation and Floatation" techniques and slides were observed under microscope for the presence of GI parasites (eggs/adults). A general GI parasitic prevalence of 16.5% (66 samples) was observed in 02 domestic and 03 wild bird species which was highest in domestic (12%) than the wild (4.5%) birds. Of the total 08 GI species identified 01 was from the protozoan (*Eimeria species*) and 07 were from the helminthes (*Trichuris* {*trichuris* and v*ulpis*}, *Ascaris*, *Ascardia*, *Taxocara*, *Fasiola* and Hymenolepis). Highest GI Parasitic prevalence was recorded in *Gallus gallus domesticus* (6.666%) followed by *Columba livia* (3.666%), *Passer domesticus* (1.666%), *Acridotheres tristis* (1.5%) and *Passer montanus* (1%). Highest degree of mixed infection was recorded in *Gallus gallus domesticus* which was infected by 06 species of GI parasites followed by the moderate degree of mixed infections in *Columba livia* and *Passer domesticus* which were infected by 03 and 02 species, respectively. *Acridotheres tristis* and *Passer montanus*, on the other hand, has shown single infection pattern of the GI parasites.

Keywords: Gastrointestinal parasites, *Gallus gallus domesticus*, *Columba livia*, *Eimeria species*.

Pyrolysis of municipal solid waste of Islamabad to derive value added products and energy recover: A step towards circular economy in Pakistan

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In Pakistan, Municipal solid waste (MSW) management is become serious environmental challenge particularly rapidly increasing urban areas such as Islamabad. Conventional approaches including landfilling, open dumping and burning are inefficient methods and can't recover resources and energy embedded in waste. Pyrolysis is promising WTE techniques that efficiently convert MSW into useful products. In this study, co-pyrolysis of various MSW blends were investigated to improve the products yield and quality via synergistic effects. The experiments were conducted in pilot scale fixed-bed reactor at 450 ºC with heating rate of 5 ºC/s and resident time of 1 hour. The results revealed that the plastic dominant MSW blend had highest yield of bio-oil (42.5%) and syngas (38%) while the textile rich blend had highest yield of biochar (53.5%). The plastic-rich composition had highest yield of CH4 (24.2%) and H2 (17.9%). FTIR spectrum revealed that the biochar produced from different municipal solid waste fractions retains a carbonaceous structure rich in both aliphatic and aromatic functionalities. Overall, this study highlights the potential of pyrolysis of MSW for efficient energy recovery, waste management and promoting the circular economy.

Deciphering the Potential of Silver-Selenium Nanocomposites on Growth Metrics, Physiological Attributes, and Antioxidant Profiles in Cotton (*Gossypium hirsutum* L.)

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The worldwide impact of viral diseases throughout history is substantial. Our research focus was SARS-CoV-2, which emerged as a substantial problem for the scientific community. Given the limitations of current therapies in terms of efficacy and availability, it is imperative to develop safe and effective inhibitors that interface between the virus and the ACE2 receptor. This study aims to synthesize peptides as ACE2 inhibitors and evaluate their efficacy in preventing SARS-CoV-2 infection via an α5β1 integrin-based mechanism. ATN-161 has shown high specificity and efficacy against SARS-CoV-2, demonstrating safety in both in vivo and in vitro studies. Based on the reported ATN-161 structure, three peptide analogs were designed by strategically modifying the position of the proline in the amino acid sequence. The ability of proline to stabilize and enhance peptide activity was exploited to improve the analog properties. The synthesis of ATN-161 analogs was accomplished using solid-phase peptide synthesis (SPPS). The stepwise addition of protected amino acids to the growing peptide chain involved affixing, deprotection, amino acid coupling, and cleavage of the synthesized peptide from the resin. To assess their potential as anti-Covid agents, the peptides were evaluated on Vero (E6) cells. Experimental results demonstrated that one of the synthesized analogs reduced the virus-receptor interaction more effectively than ATN-161, demonstrating its role in mitigating

SARS-CoV-2 infection. This is the first study reporting the potential therapeutic efficacy of synthetic analogs of ATN-161 as fusion inhibitors.

Keywords: *Gossypium hirsutum* L., Silver-Selenium Nanocomposite, Green Synthesis, Biotic Stress, Bacterial Diseases

Integrative Taxonomy of Thelandros Nematodes Infecting *Laudakia nupta* in Pakistan

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Thelandros (Oxyurida: Pharyngodonidae) are very rare nematode parasites that occur in the alimentary canal of lizards, our current knowledge of the global species composition of *Thelandros* nematodes remains very limited. Furthermore, the molecular identification, population genetics, and phylogeny of *Thelandros* remain in their infancy because of the limited genetic databases (especially mitochondrial genomes). The systematic positions of the Pharyngodonidae and Oxyuridae families are uncertain. *Thelandros* nematodes were collected from the yellow-headed rock agama *Laudakia nupta* (Squamata: *Agamidae*), from Pakistan. These specimens were identified at the species level using integrated morphological methods, species assembly by automatic partitioning (ASAP), and Bayesian inference (BI) analyses. Moreover, the complete mitochondrial genome of the present materials was sequenced and annotated to enrich the mitogenomic data and investigate the pattern of mitogenomic evolution of the family Pharyngodonidae. Phylogenetic analyses were also performed to assess the systematic position of the superfamily Oxyuroidea in the order Oxyurida and the evolutionary relationships of the four orders Ascaridida, Spirurida, Oxyurida, and Rhigonematida based on the amino acid sequences of 12 protein coding genes of mitochondrial genomes using maximum likelihood (ML) and Bayesian inference (BI), respectively. One new species *Theladros adamsoni* sp. n. and one known species *Thelandros popovi* were examined using light and scanning electron microscopy. The results of the ASAP and BI analyses based on the ITS,12S, *cox1*, and *cox2* sequences also supported that *Theladros adamsoni* sp. n. and *Thelandros popovi* represents species separated from congeners. Phylogenetic analyses based on the amino acid sequences of 12 protein-coding genes (PCGs) of mitochondrial genomes revealed that the present study also constructed the phylogenetic relationships of the orders Ascaridida, Spirurida, Oxyurida, and Rhigonematida based on the amino acid sequences of the 12 protein-coding genes (PCGs) of the mitochondrial genomes, using Maximum Likelihood (ML) and Bayesian

Inference (BI) methods, respectively. The phylogenetic results indicated that the order Ascaridida is not monophyletic, while the superfamilies Ascaridoidea and Heterakoidea is monophyletic. The present phylogenetic results suggest that the traditional superfamily Heterakoidea could be elevated as the infra-order Heterakomorpha. Within the Oxyurida, the families Pharyngodonidae and Oxyuridae formed a sister group. *Theladros adamsoni* sp. n. and *Thelandros popovi* is described using an integrated method. Characterization of the complete mitochondrial genome of *Theladros adamsoni* sp. n. and *Thelandros popovi* reported for the first time. Mitogenomic phylogenetic results suggest the erection of an infra-order Heterakomorpha for the traditional superfamily Heterakoidea. The present findings enrich the mitogenomic data and global species diversity of Pharyngodonides nematodes and provide novel insights into the systematic position of the Oxyuroidae superfamily.

Keywords: Lizard parasites, Oxyuroidea, integrative taxonomy, mitochondrial genome, phylogeny

Effect of Pastoralism on the rearing of goats and sheep in District Vehari-Punjab, Pakistan

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Pastoralism of goats and sheep is playing a significant role to fulfill the milk and meat requirements of the people of Punjab, Pakistan. Although urbanization has affected this traditional profession but still a significant number of families are continuing their family legacy. The current survey study conducted in three Tehsils of District Vehari i.e. Tehsil Vehari (site-1), Tehsil Burewala (site-2), Tehsil Mailsi (site-3). A specific questioner is designed to collect the information about the shepherd and their families. Stratified random sampling method is used to record the information about the size of herd, diversity in the herd, family involvement, possession of animals, management of animals, vaccination, and breeding strategies. Among the values of study results in the brackets indicated that the first values belong to site-1, second values belong to site-2, and third values belong to site-3. Herd size of goats (18.14, 21.75, 17.51%) and sheep (8.57, 9.47, 7.21%) at all three sites. Statically similar results observed about interest of families to continue this profession in all sites i.e. 75.67, 78.23 and 77.45%. Ownership of a herd was mixed, shepherd head owned 82.25, 78.26, 85.36% of total animals in the herd. The population of goat was higher (91.57, 96.48, 86.27% in all three sites) as compared to sheep population. Primary purpose of goat (78.25, 74.18, 81.47%) and sheep (67.48, 71.48, 65.42%) rearing is for selling of animals for meat purposes. Vaccination of animals is very poor in all three sites (6.89, 9.78, 7.96%). They are mainly dependent on free rang grazing (98.10, 96.75, 97.42%) and nighttime they kept the animals in temporary open skey shed (94.57, 91.48, 96.47%). Watering to

animals is not from any specified place and it was common practice from open watering places (97.85, 98.24, 97.05%). The cooperation of other family members (96.47, 97.26, 91.42%) was high and contribution of females (18.23, 14.25, 12.47%) are not common in any of studied place. Interestingly, they did not spend much time for the marketing of goats (0.42, 0.54, 1.14hrs) and sheep (1.58, 1.41, 1.35 hrs) selling. They preferred to sell the males of goats (91.58, 86.47, 84.67%) and sheep (97.89, 98.78, 95.36%) on some events. The study results suggested that animals rearing system could be enhanced through training, vaccination and provision of productive bread of goats and animals.

Keywords: Livestock inventory, nomadic, grazing, livelihood, food security

Molecular and Biochemical Characterization of Newly Developed Wheat Genotypes

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The development of high-yielding, genetically diverse and climate resilient wheat varieties is critical for ensuring global food security under changing climatic conditions. This study aimed to evaluate locally developed wheat lines for agronomic traits, biochemical profile and to screen the wheat genotypes for important characters through marker assisted selection. The agro-morphological assessment included plant height, days to heading, days to maturity, grain yield per plot, grain yield per hectare, thousand grain weight and the evaluation of seed quality for different minerals. The lowest days to maturity were recorded for the Genotypes 1 and 11 (172 days), while the lowest days to heading were observed for the Genotype 16 (126 days). The highest grain yield per plot was recorded for the Genotype 24 (1301 g). Genotype 21 had a maximum yield of 8185 kg/ha. Maximum thousand grain weight was recorded for the Genotype 18 which was 45 g. Furthermore, the seed quality analysis revealed that Genotype 16 had maximum zinc concentration of 39.51 ppm. The Genotype 23 had maximum concentration of iron (61.57 ppm) and maximum concentration of calcium (718 ppm). Maximum manganese concentration was noted for the Genotype 24 which was 92.3 ppm. Genotype 4 revealed maximum concentration of copper which was 7.92 ppm. Maximum magnesium concentration was observed in Genotype 22 which was 1638 ppm. Genetic analysis revealed that most of the genotypes had WMC9, WMC147, WMC596 and Ppd-D1 markers present and these markers were linked to drought tolerance and photoperiod response. UPGMA cluster analysis grouped the twenty-five genotypes into two major clusters, genotypes in group A had high yield, while genotypes grouped in B2 had high magnesium mineral. Correlation analysis showed that plant height had positive correlation with copper whereas thousand grain weight had correlation with iron and negative correlation was observed between thousand grain weight and Ppd-D1. These findings can provide important revelations into the genetic and agro-morphological profiles of the

wheat genotypes which can be useful for selecting the best genotype to be released as variety.

Spatiotemporal trends and epidemiology of cutaneous leishmaniasis in lower Dir, Khyber Pakhtunkhwa, Pakistan: An 11-year analysis

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Cutaneous leishmaniasis (CL) is a significant vector-borne parasitic disease that poses a major public health concern in the northern regions of Pakistan. This study aimed to analyze the prevalence trends of CL over eleven years (2008–2018) in Dir Lower district, Khyber Pakhtunkhwa (KP). A retrospective analysis was conducted using medical records of 7,729 registered patients diagnosed with CL. The findings revealed a high prevalence of CL, with 92.37% of cases occurring among the local population. A gradual increase in the number of cases was observed, peaking in 2018. Demographic analysis indicated that CL was more prevalent in males (68.11%) compared to females (31.89%). Age-wise distribution showed that the highest incidence was recorded in the 11–20-year age group, suggesting greater exposure and susceptibility in this demographic. Anatomical distribution of lesions revealed that the majority were located on the nose (23.35%), while fewer cases were reported on covered body parts, highlighting the role of exposed skin in disease transmission. Furthermore, an association was found between residential conditions and CL prevalence. Individuals living in kaccha (mud) houses had a higher infection rate (26.42%) compared to those in concrete houses. Additionally, proximity to domesticated animals was a significant risk factor, with 64.3% of infected individuals residing near livestock. These findings suggest that poor housing conditions and close contact with potential animal reservoirs contribute to the persistence of CL in the region. To effectively control the spread of CL, targeted public health interventions are necessary. Community awareness programs should emphasize the risks of CL, its modes of transmission, and preventive measures. The regular use of insecticide-treated bed nets, protective clothing, and improved housing structures should be encouraged to minimize exposure to sandfly vectors. Additionally, early diagnosis and prompt treatment are crucial for reducing disease burden and preventing complications.

Keywords: *Cutaneous leishmaniasis*, Epidemiology, Prevalence trends, Risk factors, Khyber Pakhtunkhwa, Vector control

Green synthesis of Ag-Au bimetallic nanoparticles for sensing of congo-red dye

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Ag-Au Bimetallic nanoparticles (BNPs) were synthesized by green method using Northern Catalpa leaf extract (*Catalpa Specoisa*) as a stabilizing and reducing agent. The synthesized Ag-Au BNPs were analyzed using UV-Vis Spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), Energy Dispersive Spectroscopy (EDS) and X-ray Diffraction (XRD) Spectroscopy. Absorption band of Ag-Au BNPs have maximum wavelength at 540nm confirm the successful formation of Ag-Au bimetallic nanoparticles. Ag-Au BNPs have stretching band at 488 cm^{-1} in their FTIR spectra which indicates the formation of Ag-O or Ag-O-Au bonds. Face-centered cubic structures of Ag-Au BNPs were confirmed by XRD, which further verified their average particle size to be 22nm. The surface morphology and particle size were determined by SEM. EDX was examined to find out the elemental composition of Ag-Au BNPs. The electrochemical process was carried out using Cyclic Voltammetry (CV) and Electrochemical Impedance Spectroscopy (EIS). Ag-Au BNPs modified Glassy Carbon Electrodes were prepared by drop-coating method for Congo-Red (CR) dye sensing. The limit of detection (LOD) was 2.85 µM and limit of quantification (LOQ) was 22.0 µM. The Ag-Au 2:1 BNPs modified electrode proved to be highly sensitive and stable for the simultaneous detection of CR.

Synthesis of Silver Nanoparticles Using *Aegle marmelos* Fruit Extract and Its Potential Biological Applications

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Aegle marmelos, often known as the Bael and also known as wood apple, Bengal quince, Japanese bitter orange, or golden apple, is a kind of tree that is inherent to Indian subcontinent and Southeast Asia. It may be found in Bangladesh, India, Sri Lanka, Nepal, and Pakistan as a naturally occurring species. The tree is considered sacred by Buddhists and Hindus. *Aegle marmelos*, a member of the Rutaceae family, has been used widely in conventional medical systems because of its many medicinal advantages. The ethanolic extracts of the fruit of *Aegle marmelos* reveal various bioactive phytochemical components, which are related to the therapeutic efficacy of medicinal plants and their secondary metabolites, or phytochemicals. The unique antibacterial properties of silver nanoparticles, or AgNPs, have garnered a lot of interest. Plant extract-mediated synthesis has shown to be more successful than other biological systems since it is simple, affordable, and easy to utilize. The current study's objective is to create silver nanoparticles utilizing the alcoholic fruit extract from *Aegle marmelos*. Due to the fact that AgNPs are synthesized under diffused solar irradiation, it is both affordable and

ecologically benign. FTIR, TGA and UV-visible spectroscopy are the analytical procedures that are employed to comprehensively analyze the produced AgNPs. We can better address the Sustainable Development Goals (SDG-3) in the health sector with the aid of this research.

Impacts of 2022 floods on the ecosystem services of the Hindu Kush Himalaya ranges of Pakistan

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In the year of 2022 and 2023 the Hindu Kush ranges received a multiple GLOFs events as well the area was hit by a severe flood. In Kumrat valley of the region, the impacts of floods and GLOFs on different land uses were assessed through GIS and field inventory. The results showed that the area of water bodies increases from 170.5 ha to 174.5 ha, while forest land reduced from 8737 ha to 8667 ha. Similarly, the area of agriculture land reduces from 632.50 ha to 550 ha, while built land decreases from 307 ha to 306.5 ha. The area of bare ground exhibits a net decrease of 1482.5 ha, while an 1103.50 ha reduction occurred in snow-glaciers and rangeland exhibits a net reduction of 176 ha. Overall agriculture land in the area reduced by 13% that resulted in a net reduction of 320.37 million USD in their total ecosystem services (ES). A reduction of 0.8% in forest land reduced the total worth of ES by 592.28 million USD, while a reduction of 1.24% area in rangeland caused a total loss of 10.61 million USD. Though the area of water increases by about 2%, however, an 11% decrease was noted for SG, thus a net decrease of 9.8% occurred in WB and SG, which caused an annual reduction of 348.92 million USD in the ES of the WB and SG. Rehabilitation of the degraded land through biological and engineering structure, flood protection and soil and water conservation measures are required to cope with future floods.

The effect of land use change and climate change on the ecosystem services of Hindu Kush Himalaya ranges of Pakistan

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Using remote sensing, field inventory and survey data, this study quantified ecosystem services dynamics with land use change (LUC) and climate change (CC) in the Hindu Kush, Himalaya ranges of Pakistan. The results show that between 2000 and 2050, the area of bare soil (BS) increased by 0.10 year^{-1}, whilst the area of grassland (GL), water bodies (WB) and built land (BL) expanded by 0.27%, 2.67% and 3.33% year^{-1} respectively. Similarly, forest land (FL), agriculture land (AL) and snow glacier (SG) were reduced at annual rates of 0.20%, 0.02% and 0.48%, respectively. The amount of area in lower LST

classes (< 6 ^{o} C -18 ^{o} C) decreased by 1.58% year^{-1} while higher LST classes (18 ^{o} C->24 ^{o} C) expanded by 2.12% year^{-1}. From the base year (2010) to 2050, CC and LUC diminish the total worth of ES by 9.2 billion USD (0.184 billion USD per year). Effective counter approaches such as agroforestry, afforestation and reforestation campaigns and community and conservation involvement in natural resources management (NRM) are quintessential for sustainable ecosystem services provision as well protection of natural resources.

Evaluation of application methods of newly developed bioinoculant on wheat crop

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As the global population continues to rise, ensuring food security and environment has become one of agriculture's most significant challenges. The overuse of chemical fertilizers has led to serious soil and water pollution, reduced soil fertility and increased costs for farmers. This has sparked interest in sustainable alternatives such as biofertilizers, which naturally enhance nutrient availability and promote plant growth without affecting the environment. Phosphate-solubilizing bacteria (PSB) such as *Bacillus subtilis* has shown one of the promises biofertilizers but still its effectiveness through different application methods remains underexplored. This study investigated the effectiveness of three different application methods (seed dipping, sand-soil granules, and spray) of *Bacillus subtilis* on the growth and physiological characteristics of two wheat varieties, Gulzar-19 and Zarghon-21. Gram staining and 16S rRNA primer were used to confirm the identity of the bacterial strain. To assess the effectiveness of the PSB bioinoculant, two types of experiments were conducted: one in pots and second in trays. Both experiments employed three methods of bioinoculant application: seed dipping, sand-soil granules, and spray application method. Chemical fertilizer and a moke sample were used as positive and negative controls respectively. Improvements were observed in both varieties with the seed dipping method. Gulzar-19 showed the maximum total chlorophyll content (33.2 µg/g), protein content (12 µg/g), and spike length (17.3 cm), while Zarghon-21 had the highest grains per spike (50 grains) and significantly increased total chlorophyll content (30.1 µg/g) and protein content (11.2 µg/g) compared with the controls. In granule application method, Zarghon-21 exhibited the longest root (11.5 cm), longest spike (18 cm), and chlorophyll b content (45.2 µg/g). Gulzar-19 also performed well, with a root length of 16.7 cm, spike length of 16.7 cm, and chlorophyll b content of 38.4 µg/g. The highest grain weight per spike was observed in Zarghon-21 (1.96 g), followed by Gulzar-19 (1.78 g), compared to untreated plants. The spray method resulted in the highest plant height (90 cm) and phenol content (1.78 µg/g) in Zarghon-21, while Gulzar-19 showed the highest sugar content (180 µg/g) and total chlorophyll concentration (55.2 µg/g). In all application methods, *Bacillus subtilis* inoculated plants performed significantly better than negative controls.

The seed dipping method was most effective, followed by granules and spray application methods. These results support the potential of *Bacillus subtilis* bioinoculants as an eco-friendly and economical alternatives to chemical fertilizers in wheat production. Further field studies across different environments are needed to validate these findings and develop large scale application strategies.

Bimetallic Nanoparticles Loaded on *Aerva javanica* Biochar for Decontamination of Malachite Green Dye

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Many environmental organizations have drawn attention to the global issue of waste entering the environment. Numerous businesses, such as those in the textile, pharmaceutical, culinary, beverage, cosmetic, paint, and leather sectors, pollute water bodies with colored effluents. One of the colors commonly used in textile manufacturing is malachite green. Numerous methods for removing dyes have been proposed in studies. However, due to their inadequacies, not all dye removal methods are worth using. In this context, adsorption is thought to be a readily accessible approach. Utilizing waste materials as a foundation for biochar production is a relatively young industry. Because it reduces waste content and provides a workable method for producing the required adsorbents. In the current work, the *Aerva javanica* plant successfully removes the Malachite green dye from aqueous media. It was crushed into tiny pieces and allowed to dry completely in the sun for a week before being ground using the mortar and pestle to grind it to a finely ground powder. The biochar was obtained by the pyrolysis of *Aerva javanica* fine powder at 650^{o}C for 3-4 hours. The loading of Al and Cu nanoparticles on some amount of biochar was done and then dried overnight at 60^{o}C in an oven. These adsorbents efficiently remove the dye. The parameters optimizing technique identified the best parameters for figuring out a particular material's adsorption potential. Using *Aerva javanica* plant biochar at optimal conditions (pH = 11, dye concentration of 100 ppm, 30 minutes, 0.5 g adsorbent dose, and 20°C), nearly 93% of the Malachite green dye is removed. While using Al-Cu@biochar nanocomposites 99% of the dye is mitigated using 0.5g nanocomposites loaded adsorbent at pH = 11, 30 minutes, 80 ppm, and 20°C. Based on the adsorption studies, the linear Langmuir isotherm proved to be the most suitable fit for the results of the experiments. The kinetic studies indicate that the mechanism is second order. Furthermore, the adsorption process was exothermic and spontaneous between 293 and 333 K. The FTIR measurements revealed that the adsorbent's surface contains carboxyl and hydroxyl functional groups. According to the SEM data, simple biochar and Al-Cu@biochar had a porous surface that effectively adsorbed the dye molecules. The correct amount of loaded Al and Cu on biochar was confirmed by the EDX analysis. The zeta sizer was used to find the size

and potential of both adsorbents. The ideal conditions needed for adsorption were determined through RSM.

Effects of various hormonal seed priming on modifying the growth and biochemical properties of chilli (*Capsicum annum* L.) under water deficit

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Chili (*Capsicum annuum* L.) belonging to family Solanaceae, that originated in Mesoamerica (Mexico and Central America) and South America and is now cultivated worldwide. It is one of the most economically important horticultural crops in the world. Abiotic stress is the primary cause of crop loss worldwide. Among the abiotic stresses, drought stress is one of the most important environmental factors. Drought, a period of abnormally dry weather, results in soil-water deficit and subsequently plant-water deficit. Water deficit, is defined as the absence of adequate moisture necessary for a plant to grow normally. Seed priming is a technique used to enhance seed performance by hydrating and drying them before germination. Seed priming has become a crucial method for alleviating the impact of abiotic stress, particularly in chilli cultivation. The aim of present study is to determine the adverse effects of water stress of different durations on the growth and biochemical properties of *Capsicum annuum* varieties (V1 (Sky Star 4 F1) & V2 (SV 786 4HM)) by using primed seeds with polyethylene glycol 6000 (5% PEG) and Gibberellic acid (GA_3 5mg/L). The unprimed and primed seeds were subjected to 1-, 2- and 3-days drought stress over 3 weeks. The results showed that the germination percentage of primed seeds significantly improved compared to unprimed seeds; seeds germinated quickly and had a higher whole plant length, shoot length, root length, shoot fresh & dry weight, and root fresh & dry weight especially for seeds primed with PEG and GA_3. Gibberellic acid (GA_3 5mg/L) treated seedlings showed much greater whole plant length, shoot length, root length, shoot fresh & dry weight, and root fresh & dry weight than PEG priming treatments and unprimed. Consequently, the priming treatment with PEG and GA_3 resulted in higher chlorophyll a and b, carotenoids, Peroxidase (POD), Superoxide Dismutase (SOD), Catalase (CAT), than unprimed. GA_3 seedlings showed higher chlorophyll a and b, SOD, CAT and POD and all other treatments. Variety V2(SV 786 4HM) outperformed the variety V1(Sky Star 4 F1) and control treatment. In result, seed priming with GA_3 and PEG significantly modified the growth and biochemical properties of chilli (*Capsicum annum* L.).

Response of seed germination and plant growth to seed pretreatment with exogenous auxin in chilli (*Capsicum annuum* L)

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The present experiment was conducted in the Botany Department of Baha Uddin Zakariya University in Multan in 2024–2025 to investigate the effects of seed pretreatment with different auxin concentrations on seed germination and plant growth in chilli (*Capsicum annuum* L.). Three auxin concentrations (25mg/L, 50mg/L, and 75mg/L) were applied for four soaking durations (8h, 16h, 24h, and 32 hours) across two chilli varieties, V1 (Sky Star 4F.1) and V2 (SV7864HM). Untreated seeds served as the control group. Chlorophyll a, chlorophyll b, chlorophyll a/b ratio, total chlorophyll contents, carotenoids, total soluble proteins, and free amino acids were among the chemical parameters evaluated in the study, along with morphological parameters like whole plant length, whole plant fresh weight, and dry weight. The findings showed that, in comparison with the control, auxin seed priming greatly enhanced seed germination and early plant development in both kinds. In variety V2 (SV7864HM), which exhibited the greater values in morphological growth and photosynthetic pigments, the most successful treatment was a 25 mg/L auxin concentration for 24 hours. A dose-dependent response was suggested by the fact that high auxin concentrations (50 mg/L and 75 mg/L) did not improve growth and, in certain situations, inhibited plant development. Increased total soluble proteins and amino acids showed better metabolic activity and stress tolerance, whereas increases in carotenoid and chlorophyll content under ideal auxin treatments suggested greater photosynthetic efficiency. According to these results, exogenous auxin seed priming has the potential to be a cost-effective and efficient method of improving chilli crops' early growth performance. The study found that varietal differences greatly affect response to plant growth regulators and that the optimal auxin dose and duration are critical for maximizing benefits. With the use of this knowledge, specialized hormone-based seed priming programs that improve chilli farming methods may be created.

Prevalence and Diversity of Gastrointestinal Parasites in Backyard Poultry in District Dir Upper

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Parasitic diseases pose a significant challenge to the developing poultry industry, causing malnutrition, poor feed conversion, weight loss, reduced egg production, and increased mortality in young birds. The purpose of this study was to determine the prevalence and diversity of gastrointestinal parasites in backyard poultry in District Dir Upper. A total of 400 fecal samples were randomly collected directly from the colon or freshly passed and were stored in plastic containers containing 10 % formalin. These samples were analyzed by

direct smear method and examined under microscope. The overall prevalence of GIPs was (52.5%). Nematodes (*Ascaridia galli, Capillaria, Heterakis gallinarum, Trichuris)* and Cestodes (*Hymenolopsis)* were identified. *Ascaridia galli* was the most prevalent parasite (53.75%). The prevalence of GIPs was higher in female chickens (51.35%) compared to males (32.78%). By age, the prevalence was higher in growers (66.66%) compared to adult chickens (51.35%). Among different breeds, Aseel chickens showed the highest prevalence of GIPs (54.76%), followed by undescriptive breeds (52.32%) and Naked Neck (50%). The study found that single gastrointestinal parasitic infections were more common, occurring in 89.04% cases, compared to mixed infections, which were found in 10.95% of cases. In the current study we concluded that backyard poultry may harbor a number of gastrointestinal parasites in District Dir Upper. The high prevalence rates, especially in specific breeds and localities, call for targeted interventions and improved management practices to control and reduce the burden of gastrointestinal parasites infections. The chi-square analysis revealed a significant association between geographical areas and the occurrence of gastrointestinal parasitic infections (single and mixed) ($\chi^2 = 27.074$, df = 6, $p < 0.001$). A significant association was also found between geographical areas and parasite species ($\chi^2 = 51.817$, df = 33, p = 0.020). Flock-wise analysis showed a highly significant association with infection occurrence ($\chi^2 = 17.728$, df = 2, $p < 0.001$), prevalence of single/mixed infections ($\chi^2 = 26.329$, df = 4, $p < 0.001$), and different parasite species ($\chi^2 = 46.589$, df = 22, p = 0.002). Risk estimate analysis showed no significant influence of gender (OR = 0.979, 95% CI: 0.580–1.651). In contrast, age groups showed a significant association with different parasite species ($\chi^2 = 29.252$, df = 11, p = 0.002).

Keywords: Prevalence, Backyard poultry, Gastrointestinal, *Ascaridia galli*

Prevalence of hemoparasites and their impact on hematological parameters in backyard poultry in district Dir upper

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Several hemoparasites frequently infect avian species, including chickens, significantly reducing productivity and often leading to high mortality rates. The purpose of this study was to determine the prevalence of hemoparasites and their impact on hematological parameters of backyard poultry in District Dir Upper. A total of 400 blood samples were collected from the wing vein of the chicken by using sterile syringes with (22-27, gauge needles), forming a thin blood smear and stained with Giemsa and screened out for parasites. The overall

prevalence of hemoparasites was 46.75%. The identified hemoparasites were *Aegyptienella, Haemoproteus, Leucocytozoon and Plasmodium*. Among these *Leucocytozoon* was the most prevalent found in *(*43.87%) of cases, followed by *Haemoproteus* (36.13%) and *Plasmodium* (18.07%). On the basis of gender and age hemoparasites were (57.14%) in male compared to female chickens (44.68%) and adult chickens exhibited a higher prevalence (47.29%) than growers (40%). Aseel chickens had the highest overall prevalence of hemoparasites at 66.66%, followed by undescriptive breeds at 44.77% and Naked Neck breeds at 35.71%. In the present study it was found that 82.88% of the infected chickens had single hemoparasitic infections, while 17.11% had mixed infections. In the current study we concluded that backyard poultry may harbor several hemoparasites in District Dir Upper. The high prevalence rates, especially in specific breeds and localities, call for targeted interventions and improved management practices to control and reduce the burden of haemoparasitic infections.

Key words: Backyard poultry, Hemoparasite**,** Prevalence, *Aegyptienella, Haemoproteus, Leucocytozoon, Plasmodium*

Removal of Polypropylene Microplastic from Aquatic Ecosystems using Different Coagulants Employing Chitosan as Coagulative Aid

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This work uses aluminium sulphate ($Al_2(SO_4)_3$) as a coagulant and hydrogel as an enhancer to remove polypropylene microplastics from aqueous matrices. Because it persists in water systems, hydrophobic microplastic polypropylene offers serious environmental problems. Aluminium sulphate neutralized charge and flocculated to produce coagulation, whereas the hydrogel enhanced particle aggregation and sedimentation. Coagulation was best at neutral pH (6-7.5), with 35-45 mg/L aluminium sulphate. Hydrogel increased microplastic removal by increasing floc size and trapping smaller particles for sedimentation. The combined method removed over 91% polypropylene microplastics and reduced water turbidity. A hybrid treatment approach for water microplastic contamination improves removal efficacy with low chemical consumption. Chitosan complements aluminium sulphate. To maximise removal effectiveness, add 10-20 mg/L chitosan and 35-45mg/L aluminium sulphate. The integrated technique allows for flexible wastewater treatment optimization, including microplastic-contaminated wastewater. Like aluminium sulphate and hydrogels, chitosan works best around pH 6-8. Hydrogels in coagulation procedures may improve microplastic treatment systems' environmental sustainability and scalability

Keywords: coagulation, flocculation, optimization, sedimentation, sustainability

Hematological, Histopathological and Hepatic Effect of Anthelmintic Drugs Derivatives in Domestic Chicken (*Gallus gallus* Domesticus)

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The aim of present study was to evaluate the effect of mebendazole derivative on hematology, liver function and histopathology in domestic chicken. Forty-five domestic chickens were divided into three groups (A, B, C) and sub-groups (R1, R2, R3) each subgroup contain five chickens. Group B and C were treated with mebendazole and mebendazole derivative orally for three consecutive days respectively. The blood sample were collected through fine needle syringe from brachial wing vein at end of experiment and analyzed for hematological and serological parameters. The chickens were sacrificed the intestine and liver were processed for histopathology. The present results of hematology of Group B (Mebendazole) and Group C (Mebendazole derivatives) revealed that The Red Blood Cells (RBCs), White Blood Cells (WBCs), Platelets (PLT), Lymphocytes (L), Granulocytes (G), Hemoglobin (HB), Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), Mean Corpuscular Hemoglobin Concentrations (MCHC), Mean Platelets Volume (MPV) were not affected ($P>0.05$) all hematological and serum biochemistry parameters(ALT, AST, SBR) value were in the normal range as compared to Group A (Control). The body weight of experimental chicken is not affected with drugs administration. Egg per gram in experimental group (B, C) show non-significant ($P<0.05$) in mebendazole group and in derivative compound as compared to control group which is significant $P>0.05$. Histomorphology of duodenum, jejunum and ilium, Villus Width (VW), Villus Height (VH), Crypt Depth (CD), Villus Surface Area (SA) show significant ($P>0.05$) as compared to Control group. It is concluded that the Mebendazole and its derivative are effective in controlling gastrointestinal parasites in chickens without any side effects. It is recommended that mebendazole derivative should be used for the control of gastrointestinal parasite infections in poultry, and further investigation and molecular study should be conducted in future.

Keywords: Anthelmintic drugs, Gastrointestinal parasite, Hematology, Histopathology

Assessment of Heavy Metal Pollution in Vehari Urban Soil

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Owing to the potential impact on human health, assessing heavy metal pollution in urban soil is critical. We conducted a thorough investigation of heavy metal contamination in Vehari urban soil and wastewater in this study. The objective of this study was to determine the levels of heavy metal contamination,

including cadmium (Cd), lead (Pb), arsenic (As), and chromium (Cr) in Vehari urban soil, wastewater, and plant samples collected from various locations. To achieve this goal, soil, wastewater, and plant samples were collected from various locations in Vehari urban areas. Heavy metal concentrations in these samples were determined using analytical techniques such as atomic absorption spectroscopy. Results revealed that pH, EC, and TDS were higher in wastewater samples collected from 75WB. Heavy metal concentrations varied from location to location in wastewater; however, maximum concentrations of Cd were found at 39WB, Cr at 39WB, and as at 75WB. The findings revealed that heavy metal contamination levels in Vehari urban soil varied. The soil samples contained Cd, Pb, As, and Cr with mean concentrations of 0.0020, 0.0032, 0.2239, and 0.0452 mg/kg, respectively. Pb and as had the highest concentrations, indicating potential sources of pollution in the urban environment. The contamination factor and pollution loading index based on the determined samples were less than 1; however, the ecological index was higher, indicating a potential threat of heavy metal pollution in this region. Plant metal concentrations were under permissible limits; however, translocation and bioaccumulation factors were greater than 1, indicating a risk of food chain contamination. Overall, this study adds to our understanding of heavy metal pollution in Vehari urban soil and the potential health risks associated with it.

Phytoremediation of cadmium from Wastewater using Water Hyacinth Plant

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In this study, water-hyacinth (*Eichhornia crassipes*) was examined as a potential Cd-remediation method from wastewater. To evaluate the water-hyacinths' Cd-removal potential, water hyacinths and suckers of the same size were planted in twelve plastic pots containing six different freshwaters (FW) to wastewater (WW) ratios (100:0, 80:20, 60:40, 40:60, 20:80, and 0:100). The first six pots contained only WW/FW (100:0, 80:20, 60:40, 40:60, 20:80, and 0:100) denoted as T1, T2, T3, T4 T5 and T6 respectively. In next six pots, 2mg/L Cd was added for each WW/FW, and denoted as by T8, T9, T10, T11, and T12. The highest Cd concentration (0.01625 mg kg-1 dwt) was observed in T11 for Root. The bioaccumulation factor (BAF) was higher (2.4 for T6 & T7) in the root than in the shoot (2.1 in T6 & T7). FW (T1) sediments act as a good sink for Cd in

addition to root and shoot, however, less Cd content in sediments at (T12) indicating inhibition of plant growth which restrict Cd bioaccumulation in *E. crassipes.* Moreover, an underlying mechanism for Cd-remediation has also been proposed. This study found that water hyacinth is a suitable plant for large-scale phytoremediation of wastewater that has a lot of heavy metals in it.

Keywords: Water-hyacinth, phytoremediation, wastewater, cadmium removal, water-pollution

Propagation method, quantitative, and qualitative phytochemical assessment of leaf and fruit extracts of a wild Himalayan grape: *Vitis jacquemontii*

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Vitis jacquemontii is a wild grape, and indigenous people use wild grapes as a substitute for cultivated grapes. Human activities pose a major threat to the plant's population. Plant tissue culture procedures are recommended for its protection. This study aimed to develop an effective method for inducing callus and shoots and to analyze the chemical constituents in the fruit and leaf extracts. The maximum callus fresh weight (3.12 grams) was achieved on a medium containing naphthalene acetic acid (NAA 1.5 mg/L). The medium supplemented with 1.5 mg/L benzyladenine (BA) produced a maximum of 8.34 per explant. The medium augmented with NAA had the highest shoot rooting percentage (51.23%) and the largest number of root (5.62). HPLC analysis confirmed eight compounds in the fruit extract (VJFME) and six in the leaf extract (VJLME). Rutine was an abundant compound in the VJLME extract, and quercetin was in the VJFME extract. Quantitative phytochemical analysis revealed higher total tannin (TTC), phenol (TPC), and flavonoids in the VJFME extract than in the VJLME extract. In conclusion, a regenerative system was established to produce materials from *V. jacquemontii* for bioactive compounds. The phytochemical analysis can enhance its commercial value and serve as a potential antioxidant compound in the future.

Keywords: Wild grape, Conservation, Micropropagation, Phytochemical profiling

Eco-Friendly Iron Oxide Nanoparticles for Seed Nano-Priming Boost Germination, Growth, Yield, and Iron Biofortification in Rice

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Nanoparticle-based fertilizers offer next-generation solutions for sustainably improving crop productivity and nutrient content. In this study, green-synthesized hematite nanoparticles (Fe_2O_3 NPs), derived from Brassica nigra seed extract, were applied as a seed nano-priming treatment in rice (Oryza sativa). The Fe_2O_3 NPs were spherical (14.05 ± 6.96 nm), highly stable (–50

mV), and characterized using standard techniques. Priming seeds with 50–150 mg/L of Fe_2O_3 NPs enhanced germination, α-amylase activity, water uptake, and early growth. At 150 mg/L, shoot and root lengths increased by 41% and 109%, respectively, while grain yield rose by 126% and 1000-grain weight by 62%. Chlorophyll a and b levels increased by 62% and 85%, and grain iron content rose by 144% (16.67 mg/kg), contributing up to 21% of daily iron requirements for men. The hazard risk index remained below 1, indicating safe application. These results suggest that phytogenic Fe_2O_3 NPs are effective, eco-friendly nano-fertilizers for improving rice yield and iron nutrition through a safe and sustainable approach.

Anthropogenic and Natural Drivers of Land Transformation: A Geospatial Investigation of LULC Dynamics in Dir District, Pakistan

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Land use and land cover changes (LULC) are caused both by natural as well as anthropogenic activities. While its impacts and associated driving forces on the regional environment is of great importance to understand the relationship between these changes and socioeconomic activities. For this purpose, the study in hand is aimed to investigate LULC during 2010-2022. Therefore, based on availability of data, Landsat satellite images for 2010, 2016, and 2021 for Dir District of KhyberPakhtunkhwa Province in Pakistan were acquired. These images were classified into five different types like snow, dense vegetation, light vegetation, waterbodies, and barren land using geospatial techniques. The results revealed a slight decrease in snow covered area from 2010 to 2016 while a notable decrease was observed from 2016 to 2021. There was a significant increase in the area under light vegetation, waterbodies, and barren land throughout the study period. Overall, area under snow cover decreased by 5.71% of the study area during the study period, while increased values of 9.13%, 2.44%, and 0.31% for light vegetation, barren land, and waterbodies, respectively. Similarly, dense vegetation was found with a decrease of 6.17% of the total study area. The outcomes of this study revealed that a significant land transformation has taken place in Dir District regarding a decrease in dense vegetation (forest and big trees) which is attributed with increase in urbanization and other associated infrastructure developments. Further, the increase in light vegetation is linked with increasing agriculture activities to fulfil the requirements of increased population. In this study, the remote sensing and geographical information system (RS and GIS) are found better to identify and

monitor these changes. This will help to restore degraded ecosystem services in the Dir District as well as other neighboring areas with same expected impacts. Further, these results will be used to manage agriculture activities in future environmental dynamics.

Keywords: land use and land cover, Landsat, remote sensing, GIS.

Determining Optimal First Flush Volumes to Enhance Rainwater Quality: Insights from Physicochemical Analysis in Nathiagali, Pakistan

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The first flush diversion is purposefully described as a practice to reduce both dissolved and suspended contaminants in rainwater installations. The use of a first flush diverter (FFD) is a low-cost method of improving the quality of the rainwater you harvest. This paper describes the calculated amount of first flush and quality of harvested rainwater in Nathiagali, Abbottabad through volume-based grab sampling of rainwater picked up directly from the catchments area (roof) and contains analysis of some physicochemical water quality parameters, including pH, turbidity, electrical conductivity (EC) and total dissolved solids. The first flush phenomenon isolates sediments, bird droppings, spiders, insects, mosquito eggs, and debris from reaching the storage tanks. Any initial rain should wash the roof before the water enters the main tank. While there is near consensus that this is a good practice, there are no accepted standards or conventions in the literature on the amount of water that should be diverted in the first flush as documented values are inconsistent. It depends on many subsequent factors influencing; the initial rainfall (rainfall intensity or average), size of roof, roof materials, slope, time and exposure before rainfall. The paper suggested that, first, 25 to 30 gallons of water should be diverted to the first flush.

Keywords: Rainwater quality, rainwater quantity, rainwater harvesting, first flush diverter

Integrative Omics Analysis Reveals Carbon and Flavonoid Biosynthesis Pathways Underlying Low-Phosphorus Resilience in Cotton

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Phosphorus (P) is an essential nutrient controlling plant growth and development through the regulation of basic metabolic processes; however, the molecular details of these pathways remain largely unknown. In this study, physiological, transcriptome, and metabolome analysis were compared for two cotton genotypes with different low P tolerance under P starvation and resupply. The results showed that the glucose, fructose, sucrose, and starch contents increased by 18.2%, 20.4%, 20.2%, and 14.3% in the roots and 18.3%, 23.3%, 11.0%, and 13.6% in the shoot of Jimian169 than DES926, respectively. Moreover, the activities of enzymes related to carbon and phosphorus metabolism were higher in the roots and shoots of Jimian169 than DES926. In addition, transcriptome analysis revealed that the number of differentially expressed genes (DEGs) was higher in both roots (830) and shoots (730) under P starvation and the DEGs drastically reduced upon P resupply. The KEGG analysis indicated that DEGs were mainly enriched in phenylpropanoid biosynthesis, carbon metabolism, and photosynthesis. The metabolome analysis showed the enrichment of phenylpropanoid, organic acids and derivatives, and lipids in all the pairs at a given time point. The combined transcriptome and metabolome analysis revealed that carbon metabolism and flavonoid biosynthesis are involved in the P starvation response in cotton. Moreover, co-expression network analysis identified 3 hub genes in the roots and shoots that regulate the pathways involved in the P starvation response. This study provides the foundation for understanding the mechanisms of low P tolerance and the hub genes as a potential target for the development of low P-tolerant genotypes.

Keywords: Cotton; Phosphorus starvation; Transcriptome analysis; Metabolome analysis; Flavonoid biosynthesis

Au–Ag Nanohybrid Immobilization of Fungal Cellulase for Enhanced Cellulose Degradation: A Comparative Assessment

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Cellulases play a pivotal role as hydrolytic enzymes responsible for breaking down cellulose into glucose. They are crucial for biofuel production and for waste, textile, and food processing industries. However, industrial applications are limited by low stability, poor enzymatic reusability, and high production costs. Using nanomaterials for enzyme immobilization offers enhancement in catalytic and operational stability. In this work, cellulase from *Aspergillus niger* was immobilized on silver-gold hybrid (Ag Au) nanoparticles which were synthesized using *Northern catalpa* leaf extract. Structural, compositional, and

morphological characterization of the nanohybrids was done using FTIR, XRD, SEM. Kinetic studies on free and immobilized cellulase comparisons showed the difference in Vmax and Km parameters, which showed increased catalytic activity and substrate affinity post-immobilization. In addition, the immobilized enzyme showed increased thermal and pH stability as well as increased reusability in multi-cycle operation. Permanent hydrolysis of cellulose were observed as continuous glucose was produced, which indicates a significant amount of cellulase remains functional in the system. This study offers a novel and environmentally friendly approach for cellulase immobilization with increased efficiency which may be utilized in biofuel production and other biotechnological applications.

Bioconversion of Feather Waste into Protein Hydrolysate Using Fungal Keratinase

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Over 24 million tons of chicken feather waste are generated annually by global poultry production, and improper disposal contributes to environmental hazards and loss of protein-rich resources. Keratinases, produced by microbes such as *Bacillus* and *Aspergillus*, play a crucial role in degrading resistant keratin from feathers, enabling their conversion into value-added products like organic fertilizers, animal feed, and biotechnological materials. The high keratin content of poultry feather waste makes it a significant environmental disposal challenge due to its slow degradation. The aim of the study was to produce and optimize keratinase from an indigenously isolated fungal source, characterize its activity and stability, and apply it to hydrolyze chicken feathers for the development of feather protein hydrolysate. Keratin was extracted from the chicken feathers to obtain a high yield of keratin. The yield of keratin was optimized by varying NaOH concentration, HCL concentration, alkaline hydrolysis time and neutralization time and its properties were analyzed through various biochemical and spectroscopic techniques such as SEM, FTIR and XRD, with the results indicating that higher amount of keratin production from chicken feathers and it was potential for future industrial applications. Keratinase was produced from microorganisms and then their production was optimized via BBD model of RSM. The study is consistent with the goals of environmental sustainability, economic development, and the advancement of green biotechnology and as a result feather protein hydrolysate can be utilized as a slow-release organic fertilizer, particularly for nitrogen, to provide an organic supply of nitrogen fertilizer.

Antioxidants and Nutraceuticals from Green Biotechnology

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Green biotechnology is increasingly recognized as a transformative approach for developing sustainable health-promoting compounds. Among its notable

contributions is the production of antioxidants and nutraceuticals, which play a critical role in combating oxidative stress, delaying cellular aging, and reducing the risk of chronic diseases. Traditionally, these bioactive molecules such as polyphenols, flavonoids, carotenoids, and vitamins have been sourced from plants, fungi, or marine organisms. However, conventional extraction methods are often limited by ecological constraints, variable yields, and high production costs. Biotechnological innovations provide an alternative, scalable pathway for consistent and eco-friendly production. Plant tissue culture and metabolic engineering enable the targeted synthesis of antioxidant molecules, while microalgae cultivation offers rich and renewable sources of carotenoids and polyunsaturated fatty acids. Synthetic biology tools and omics-guided approaches further allow the reprogramming of biosynthetic pathways, resulting in nutraceuticals with enhanced stability and bioavailability. Recent developments in nanobiotechnology and smart delivery systems have also improved the efficacy of these compounds, enabling precision applications in managing lifestyle-related disorders, cardiovascular disease, and neurodegeneration. Beyond health benefits, green biotechnology contributes to sustainability by reducing reliance on chemical synthesis and minimizing environmental impact. It also supports the principles of a circular bioeconomy by valorizing agricultural and food waste into high-value nutraceutical products. Nonetheless, challenges remain, including regulatory hurdles, public perception, and large-scale commercialization.

Keywords: Green biotechnology; antioxidants; nutraceuticals; metabolic engineering; microalgae; synthetic biology; bioeconomy

Development and operation of electrodialysis as sustainable water treatment technology

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The discharge of dye-containing effluents from textile industries poses a significant environmental challenge due to their toxicity, persistence, and resistance to biodegradation. In this study, a laboratory-scale electrodialysis (ED) system was developed to treat synthetic wastewater containing a model textile dye (Drim Black), with emphasis on cell design, operating conditions, and performance evaluation. The ED cell was fabricated from acrylic and comprised alternating cation- and anion-exchange membranes, carbon cloth–supported electrodes (aluminium anode and copper cathode), and a peristaltic feedback loop. Dye removal was monitored by UV–Vis spectrophotometry at 590 nm using a calibration curve (1–20 ppm). Under optimized conditions (12 V, 15 ppm dye, 120 min), the system achieved >90% decolorization, with

absorbance declining to ~0.01 (97% removal). Conductivity in the dilute stream decreased by ~70%, indicating efficient ion extraction, while solution pH remained near neutrality due to electrode reactions. Energy consumption was relatively low (~0.5 A at 12 V for 1 h), highlighting the economic feasibility of the process. The results demonstrate that electrodialysis with carbon cloth and sacrificial electrodes offers a cost-effective, energy-efficient, and environmentally sustainable approach for textile dye wastewater treatment. This work underscores the potential of ED technology as a climate-resilient alternative for industrial effluent management, minimizing chemical usage while ensuring high pollutant removal.

Keywords: Dyes, Electrodialysis, Drim Black, Wastewater, Energy

Proprietary-assured secure chemical compound search over public cloud

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Chemical compound data, often represented as graph-structured molecular graphs, plays a vital role in fields such as drug discovery, chemical informatics, and bioinformatics. Outsourcing such compound databases to public cloud platforms offers scalable computational resources for handling complex analytical tasks. Among these, full graph similarity search is an essential function for identifying structurally related compounds, which is crucial for compound retrieval, activity prediction, and molecular property analysis. However, outsourcing proprietary chemical data to the public cloud introduces serious privacy risks, as sensitive compounds must be encrypted before outsourcing. This encryption not only hinders the effectiveness of traditional similarity search algorithms but also complicates the enforcement of secure access control over outsourced data. In this paper, we tackle the problem of proprietary-assured secure chemical compound search in a privacy-preserving cloud computing framework. We propose a structure-aware and privacy-preserving similarity search scheme with integrated access control. The compound owner (CO) utilizes the neural Graph2vec model to generate feature indices for encrypted molecular graphs. A secure transfer learning mechanism enables compound searchers (CS) to construct query feature indices using the same pre-trained model without access to the raw data. Furthermore, the CO is able to define and enforce flexible access-control policies to safeguard proprietary chemical knowledge. A rigorous security analysis shows that the proposed framework achieves strong privacy guarantees against both known-ciphertext and known-background attacks, while maintaining efficient search performance. This makes our scheme a practical and secure solution for chemical compound retrieval over the public cloud.

Screening of Multi-Metals Hyperaccumulator Plants: Effects of Heavy Metals on Uptake and Tolerance

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Restoration of heavy metals contaminated soil is challenging due to the persistence and non-biodegradable nature of heavy metals. Due to the heterogenous nature of soil, one plant may be affective in the remediation of specific metal but may not efficiently remove other heavy metals. Therefore, the present study was conducted to evaluate the potential of ornamental plants for the uptake of lead (Pb), cadmium (Cd) and zinc (Zn). For this purpose, soil was spiked with Cd, Pb and Cd at150 mg kg-1, 1500 mg kg-1 and 1500 mg kg-1, respectively alone and in combinations. Seedlings of four ornamental plants (Marigold, Zinnia, Sunflower and Vinca) were transplanted in spiked and control soil (No heavy metal added). Plants were exposed for 30 days, kept in greenhouse, watered daily, and illuminated with natural light. Plant biomass was reduced in spiked soils as compared to control soil. Moreover, all plant species survived in soil spiked with single heavy metal. The plants showed lower biomass in soil spiked with Pb+Cd and Pb+Cd+Zn. The maximum toxicity was found in Pb+Cd treatment and Pb+Cd+Zn treatment as compared to the other treatments. Further, the maximum metal uptake was observed in Marigold and translocation factor was greater than 1. The Marigold plant is considered as multi-metal hyperaccumulator plant.

Keywords: Growth response, ornamental plants, heavy metals, metal accumulation

Detection and Molecular Typing of Multidrug-Resistant Milk-Borne Bacteria from local shops of district Mardan

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Milk possesses significant nutritional content, making it an ideal medium for bacterial proliferation; hence, it is vulnerable to contamination from diverse sources. This study examines the occurrence and genotyping of pathogenic bacteria (MDR) in milk samples obtained from different local milk vendors in the Mardan District. Total of 60 samples were collected and cultured on Mannitol salt agar (MSA), Eosin Methylene Blue (EMB) and MacConkey Agar (MAC). These isolates were initially identified through biochemicals tests like Gram staining, oxidase, coagulase, catalase and triple sugar iron (TSI) tests. The bacterial identification process uncovered several groups, including *E. coli,*

Klebsiella Species, *S. aureus* and *Shigella Species*. Among the 60 isolates, 11 demonstrated multi-drug resistance, showing resistance to a minimum of three distinct classes of antibiotics. The identification of these isolates, which are resistant to multiple drugs, was achieved by amplifying the 16S rRNA gene. Phylogenetic analysis revealed that five multi-drug-resistant isolates (EC1-MDR, EC2-MDR, EC3-MDR, EC4-MDR and EC5-MDR) were observed *E. coli* strains, while three isolate (SG1-MDR, SG2-MDR and SG3-MDR) was *Shigella Spp.* and two species were identified *Klebsiella Spp.* (KP1-MDR and KP2-MDR). Among all the isolates, Ciprofloxacin and Meropenem consistently showed the highest rates of susceptibility with averages between 84.67% and 92%, highlighting their potential as effective treatment options. Conversely, Ceftriaxone, Amoxicillin, and Nalidixic Acid demonstrated moderate susceptibility in specific groups. Conversely, antibiotics such as Penicillin, Chloramphenicol, Ampicillin, and Cefotaxime generally showed high levels of resistance, with averages surpassing 70%, indicating their reduced effectiveness in treatment. The highest levels of resistance were noted with Cefotaxime, Ceftriaxone, Ampicillin, and Penicillin, with average rates surpassing 80%, indicating substantial bacterial resistance. Most antibiotics showed low standard deviations (St dev = 1), suggesting consistent results across trials, except for Ampicillin in *Shigella Spp.* (St dev = 1.25) and Meropenem in *Klebsiella Spp*. and *S. aureus,* which exhibited slight variability. Statistical analysis indicates an inverse correlation between susceptibility and resistance, emphasizing the presence of multi-drug resistance in all isolates. Antibiotics like Ciprofloxacin, Ceftriaxone, and Nalidixic Acid, with susceptibility rates over 50%, were more effective. Conversely, those such as Cefotaxime, Amoxicillin, Penicillin, and Ampicillin, with resistance rates above 90%, showed significant bacterial resistance, potentially limiting their clinical application. The detection of these multi-drug-resistant bacteria in milk samples from local stores highlights the potential public health risks of consuming contaminated dairy products, posing a significant threat to people in the near future.

Key words: Milk contamination, Dairy safety, Antibiotics, Resistant profile, Public Health Risk

Phage-Based Biocontrol of Multi Drug Resistant *Salmonella Typhimurium* in Poultry

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In the poultry sector, significant financial losses are attributed to veterinary infections known as salmonellosis. *Salmonella* ranks among the leading

foodborne pathogens impacting global food producers and public health systems. The indiscriminate use of antibiotics has contributed to the proliferation of multidrug-resistant bacterial infections in livestock, diminishing the effectiveness of traditional treatment methods for infectious diseases. This situation has sparked renewed interest in phages among researchers since the early 21st century. Phages are abundant in nature, with up to 10^{31} particles present. In this study, we have successfully isolated and analyzed the Sal_J1 phage, which targets *Salmonella Typhimurium*, a primary cause of Salmonellosis. We assessed various characteristics of the Sal_J1 phage, including its stability under different heat and pH conditions, its one-step growth curve, host range, and how cations influence its adsorption rate to host species. The Sal_J1 phage produced well-defined boundaries and clear plaques, measuring between 1.7 and 3.2 mm, and exhibited a narrow host range, affecting only a few isolates of the bacteria under investigation. The phage could endure pH levels from 4 to 10 and withstand a temperature of 70°C for 60 minutes. Sal_J1 demonstrated an optimal multiplicity of infection ranging from 0.1 to 1. Transmission Electron Microscopy identified Sal_J1 as part of the Myoviridae family, featuring a contractile tail 25 nm wide and 140 nm long, with a 55 nm head. The one-step growth kinetics indicated latent periods of less than 22 minutes and a burst size of 256 PFU/Virion. These characterizations of the Sal_J1 phage provide a foundation for selecting the most effective bacteriophage to manage bacterial infections in the poultry industry.

Key words: *Salmonella Typhimurium*, Phage Therapy, Poultry, Antimicrobial Resistance.

CuO–ZnO Hybrid Nanoparticle Immobilized Fungal α-Amylase for Cassava Starch Liquefaction

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Fungal alpha amylase extracted from *Aspergillus niger* catalyses breakdown of starch into maltose. An enzyme with great industrial value used in food, pharmaceutical, brewing, and biofuel industries. Free α-amylase, nevertheless, is constrained by instability, low reusability, and troublesome recovery, limiting its practical application on an industrial scale. Immobilization of the enzyme on nanostructured materials provides an excellent approach to circumvent the disadvantages by enhancing enzyme stability, activity, and cost-effectiveness. The objective is to produce fungal αamylase, immobilize it on CuO/ZnO nanoparticles, and examine its kinetic, stability, and reusability properties in comparison to the free enzyme. CuO/ZnO hybrid nanoparticles were prepared by *Northern catalpa* leaf extract and used as a new support for immobilizing fungal α-amylase in this research. The nanoparticles and immobilized enzyme were characterized by FTIR, XRD, and SEM analysis. Free and immobilized α-amylase were compared in kinetic parameters, thermal and pH stability, reusability, and catalytic efficiency in cassava starch liquefaction. The

immobilized α-amylase showed increased thermal stability, better catalytic activity and retained its activity after 10 cycles of reuse. The immobilized enzyme showed activity after 30 days of storage while free enzyme lost its activity after few days. These results make CuO/ZnO hybrid nanoparticles environmentally friendly, and biocompatible immobilization support for enzymes that provides sustainable and cost-effective solutions to starch processing and other industrial enzyme applications.

Electrochemical cleaner water production from industrial effluent and it's effect on wheat crop

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Wastewater produced from industrial sector including cosmetic industry introduced hazardous organic compounds such as phthalates which are categorized as endocrine-disrupting chemicals (EDC) into the environment, posing significant serious risk to ecosystem and agricultural productivity. These substances are resistant to traditional treatment methods and persistent in environment. In this study, an electrochemical treatment method with three electrode system i.e., refrence, counter and working electrode was developed in order to breakdown of phthalates from industrial wastewater, with emphasis on assessing the treatment efficiency and then reuse of the treated water for agricultural purposes. For this Carbon nanotubes (CNTs) were synthesized by Chemical vapor deposition (CVD) method using lemon peel as a carbon source. Modification of carbon nanotubes were accomplished by using sodium molybdate (Na2MoO4) and nickle-aluminum (Ni-Al). These materials were used as electrode for the wastewater treatment in the electrochemical cell. The performance of the synthesized materials toward the hydrogen evolution reaction (HER) and oxygen evolution reaction (OER) was evaluated using linear sweep voltammetry (LSV), cyclic voltammetry (CV) to evaluate their activity toward the hydrogen evolution reaction (HER) and oxygen evolution reaction (OER). The experiments were conducted in both acidic (H_2SO_4) and alkaline (KOH) media with different scan rates and different phthalate concentrations of 30 ppm, 60 ppm, and 90 ppm, and chronopotentiometry was used to assess the phthalates degradation in real cosmetic industrial wastewater. The removal efficiency showed by modified CNTs for removal of phthalates was 93% and 88% respectively. The treated wastewater was further applied to pot experiment to examine the effect of plant growth with 2 varieties of wheat i.e. Akbar-19 and Desi variety was examined. Growth parametes like Root length, shoot length, root and shoot weight and rot and shoot dry weight was monitored. Both varieties of wheat showed improved growth irrigated with treated WW as compared to those irrigated with untreated WW. This research shows that synthesis of modified CNTs was proven to be an efficient catalyst in

electrochemical cell in terms of phthalate removal and treated WW showed significant growth in wheat.

Keywords: Wastewater, Phthalates, Electrochemical treatment, Wheat, Climate, Nano tubes

Removal of polyethylene in wastewater using electrocatalysis

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Polyethylene (PE) is the polymer that is used in almost all pipe-manufacturing industries. After that, it is often disposed of in nearby water bodies, causing water pollution. PE has a severe impact on human and environmental health even at low concentrations. It also significantly affects the aquatic environment. The electrocatalysis method has shown high efficiency in degrading a variety of organic substances in wastewater. In the present study, NiMoMn, NiMn, NiMoBa, and NiMo were developed as working electrodes to remove PE in wastewater. The samples were collected from the I-9 industrial area (Akbar & Zikria (Pvt) ltd) and analyzed for physicochemical properties and organic constituents, including concentration of PE. This study examined the electrochemical removal of polyethylene utilizing nickel-based aerogels and nanocatalysts. The performance of synthesized materials towards the hydrogen evolution reaction (HER) and oxygen evolution reaction (OER) was evaluated using linear sweep voltammetry (LSV), cyclic voltammetry (CV), and Chrono potentiometry were used to test electro-oxidation and catalytic efficiency. The experiment was conducted in both acidic (H2SO4) and alkaline medium (KOH) with different scan rates and different polyethylene concentrations of 25 ppm, 50 ppm, and 75 ppm. The process was monitored using a three-electrode system, i.e., reference, counter, and working electrode, equipped with a potentiostat. The results showed the 92% removal by NiMoMn aerogel, while the NiMo nano catalyst shows maximum degradation to 94.95% of PE in synthetic wastewater. All the electrode materials remain stable for an 8 h experiment of Chrono potentiometry, showing that the novel material has good electrochemical degradation and can be used for large-scale medium.

Keywords: Electro-catalysis; Polyethylene (PE); Wastewater Treatment; Nickel, Electro aerogel

Green Synthesis of Iron Oxide Nanoparticles for Improved Rice Growth and Iron Translocation

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Iron is an essential trace element, and its deficiency has become a major global concern affecting the health and nutrition of staple crops. In this study, iron oxide nanoparticles were biosynthesized using a green synthesis approach and

characterized by UV–Vis, XRD, SEM, TEM, EDX, and FTIR analyses. The effect of foliar application of these nanoparticles on rice growth and iron accumulation in roots and shoots was evaluated. The UV–Vis spectrum showed an absorption peak at 358 nm, while XRD confirmed their crystalline nature. EDX analysis revealed a high proportion of iron and oxygen, and TEM images showed spherical nanoparticles with an average size of 6.6 nm. FTIR spectra indicated the presence of functional groups involved in nanoparticle formation. Foliar application at 100 mg/L significantly improved plant height, biomass, photosynthetic pigments, and iron content compared with controls. These findings suggest that iron oxide nanoparticles are a promising strategy for enhancing iron translocation and promoting rice growth. Their application could also be extended to other major crops such as wheat and maize to improve development and nutrient uptake.

Identification and molecular characterization of mobile antibiotic resistance gene in clinical bacterial isolates form hospital samples

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The rise of multidrug-resistant (MDR) bacteria is a critical threat to healthcare, largely driven by mobile antibiotic resistance genes (ARGs) carried on plasmids, integrin's, and transposons. This study aims to identify and characterize mobile ARGs in bacterial isolates from hospital samples. Clinical specimens (blood, urine, sputum, wound swabs) will be processed for bacterial identification, antibiotic susceptibility testing, and molecular detection of ARGs. Whole-genome sequencing and bioinformatics will be used to explore genetic contexts, while conjugation assays will assess gene transferability. The findings will provide essential data on the prevalence and mobility of ARGs in clinical pathogens, contributing to infection control measures and antibiotic stewardship programs.

Keywords: Antibiotic resistance, Mobile genetic elements, Multidrug-resistant bacteria, Clinical isolates, Horizontal gene transfer, Whole-genome sequencing

Green Biotechnology, Climate Change and the Role of Law: Lessons from the Floods in Buner

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This paper explores the connection between green biotechnology, climate change, and legal frameworks with a particular focus on the recent floods in Buner, Khyber Pakhtunkhwa. The study highlights how deforestation, unplanned construction, and human negligence have aggravated the impacts of climate change, leading to frequent floods and soil erosion in the region. Green biotechnology offers sustainable solutions such as genetically modified crops,

biofuels, and eco-friendly agricultural practices that can help reduce environmental damage. The legal system has a vital role in implementing environmental laws, ensuring responsible land use, and protecting natural resources. The paper argues that science and law must work hand in hand to mitigate the threats of climate change. The case of Buner's devastating floods provides a lesson that negligence of nature and weak governance intensify climate risks. If appropriate legal and environmental steps are not taken, the people of Buner and other regions of Pakistan will continue to face devastating floods and climate-induced disasters.

Keywords: Green Biotechnology, Climate Change, Law, Buner Floods, Environmental Governance

Climate Change and Sustainable Tourism in Pakistan: Challenges and Opportunities A Case Study of District Dir Upper

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Tourism plays a big role in Pakistan's economy, culture, and community growth. But climate change is becoming a bigger problem for tourism, especially in areas that are ecologically important and located in mountains, like District Dir Upper. This study looks at how things like hotter weather, unpredictable rain, and damage to the environment are affecting tourism activities, the buildings and facilities that support tourism, and the jobs and income of local people. It also looks at ways to make tourism more sustainable and able to handle climate challenges, such as using eco-friendly methods, getting local people involved, and making good plans. The study uses a case study of District Dir Upper to show how local efforts, green buildings, and efforts to raise awareness can help deal with climate risks and improve tourism. The study finds that including smart climate strategies in tourism development is key to protecting nature, helping local communities, and making sure tourism is both economically and environmentally sustainable in the long run. In the end, this study shows that making tourism in District Dir Upper sustainable can be a good example for other parts of Pakistan to follow in balancing development with the ability to handle climate change.

Keywords: Climate Change, Sustainable Tourism, District Dir Upper, Tourism Development, Environmental Challenges, Opportunities, Community Resilience, Eco-Tourism

Quantifying the population ecology of common crane in captivity in Bannu district

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Identifying the population environment is a crucial step in determining whether the population is fluctuating in the study area or declining. It also helps determine conservation actions. In order to quantify the population ecology of

common cranes in district Bannu and to understand their major threats, a questionnaire survey was conducted. A demographic analysis revealed that the respondents were males, females, and children. There is a wide range of age groups and professions among them. In wilderness, a total 727 individuals of Demoiselle cranes (51.44%) and Eurasian cranes (48.56%) were recorded by direct visual observations. The populations of both crane species included chicks, males, and females. A major threat to cranes was trapping with nets and soya (27.20%), while a minor threat is habitat fragmentation (6.40%). The majority of attacks on the common crane were caused by domestic dogs (37.60%), while eagles were less frequently attacked (8.00%). As a result of various anthropogenic threats, the population of common cranes in Bannu district is declining day by day. A comprehensive study is therefore necessary to determine the population, threats, breeding ecology, foraging and breeding behavior, as well as habitat preferences.

Keywords: captive breeding, demoiselle crane, Eurasian crane, pesticide, mortality.

Seroepidemiology of *Toxoplasma gondii* in Pregnant Women of Northern Pakistan

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Toxoplasma gondii is an intracellular protozoan parasite of major zoonotic importance, with transmission pathways that connect humans, domestic animals, and the environment. Pregnant women represent a particularly vulnerable group, as infection can lead to severe outcomes for both mother and fetus. Understanding the epidemiology of *T. gondii* is essential for developing integrated strategies under the One Health framework, particularly in climate-vulnerable regions where changes in environmental conditions may influence pathogen persistence and transmission dynamics. This study investigated the seroepidemiology of *T. gondii* among 367 pregnant women in Dir Upper District. Venous blood samples were collected and analyzed using immune chromatographic tests (ICT) and enzyme-linked immunosorbent assay (ELISA) for detection of IgM and IgG antibodies. Socio-demographic and exposure-related data were gathered through structured questionnaires, and chi-square tests were applied to identify risk associations. The overall seroprevalence of *T. gondii* infection was 34.6%. A significant association ($P < 0.05$) was observed between infection status and contact with domestic animals, particularly cats, whereas maternal age, trimester of pregnancy, and history of stillbirth showed no significant correlation ($P > 0.05$). These findings highlight the importance of awareness campaigns, improved food safety practices, and minimizing direct exposure to potential reservoirs during pregnancy. By integrating zoonotic surveillance with maternal health interventions, this study contributes One Health insights that can support climate-resilient public health strategies.

Strengthening community-level awareness and preventive practices is crucial to mitigating the risks of *T. gondii* infection in vulnerable populations.

Keywords: *Toxoplasma gondii*; seroepidemiology; zoonotic disease; pregnant women; One Health; climate resilience; Pakistan

Exploring the biological application of exopolysaccharides derived from endophytic

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Endophytic fungi inhabiting plant tissues are gaining recognition as rich sources of bioactive secondary metabolites with diverse biomedical potential. Among these, exopolysaccharides (EPS) have drawn significant attention due to their antioxidant, anti-inflammatory, antidiabetic, and antibacterial properties. In this study, fungal endophytes were isolated from different parts of the wheat plant (*Triticum aestivum*) and identified as Wh1, Wh2, Wh3, and Wh4. Strains producing high EPS content were cultivated in yeast extract–peptone–dextrose broth at 25 °C for 7 days under shaking conditions. EPS were precipitated with ice-chilled ethanol and biochemically characterized, revealing considerable carbohydrate content in all isolates, with Wh4 showing the highest (10.8 µg/mL). Monosaccharide analysis showed varying concentrations of uronic acids, unsaturated uronic acids, pentoses, and hexoses. Biological assays revealed remarkable bioactivities. Wh2 and Wh3 demonstrated strong antioxidant potential, scavenging 73.00% ± 3.22 and 77.81% ± 1.42 of DPPH radicals, respectively, at 1000 µg/mL. Wh4 exhibited the highest anti-inflammatory activity (88.34% ± 1.14; IC_{50} = 163.60 µg/mL). Wh3 showed the most potent α-amylase inhibition (87.17% ± 4.21; IC_{50} = 301.39 µg/mL), signifying promising antidiabetic potential. In antibacterial testing, EPS from all strains exhibited reasonable to strong inhibition against *Escherichia coli* and *Staphylococcus aureus*, with Wh2 achieving maximum zones of inhibition of 6.75 mm (*E. coli*) and 10.75 mm (*S. aureus*) at the highest concentration. Overall, these findings highlight wheat-derived endophytic EPS as multifunctional bioactive compounds with significant therapeutic promise. Their natural origin, sustainability, and broad-spectrum biological activities position them as a valuable resource for developing eco-friendly and innovative biomedical solutions.

Keywords: Endophytes, Exopolysaccharides, Wheat plant, Bioactive compounds

The role of transcription factor genes (CBF/DREB) in metals phytoremediation.

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The C-repeat binding factor/dehydration responsive element binding proteins (CBF/DREB) constitute a large group of transcriptional factors. Their role in abiotic stresses such as drought, salinity and low temperature tolerance in plants have been well established, while little information about their role in metals stress tolerance is available. Transcriptomic analyses of four genes (DREB-1A, DREB-1B, DREB-1F and CBF) were carried out in Ricinus communis under cadmium (Cd) and molybdenum (Mo) treatments. Cadmium (in soil) and Mo (as foliar spray) were used separate as well as in combinations. All the genes (except DREB 1A) expressed under Cd stress, while Mo further enhanced their expression. The proline (55.68±5.51ppm) and phenolic (120.00±14.40ppm) contents were significant increase in combination treatments of Cd and Mo. Positive and significant correlations of DREB 1B, DREB 1F and CBF genes expressions with free proline (0.92, 0.93 and 0.88 respectively), phenolic (075, 0.77 and 0.62 respectively) contents and Cd accumulation were demonstrated. Nucleotide sequence of R. comunis DREB1F and CBF genes showed more than 80% homology with related genes of other flowering plants. Predicted amino acids sequence of R. communis DREB 1F and CBF protein fragment demonstrated more than 75% homology with related proteins from other flowering plants.

Keywords: Ricinus communis, DREB/CBF, Cadmium tolerance

Prevalence, Risk Determinants, and Diagnostic Performance of ELISA and SPAT in Human Brucellosis

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Brucellosis is a zoonotic disease caused by the gram-negative, intracellular bacterium *Brucella*. Although endemic in Pakistan, data on its prevalence, risk factors, and diagnostic accuracy remain limited. This study assessed the prevalence of brucellosis, identified associated risk factors, and evaluated the performance of diagnostic tests in local communities of District Dir Upper, Khyber Pakhtunkhwa, Pakistan. A total of 345 suspected individuals were investigated. Blood samples and structured questionnaires were collected to document socio-demographic information and potential exposures. To evaluate diagnostic performance, 50 culture-confirmed positive cases and 50 negative controls were tested using the Enzyme-Linked Immunosorbent Assay (ELISA) and Serum Plate Agglutination Test (SPAT). The overall prevalence of brucellosis was 17.1% (59/345). Females showed a slightly higher prevalence

(17.58%) than males (16.56%), with the highest rate in individuals aged ≤ 20 years (32.5%). Significant risk factors included animal contact ($p = 0.0075$) and raw milk consumption ($p < 0.001$). ELISA demonstrated higher diagnostic accuracy, with a sensitivity of 94.0% and specificity of 98.0%, compared to SPAT (sensitivity: 92.0%, specificity: 96.0%). These findings confirm that brucellosis remains a public health concern in the region. ELISA is a more reliable diagnostic tool than SPAT. Broader studies are needed to validate these results and guide prevention and control strategies in endemic communities.

Keywords: Brucellosis; zoonotic disease; *Brucella* spp.; prevalence; risk factors; ELISA; SPAT; Pakistan

Cress polysaccharides mediated synthesis of nickel oxide and silver nanoparticles for biological applications

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Phytochemical-assisted biosynthesis of nanomaterials offers an eco-friendly alternative to traditional methods. This study presents the synthesis of silver (Ag-NPs) and nickel oxide nanoparticles (NiO-NPs) using cress seed mucilage polysaccharides (CSMP) as a reducing, stabilizing, and capping agent. AgNO3 and NiNO3 served as precursors in the hot plate combustion method. Characterization of the NPs was conducted using UV-visible and Fourier-transform infrared (FT-IR) spectroscopy. The biocompatibility of Ag-NPs and NiO-NPs was confirmed through hemolysis assays, showing no toxicity at low concentrations. Cytotoxicity assessments revealed CC50 values greater than 10,000 µg/mL for CSMP, 2346 µg/mL for Ag-NPs, and 1987 µg/mL for NiO-NPs, indicating their safety at lower concentrations. The antioxidant activity of the NPs, evaluated using the DPPH assay, showed Ag-NPs stabilizing DPPH radicals by 85.67 ± 1.01% at 400 µg/mL, comparable to ascorbic acid (96.91 ± 2.05%). Ag-NPs also exhibited significant inhibition of α-amylase (89.03 ± 3.71%) and α-glucosidase (90.83 ± 3.54%) at 400 µg/mL, surpassing NiO-NPs and CSMP, and approaching the effectiveness of the standard drug acarbose. Antibacterial assays demonstrated that both Ag-NPs and NiO-NPs effectively inhibited the growth of Pseudomonas aeruginosa, Klebsiella pneumoniae, Haemophilus influenzae, and Escherichia coli. These findings suggest that CSMP offers a sustainable and effective method for the green synthesis of bioactive Ag-NPs and NiO-NPs with potential applications in biomedicine and agriculture.

Keywords: Silver nanoparticles, nickel oxide nanoparticles, antioxidant, antidiabetic, antibacterial, green synthesis

Evaluation of *in vitro* and *in vivo* anti-inflammatory potential of bioactive polysaccharides from *Salvia hispanica l.* (chia) seed mucilage

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Inflammation is a crucial immune response to pathogens, cell damage, and harmful substances. Although various drugs are available to treat inflammation, they often have side effects. Plants, especially those with bioactive compounds, offer alternative therapeutic options. *Salvia hispanica L,* commonly known as chia, is a significant medicinal plant rich in bioactive ingredients and therapeutic polysaccharides. This study aimed to extract and fractionate the bioactive polysaccharides from chia seed mucilage and determine their anti-inflammatory effects *in vivo* and *in vitro*. Chia seeds were soaked in distilled water, and mucilage was precipitated using 75% ethanol. The resulting fraction underwent size-based fractionation using Bio-Gel-P-10 gel filtration chromatography, yielding 60 fractions screened for carbohydrate content. Biochemical analysis revealed the presence of uronic acids, pentoses, and hexoses. *In vitro* anti-inflammatory activity was assessed using the HRBC membrane stabilization assay, while *in vivo* effects were evaluated with the carrageenan-induced paw edema model in mice. Results showed that the Ch19 fraction significantly stabilized HRBC membranes (EC50=8.75 µg/mL), and the Ch39 fraction at 1000 µg/mL resisted heat-induced membrane destabilization by 97.20%. Furthermore, the *in vivo* activity showed that Ch31 fraction significantly reduced the volume of the mice's paw edema by 91.37%. These findings suggest that the ethanol-precipitated fraction of chia seed mucilage contains medium-sized polysaccharides with substantial anti-inflammatory potential, indicating their promise for further preclinical and clinical trials as treatments for inflammation and related diseases.

Keywords: Anti-inflammatory, Bioactive polysaccharides, *Salvia hispanica L.*, Mucilage

Effects of melatonin on biomass and secondary metabolites production in *Moringa oleifera*

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Melatonin is a pleotropic molecule, regulating key biological pathways in plant including growth, rooting, seed germination, photosynthesis and defense against biotic and abiotic stresses. Moringa oleifera, commonly known as drumstick trees, is a nutritional plant found across the globe. The current study aims to

evaluate the effect of melatonin on callogenesis and regeneration in Moringa and to analyze the biochemical and metabolomics profile of the calli and regenerated plants. Moringa seeds were cultured on MS basal medium containing 3% sucrose, 0.9% agar supplemented with different concentrations of melatonin (0, 5, 10, 15, 25, 35 and 50 mg/L) and incubated at 25 ± 1°C for germination. Next, Moringa seeds were cut down into 2 to 4 pieces and then cultured on the same medium with addition of BAP (1.0 mg/l) and 2,4-D (2.0 mg/l). Further, color, texture, fresh and dry biomass of the calli were evaluated. In addition, the seedlings were explored for their morphological and biochemical attributes. The results revealed that melatonin supplemented with BAP and 2,4-D, significantly improved the quality and biomass production. Biochemical characterization shows that enhanced concentration of phenolics, alkaloids and terpenoids were produced in the in vitro Moringa plant and callus. The current study concludes that melatonin as an effective elicitor in improving the quality and quantity of bioactive compounds in M. oleifera cultures. However, further studies are needed to explore the molecular pathways, involved in melatonin-induced metabolites production, contributing to the production of plant-derived pharmaceuticals.

Keywords: Melatonin, Moringa oleifera, in vitro culture, bioactive metabolites

Faith-Based Approaches to Climate Resilience & Sustainable Development: Ethical, Spiritual and Policy Perspectives

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Climate change has emerged as one of the most critical global challenges, threatening ecosystems, livelihoods, and the achievement of Sustainable Development Goals (SDGs). While scientific and technological innovations remain indispensable, faith-based approaches provide a unique moral and spiritual dimension to climate resilience and sustainability. Rooted in sacred texts, theological traditions, and responsibility toward future generations. The Quranic concepts of Khalifah (stewardship), Meezan (balance), and prohibition of Israf (wastefulness) directly complement SDG 13 (Climate Action) and SDG 15 (Life on Land). similarly, Christian theology, particularly in Pope Francis Laudato Si, highlights ecological justice and care for the common home, while Buddhist and Hindu philosophies underscore compassion, harmony, and interconnectedness. Indigenous traditions further enrich this discourse by linking spirituality with land, forests, and water systems as sacred trusts. Faith-based organizations (FBOs) represent some of the world's largest social networks, capable of mobilizing millions for grassroots climate action. Their engagement in disaster relief, renewable energy initiatives, and advocacy for climate justice demonstrates the intersection of spirituality and practical resilience. Moreover, interfaith collaboration offers a powerful platform for building global solidarity in advancing the SDGs. This paper argues that integrating faith-based ethics with scientific strategies creates a holistic framework for climate resilience. By bridging spirituality, policy, and environmental stewardship, faith traditions can

transform climate discourse into a moral imperative, making sustainability not only a policy goal but also a spiritual duty.

Keywords: Climate Resilience, Sustainable Development Goals (SDGs), Faith-Based Approaches, Islamic Environmental Ethics, Eco-Theology, Interfaith Collaboration, Climate Justice, Spiritual Ecology, Indigenous Knowledge, Moral Responsibility

Wheat exopolysaccharide-mediated green synthesis of nickel oxide nanoparticles with enhanced antioxidant activity

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Nanoparticles, fundamental to nanotechnology, are known for their distinct chemical, optical, and mechanical properties, which differ significantly from their bulk material counterparts. Due to increasing environmental toxicity concerns, this study focused on the eco-friendly biosynthesis of metallic nanoparticles (MNPs) using exopolysaccharides (EPS) extracted from endophytes of *Triticum aestivum* (wheat). The process involved dissolving 10 mg of wheat seed polysaccharides in distilled water, followed by mixing with nickel nitrate to achieve a final concentration of 10 mM. The formation of nickel oxide nanoparticles (NiO-NPs) was indicated by a color change and confirmed through UV-visible spectroscopy. The green-synthesized MNPs were characterized using double-beam UV and FT-IR spectroscopy to identify the specific biomolecules involved in their formation, with X-ray diffraction (XRD) analysis determining their crystalline structure. The biological potential of these nanoparticles was assessed through various bioassays, including antioxidant activity evaluation using the DPPH radical scavenging method and hydrogen peroxide inhibition. Among all screened samples, NiO NPs showed the most significant antioxidant potential, with an EC50 value of 37.93 µg/mL, followed by EPS at 66.04 µg/mL. At 200 µg/mL, NiO NPs effectively scavenged the H2O2 free radical by 81.9%±0.24, followed by EPS at 76.54%±0.65. These results highlighted the effectiveness of NiO NPs, emphasizing their potential for sustainable applications in nanomedicine and nanobiotechnology.

Keywords: Eco-friendly synthesis, Nickel oxide nanoparticles, Exopolysaccharides, *Triticum aestivum*, Antioxidant activity

Avifauna Diversity, Distribution and Abundance at Tehsil Sheringal, District Upper Dir, Khyber Pakhtunkhwa Pakistan

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The current study was undertaken at tehsil Sheringal to find out the avifauna diversity, distribution and abundance at four different habitats viz alpine, forest,

agro forest and riparian habitat of the study area in the summer season during the period from April, 2018 to September, 2018. Direct survey methods such as point count and line transects were employed and the diversity, distribution and abundance of bird's species have been determined by visual sighting, calls and capturing pictures. During the entire survey total 3958 individuals were recorded belonging to 66 different species and 24 different families. Data were analyzed by Species Diversity Richness software (SDR). And the diversity index, species richness and species evenness of each habitat type was determined which shows that agroforest is densely populated with Shannon-Weiner diversity index is 3.367, in forest 3.296, in riparian 3.135 whereas the alpine habitat is least populated with diversity index is 2.639. Similarly, the species evenness is highest in the forest habitat 0.904, agroforest 0.848, riparian 0.843 and lowest 0.799 in alpine habitat. The dominant families were Muscicapidae represented by 15 species, Passiridae 09 species and Corvidae comprising 06 species. The most common and wide spread species of the area were Common myna (11.82%), House sparrow (8.49%), Yellow-belled cough (7.40%), Great tit (6.90%) and Streak laughing thrush (6.75%). The major threats to the avifauna of the study area have also observed such as deforestation, use of insecticides and pesticides in agriculture field, removing of shrubs, illegal hunting, overgrazing and trapping etc. The conservation status of most of the recorded species is least concern.

Occupancy of amphibians' population in different habitats of tehsil Sheringal district Dir upper, Khyber Pakhtunkhwa, Pakistan

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The current study was carried out at Sheringal valley, Dir Upper to find out the occupancy of amphibian's population in three different habitats viz riparian, agriculture and forest. An extensive field surveys were conducted from June 2020 to August 2020. During the field work different physical parameters like temperature, humidity and water level were recorded along with the amphibian specimens. In this entire field work total 89 specimens were collected and then photographed. Out of 89 specimens 51 were collected from the riparian habitat, 38 from the agriculture while no species was found in forest habitat. The samples were identified with the help of dichotomous taxonomic keys and experts which confirmed that they are different phenotypes based on habitats, sex, age and belong to single species *Bufo stomaticus* and order Anura (Salientia). Similarly, percentage of occupancy at habitat wise is 57.3%, 42.7% and 0% respectively. Riparian habitat was declared as the most favorable followed by agriculture habitat due to abundant food sources, vicinity to the water, whereas forest habitat was declared as the poorest for the survival of Indus valley toad due to the distance from the water and abundance of predators. In the survey no major threats were observed to the species. According to IUCN

the conservation status of the species is Least Concern (LC) while the species was found to be most abundant and widely spread in the study area.

Biofertilizer Potential of *Gallus gallus domesticus* Feathers using Indigenous Bacterial Strains

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Biofertilizers are increasingly recognized as eco-friendly alternatives to chemical fertilizers in response to the global demand for sustainable agriculture. This study explores the potential of utilizing locally isolated microbial strains to convert poultry feather waste, a major byproduct of the poultry industry into nutrient-rich biofertilizers. Keratinolytic *Bacillus* strains were isolated from poultry farm soils in Peshawar, Pakistan, with a focus on the degradation of *Gallus gallus domesticus* feathers. Among the tested samples, rooster feathers exhibited the highest degradation rate when treated with *Bacillus* strain A, compared to domestic and agricultural feathers. Optimal degradation occurred at 50 °C, pH 7.0, and a 10-day incubation period. The resulting feather-derived biofertilizer (FDBG) significantly outperformed synthetic fertilizers, enhancing the growth of *Pongamia pinnata* (Sukh chain) seedlings in height and in leaf number over 30 days. Soil analysis further confirmed improved nutrient availability, particularly nitrogen, phosphorus, and potassium, in FDBG-treated plots. These findings highlight the dual benefits of feather waste valorization, reducing environmental challenges linked to poultry waste disposal while producing a sustainable, low-cost biofertilizer. The study underscores the promise of indigenous microbial strains in advancing circular economy practices and delivering scalable solutions for resource-limited agricultural systems in Pakistan and similar contexts.

Clinical and demographic variables of Beta-Thalassemia patients from Swat

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Cotton is one of the leading sources of foreign-exchange revenues playing a key role in the economy of Pakistan. Most of the cotton produced in the area initiates from *Gossypium hirsutum* (the tetraploid cotton), even though the diploid inherent species *G. arboreum* still subsidize to its manufacture in the region. It is feared that the Begomovirus-complexes, responsible for the 1st epidemics of Cotton Leaf Curl Disease (CLCuD) in the 1990s and more specifically the 2nd epidemics in the 2001-02 which was caused by a single (the Burewala) strain of Cotton Leaf Curl Kokhran Virus (CLCuKoV-Bu), might spread its circle of occupancy to regions where it is right now extinct __ as was evident from its newest invasion to parts of China, a considerably far located area from CLCuD-affected zones in the Indo-Pak sub-continent. The terror was broadcasted even further when the CLCuBuV-Bu was testified in *Hibiscus Rosa sinensis* and in

plants like *Solanum melongena*. Currently no single commercially available cotton or alternative host-plants are fully capable of resisting CLCuKoV-Bu. Owing to the very devastating nature of the CLCuKoV-Bu in Punjab and Sindh regions of Pakistan it was dreaded that CLCuKoV-Bu might find its way to Northern regions (Dir Upper) of Pakistan. Begomovirus-specific symptoms were observed in Brinjal and Turnip plants in Darora and Chokyatan regions of Dir (Upper). The presence of Begomovius-complex was detected by rolling circle amplification/polymerase chain reaction (RCA/PCR) diagnostics. Through RCA/PCR, using full-length virus and betasatellite specific primers pairs, Begomovirus-complexes were amplified, cloned and sequenced. The sequencing analysis have shown these Begomoviruses-complexes from both Brinjal and Turnip plants to be CLCuKoVBu/CLCuMuB.

Keywords: CLCuD, Brinjal, Tunip, CLCuKoV-Bu, *Gossypium hirsutum*.

Evaluating the prebiotic effects of chia seed-derived oligosaccharides on human probiotics

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Prebiotics, non-digestible compounds that enhance beneficial gut microbiota, have gained attention for their role in improving gut microbiome health. Mucilage from *Salvia hispanica* (chia), rich in polysaccharides, is a promising dietary component with multiple health benefits. The current research aimed to produce bioactive oligosaccharides from chia seed mucilage and evaluate in vitro prebiotic effects on human probiotics. Polysaccharides extracted from chia seed mucilage were precipitated with 75% ethanol, digested by *Pichia pastoris*, and purified via size exclusion chromatography. Biochemical analysis revealed that fraction ChF78 had the highest unsaturated uronic acid (7.79 ± 0.71 mg/mL), fraction EPP had the highest uronic acid (5.57 ± 0.32 mg/mL) and pentose (6.54 ± 0.30 mg/mL), while fraction ChF90 had the highest hexose content (4.60 ± 0.12 mg/mL). Prebiotic effects were notable in fractions ChF91 and ChF90, which significantly enhanced the proliferation of *Bifidobacterium bifidum* and *Bifidobacterium clausi*, achieving cell counts of 9.11 ± 0.17 log10 CFU/mL and 9.96 ± 0.30 log10 CFU/mL, respectively, at 48 hours. The acidifying effect was strongest in EPP and ChF91 fractions, with pH levels dropping to 4.14 ± 0.13 and 4.46 ± 0.28. Prebiotic index and score analyses further highlighted ChF91 and ChF90 for their potent prebiotic potential. The prebiotic analysis highlighted ChF91 with the highest scores for both *B. bifidum* (5.67 ± 0.13) and *B. clausi* (5.47 ± 0.23), while ChF90 showed a strong prebiotic index (2.15 ± 0.07) for *B. bifidum* and (3.25 ± 0.12) for *B. clausi*. These findings support the potential for developing functional foods, paving the way for novel dietary interventions and functional food development to enhance gut health.

Keywords: Chia seed mucilage, Oligosaccharides, *Pichia pastoris* fermentation, Probiotics

Green synthesis and characterization of *Triticum aestivum* derived biocompatible silver nanoparticles and evaluation of their antidiabetic potential

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Current therapeutic options for various human ailments have faced challenges such as resistance, low efficacy, high costs, and increasing market demands, driving the search for novel, cost-effective natural alternatives. Nanoparticles, particularly those synthesized through green methods, have emerged as pivotal in biotechnology and therapeutics due to their high biocompatibility and potent bioactivities, including antimicrobial, anti-inflammatory, antioxidant, and anticancer properties. This study focused on the biosynthesis of silver nanoparticles from endophytic exopolysaccharides (EPS) of *Triticum aestivum*. The EPS was extracted and precipitated using ethanol, followed by lyophilization. The presence of polysaccharides was confirmed through the phenol-sulfuric acid (PSA) method. Silver nanoparticles (AgNPs) were synthesized by treating the polysaccharide extracts with the respective metallic salts. The biosynthesis process was optimized using UV-visible spectrophotometry and characterized using FT-IR techniques to confirm the formation and stability of the nanoparticles. The in vitro potential of the synthesized nanoparticles was assessed through α-amylase and α-glucosidase inhibition assays. The results revealed that AgNPs significantly inhibited α-amylase activity, with an IC50 of 265.75 µg/mL, followed by EPS (357.18 µg/mL). NiO NPs, on the other hand, were found to significantly inhibit α-glucosidase, with an IC50 of 441.87 µg/mL, followed by EPS (590.68 µg/mL). These findings underscore the potential of biosynthesized MNPs as effective natural therapeutics, offering a promising alternative to conventional treatments, with significant implications for the development of cost-effective and biocompatible therapeutic agents.

Keywords: *Triticum aestivum*, Endophytic exopolysaccharides, Green synthesis, Silver nanoparticles

Comparison of Synthesis of Alpha Amylase on Starch Rich Natural and Synthetic Substrates

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One basic polysaccharide that is frequently used in industrial settings is starch, which frequently needs to be hydrolyzed by α-amylase to produce simpler sugars. The search for sustainable and affordable enzyme production methods has prompted researchers to investigate agro-waste substrates as potential substitutes for synthetic media. Microbial strains, namely bacterial strain EP3(Bacillus Lenchiforma) and fungal strains Aspergillus Niger and Penicillium, were cultivated on agro-waste-derived media made of potato,

mango, and banana peels in order to create α-amylase in this study. These substrates were included in a starch-based fermentation medium that was enhanced with peptone, MgSO4, KH_2PO_4, yeast extract, and sun-dried and crushed. After being aseptically sterilized and inoculated, the media was incubated at regulated temperatures. By adjusting the pH (6, 7, and 8) and the fermentation length (12, 24, and 48 hours), the synthesis of enzymes was maximized. Following incubation, the culture filtrates were collected, and the DNS method was used to determine absorbance at 546 nm and test for α-amylase activity. Mango peel was found to be the most efficient substrate, and the EP3 bacterial strain showed the highest level of enzyme activity at neutral pH (7) and 24 hours. The potential of agro-waste, especially fruit peels, as affordable and environmentally beneficial substrates for industrial enzyme synthesis is highlighted by this study. With potential uses in the food, textile, pharmaceutical, and biofuel sectors, the discoveries further the development of sustainable bioprocessing technology.

Biotechnological Screening of Barley Genotypes for Drought Tolerance under PEG-Induced Stress

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Drought is one of the most critical abiotic stresses limiting the establishment and productivity of crops, especially during germination and seedling development. To study the genetic variations among barley genotypes for drought tolerance at the early stages, thirty-five genotypes were evaluated under polyethylene glycol (PEG)-induced drought stress (0, 10, 20, and 30% PEG) at the Crop Sciences Institute (CSI), National Agricultural Research Center (NARC), Islamabad, Pakistan. Ten seeds of each genotype were sown in petri dishes, arranged in completely randomized design (CRD), and replicated three times. The results showed significant differences among barley genotypes and PEG concentrations. The genotypes 1, 7, 13, 16, and 34 germinated more rapidly, while higher germination percentage, root, shoot, and coleoptile lengths were recorded in genotypes 1, 4, 6, 7, 10, 13, 14, 16, 17, and 34. Root dry weight was greater in genotypes 1, 4, 7, 13, 14, and 17, whereas higher shoot dry weight was recorded in genotypes 1, 4, 6, 7, 13, 14, 16, 17, and 34. The seedling vigor index was highest in genotypes 1, 7, and 13, followed by 4, 6, 10, 14, 16, 17, and 34. The coefficient of relative inhibition was comparatively higher in genotypes 5, 8, 11, 12, 15, 20, 26, and 35. Overall, we noted that increasing PEG levels reduced performance in most of the parameters. The findings highlight the usefulness of laboratory-based biotechnological screening as a rapid and reliable approach for identifying drought-tolerant genotypes. The promising genotypes identified in this study may be further evaluated under field conditions and can serve as the parent material for the development of drought-resilient barley cultivars through plant breeding programs.

Keywords: Barley genotypes, polyethylene glycol, in-vitro screening, drought tolerance, seedling vigor index, genetic variation, plant breeding

Eco-friendly and Sustainable Meal Preparation from Feather Waste of Different Types of *Gallus gallus domesticus*

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This study investigated the potential of poultry feathers, a keratin-rich byproduct of the poultry industry, as an alternative protein source for broiler feed through microbial hydrolysis. Feathers from roaster, broiler, and domestic chickens (*Gallus gallus* domesticus) were evaluated under a completely randomized design with standardized cage management. Birds were randomly allocated to three dietary treatments: commercial feed, hydrolyzed feather meal, and unhydrolyzed feather meal. Feathers were collected, pretreated, and enzymatically hydrolyzed using keratinase-producing bacteria under optimized conditions of pH and temperature to enhance protein digestibility. Crude protein content was determined by the Kjeldahl method, revealing domestic feathers to have the highest protein content (24.40%), followed by broiler (19.07%) and roaster feathers (16.68%). Optimization experiments indicated that keratin degradation was most efficient at pH 3 and 50 °C, resulting in significant weight loss and improved disruption of the keratin matrix. The hydrolyzed feather meal was subsequently incorporated into broiler diets to assess its effects on growth performance, feed conversion ratio, carcass traits, nutrient digestibility, and nitrogen retention. Results demonstrated that birds receiving hydrolyzed feather meal exhibited enhanced protein utilization and superior growth compared to those fed untreated feather meal or commercial feed. Overall, this study demonstrates the feasibility of converting poultry feather waste into a nutritionally valuable feed ingredient through microbial bioconversion, offering both economic and environmental benefits by lowering feed costs and reducing waste disposal challenges.

In silico analysis and association study of *il-17f* gene variant(s) with obesity

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Obesity is one of the most prevalent global health issues and a major risk factor for non-communicable diseases such as diabetes, dyslipidemia, hypertension, and cardiovascular disorders, thereby increasing morbidity and mortality. According to the World Health Organization, obesity incidence has tripled since 1975. Obese individuals show elevated levels of acute phase proteins, pro-inflammatory mediators, and circulating cytokines, predisposing them to autoimmune and inflammatory diseases. This study investigated the correlation between the IL-17F rs23977084 variant and obesity using a case-control design,

while also identifying the most damaging nsSNPs with bioinformatics tools. Blood samples from 200 participants (100 obese, 100 controls) were collected, and DNA was extracted using the phenol-chloroform method. Genotypic and allelic distributions of IL-17F SNP (rs2397084) were analyzed via ARMS-PCR. Results indicated no significant difference in genotype distribution (P=0.5698, $\chi 2$ =1.125) or allele frequency between cases and controls, suggesting that this SNP is not strongly associated with obesity risk. Advanced bioinformatics platforms, including SNPs&GO, SIFT, PolyPhen2, PHD SNP, and Panther, were used to identify deleterious nsSNPs in IL-17F. Additional validation of protein stability, structure, and functional impact was performed using I-Mutant, MutPred, and ConSurf. Three-dimensional protein models were generated with I-TASSER and visualized using Chimera v1.11, while RMSD and TM-scores were predicted using TM-align. Gene-gene interaction networks were also constructed. Several damaging nsSNPs were identified, including R77S, R77C, S78Y, P81S, D89H, R92G, R92W, R92Q, A100T, A100V, C107R, G112R, I123T, V129A, R131W, R132S, C152R, C152Y, C152F, T153A, T153I, V155G, and P157L. These variants may cause significant structural and functional defects in IL-17F, potentially contributing to obesity and autoimmune disorders.

Antimicrobial efficacy of seed extracts from *Trigonella, salvia, Ocimum,* and *Coriandrum* against resistant pathogens

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The increasing risk of bacterial resistance to antibiotics and associated side effects has driven researchers to explore medicinal plants as natural alternatives to synthetic drugs. This study investigates the antimicrobial activities of four seeds (*Trigonella foenum-graecum, Salvia hispanica, Ocimum basilicum,* and *Coriandrum sativum*) commonly used in traditional medicine against five bacterial strains (*E. coli, Klebsiella pneumoniae, Proteus mirabilis, Salmonella spp.,* and *Staphylococcus aureus*) and one fungal strain (*Candida spp*) isolated from fruit samples. The bacteria were identified based on cultural morphology, Gram staining, and Analytical Profile Index (API 20E) testing. The antimicrobial activity of the seed extracts was tested using ethanol, methanol, acetone and distilled water as solvents in a disc diffusion method. Ethanol extracts generally exhibited higher activity than methanol, acetone, and distilled water, except for *Trigonella foenum-graecum*, which showed better activity in methanol. *Trigonella foenum-graecum* demonstrated a significant zone of inhibition against *Proteus mirabilis*, while *Salvia hispanica* and *Ocimum basilicum* were particularly effective against *E. coli*. *Coriandrum sativum* exhibited broad-spectrum activity against all tested bacteria, with notable efficacy against *Salmonella spp*. None of the seed extracts in distilled water showed activity against the bacteria, and *Coriandrum sativum* did not exhibit antifungal activity against *Candida spp*. Antibiotic sensitivity tests with

Azithromycin and Linezolid showed that the ethanol extracts were more effective than the reference drugs. The findings suggest that seed extracts could be a valuable source for developing new antimicrobial compounds

Keywords: Medicinal plants, antimicrobial resistance, antibacterial activity.

Molecular detection of *Mycobacterium tuberculosis* and drug resistance in suspected tuberculosis (tb) patients from different regions of district Dir (U)

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Tuberculosis (TB) remains a persistent worldwide health threat, with 10.6 million fresh cases and 1.3 million reported-deaths in the year 2022. Pakistan ranks amongst the top five high burden TB countries, with the Khyber Pakhtunkhwa (KP) province, with a particular emphasis on remote districts like Dir (U)-facing extensive diagnostic and treatment challenges. This cross-sectional study was conducted to conclude the molecular prevalence, comorbidities, and drug resistance patterns of *Mycobacterium tuberculosis* (MTB) in sixteen (16) zones of district Dir (U). A total of 990 clinically-alleged TB cases were enrolled from these zones across five tehsils from July-November 2024. Sputum samples were analyzed using the smear microscopic detection approaches the most significant GeneXpert MTB/RIF assay, a WHO-endorsed rapid molecular diagnostic tool for simultaneous detection of MTB and first-line drug/s resistance. Of the 990 samples, 70 (7.07%) were confirmed TB-positive. Kalkot tehsil exhibited the highest TB positivity rate despite a lower sample size. Male patients consistently showed higher infection rates than females. Comorbidity analysis revealed strong associations with diabetes mellitus, hepatitis C-inflicted contagions, hypertension, and ischemic heart disease, particularly in the Kalkot, Sheringal, and Dir tehsils. GeneXpert detected resistance against the first-line drugs (Rifampicin) in 11 cases (15.71%), indicative of multidrug-resistant TB (MDR-TB), while 4 cases (5.71%) were further classified as extensively drug-resistant TB (XDR-TB) resisting the second-line drugs (the Moxifloxacin). These findings underscore the importance of integrating rapid molecular diagnostics like GeneXpert in high-burden and underserved regions to enhance early detection and containment of drug-resistant TB. Strengthening regional TB surveillance, treatment adherence, and diagnostic infrastructure is critical to controlling TB in Pakistan.

Keywords: GeneXpert MTB/RIF, MTB, MDR-TB, XDR-TB, Moxifloxacin, Rifampicin

Green synthesis of bioactive silver and nickel oxide nanoparticles using chia seed mucilage polysaccharides

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The eco-friendly synthesis of nanoparticles has gained attention due to their diverse biological applications. This study presents the sustainable production of silver (Ag) and nickel oxide (NiO) nanoparticles (NPs) using water-soluble polysaccharides extracted from chia *(Salvia hispanica)* seed mucilage. Polysaccharides were extracted via ethanol precipitation, and the biosynthesized NPs were characterized by UV-visible spectroscopy, revealing absorption peaks at 473 nm for Ag-NPs and 343 nm for NiO-NPs. The antioxidant potential of the NPs was assessed using the DPPH assay, with Ag-NPs and NiO-NPs showing EC50 values of 118.85 ± 2.52 µg/mL and 97.21 ± 1.39 µg/mL, respectively, compared to 80.78 ± 1.65 µg/mL for ascorbic acid. Additionally, both NPs demonstrated promising in vitro antidiabetic activity, with IC50 values of 87.70 ± 3.65 µg/mL (Ag-NPs) and 146.15 ± 1.94 µg/mL (NiO-NPs) against alpha amylase, compared to acarbose (71.75 ± 2.63 µg/mL). The antibacterial effectiveness of the nanoparticles against three distinct variants of human pathogens was assessed using the agar well diffusion technique. The findings indicated that Ag-NPs effectively suppressed the growth of three pathogenic strains: *Staphylococcus aureus* (9.5mm ± 0.5mm), *Escherichia coli* (11.75mm ± 0.82mm), and *Hemophilus influenza* (8.5mm ± 0.82mm). These findings indicate that chia seed-derived polysaccharides are effective in synthesizing bioactive Ag-NPs and NiO-NPs with strong antimicrobial and antioxidant properties, making them valuable for biomedical applications. This study underscores the potential of mucilage polysaccharides as a sustainable resource for producing bioactive nanoparticles.

Keywords: Nanoparticles, polysaccharides, Chia, Antimicrobial, antioxidant

Comparison of different iron-based nanoparticles for nitrate removal from aqueous solution

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Nanosized Zero Valent Iron (Fe0, NZVI), renowned for its high surface area and specific affinity for nitrate, a ubiquitous contaminant in drinking water. In this study, Nitrate reduction was performed using freshly synthesized NZVI, Iron-Nickle (Fe-Ni) and Iron-Copper (Fe-Cu) bimetallic Nanoparticles (NPs) using chemical reduction method. To avoid oxidation of NPs, all the synthesis and batch reactions were performed in a glove box purged with an inert atmosphere of nitrogen. The compositional and structural properties of the NPs were characterized using Scanning Electron Microscopy (SEM), X-Ray Fluorescence (XRF), and X-Ray Diffraction (XRD), confirming a particle size distribution of 20-50 nm. From comparative analysis it was revealed that compared to NZVI,

the bimetallic Fe-Cu and Fe-Ni NPs exhibited superior catalytic activity for nitrate reduction, with Fe-Ni demonstrating the highest efficiency. The effect of dopant concentration was evaluated by trying various metal loadings (2, 4, 6, 8, and 10 wt %) of Cu and Ni on the Fe^0 matrix. Maximum catalytic efficiency was observed at an optimum metal loading of 4%. Moreover, the effects of environmental parameters on the nitrate-reduction ability of our synthesized NPs were investigated, confirming maximum efficiency under acidic pH conditions and at lower temperatures. The experimental data derived from our nitrate-reduction studies exhibited strong correlation with both the Langmuir and Freundlich adsorption isotherm models. Kinetic analysis determined that the reaction followed a pseudo-second-order model.

Keywords: Nanosized Zero Valent Iron (NZVI), Nitrate reduction, Bimetallic nanoparticles, Adsorption Isotherm, Pseudo-second order kinetics.

Crucial relationship between the SDGs and climate resilience, emphasizing how resilience-building strategies protect advancements, in the eastern Hindukush Mountain region of Pakistan.

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In the Eastern Hindu Kush region, mountain ecosystems are essential for sustaining biodiversity, controlling hydrological cycles, and supporting local livelihoods. However, the effects of climate change, such as glacier retreat, changed precipitation patterns, and an increase in the frequency of extreme weather events, pose a serious threat to these ecosystems. With an emphasis on mountain forests in the Eastern Hindu Kush, this study explores the vital connection between climate resilience and the Sustainable Development Goals (SDGs). The report highlights the ways in which resilience-building tactics might protect the advancement of important SDGs, including SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 6 (Clean Water and Sanitation), SDG 13 (Climate Action), and SDG 15 (Life on Land). Critical vulnerabilities and adaptation priorities are identified by the research using a mixed-method approach that includes stakeholder interviews, GIS and remote sensing analysis, and field-based ecological assessments. Ecosystem-based adaptation (EbA), forest restoration, community-based resource management, and the use of GIS tools for risk mapping and monitoring are important resilience tactics. According to research, implementing these tactics into local development plans strengthens livelihood resilience, protects water resources, and promotes ecological stability—all of which support long-term SDG accomplishments. This study emphasizes how climate resilience in mountain forests is essential for sustainable development in delicate high-altitude environments, in addition to being an environmental requirement.

Keywords: Climate resilience, SDGs, Mountain forests, Eastern Hindu Kush, Ecosystem-based adaptation, GIS, Forest restoration.

In silico assessment of cytokinin signal transduction in plant-associated microbes

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Cytokinin (CKs) are classical phytohormones regulating diverse aspects of plant growth and development. Their perception in plants occurs via membrane-bound Arabidopsis histidine kinases (AHKs), which transmit signals through histidine phosphor-transfer proteins and response regulators. Increasing evidence suggests that plant-associated microbes can also perceive and respond to CKs, yet knowledge of their perception pathways remains limited. This study employed a bioinformatics-based approach to investigate putative orthologues of CK signalling components in *Pseudomonas fluorescens*, *Pseudomonas syringae*, and *Botrytis cinerea*. Orthologous proteins with kinase, histidine phosphatase, and hybrid histidine kinase domains were identified, all containing a conserved histidine kinase (HK) domain essential for signal transduction. Notably, *P. syringae* AHP1 exhibited HK, HPT, and RR domains, suggesting functional versatility. Homology modelling revealed strong structural similarity of microbial orthologues to Arabidopsis CK receptors, and docking analysis demonstrated significant CK binding, particularly by the receiver domain of the *P. syringae* AHK4 orthologue. Key interacting residues included leucine, glutamine, and serine. These findings provide evidence that plant-associated microbes possess CK perception machinery and may respond to plant-derived CKs in the rhizosphere. Such microbial signalling capacity could have important implications for plant–microbe interactions, potentially influencing microbial colonization and plant health.

Keywords: phytohormones, cytokinin signalling, *Arabidopsis thaliana*, plant–microbe interactions

Green synthesis and antibacterial evaluation of iron oxide nanoparticles using chia seed polysaccharides

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Chia seeds (*Salvia hispanica L.)*, a natural source of mucilage polysaccharides, exhibit remarkable biological potential with demonstrated antioxidant, prebiotic, and antimicrobial activities. This study presents the green synthesis of iron nanoparticles using chia seed polysaccharides as both a reducing and stabilizing agent. The biosynthesized iron nanoparticles were characterized through UV-visible spectroscopy, X-ray diffraction (XRD), scanning electron microscopy (SEM), and X-ray diffraction analysis, confirming successful nanoparticle formation. The antibacterial potential of Fe-NPs was assessed against five human pathogenic strains i.e *Staphylococcus aureus, Salmonella typhi, Shigella spp., Klebsiella pneumoniae*, and *Salmonella spp* using agar well diffusion,

microbial biofilm inhibition, and minimal inhibitory concentration (MIC) assays. Results demonstrated that Fe-NPs at 100 µg/mL produced inhibition zones of 8.78 mm against *S. aureus* and 8.7 mm against *S. typhi*, compared to 7.73 mm for chia seed polysaccharides alone against *S. aureus*. The microbial biofilm inhibition assay revealed an IC50 of 15.67 µg/mL for Fe-NPs, while chia seed polysaccharides exhibited an IC50 of 14.21 µg/mL against *Klebsiella pneumoniae.* MIC assays indicated that Fe-NPs effectively inhibited the growth of *S. aureus* at a concentration of 28.12 µg/mL, with higher concentrations required for *Shigella spp*. (57.59 µg/mL), *Klebsiella pneumoniae* (87.49 µg/mL), and *Salmonella spp.* (54.22 µg/mL). These findings underscore the potent antibacterial activity of chia polysaccharide-based Fe-NPs, highlighting their potential as a natural, eco-friendly alternative for biomedical applications in combating bacterial infections.

Keywords: Chia seeds, Mucilage, Polysaccharides, Iron Oxide Nanoparticles, Antibacterial

Exploring anti-diabetic and anti-inflammatory effects of endophytic fungi-derived exopolysaccharides from wheat and parthenium

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Endophytes are microbes that colonize living, internal tissues of plants without causing any negative effects. In recent years, endophytic fungi have been demonstrated to be excellent exopolysaccharide (EPS) producers. EPS are high-molecular-weight carbohydrates with a wide range of biological activities. This study was, therefore, designed to extract and purify EPS-producing endophytic fungi from wheat (*Triticum aestivum*) and Parthenium (*Parthenium hysterophorus*) and explore their biological applications using different bioassays. The purified EPS were labelled as EPSW1, EPSW2, EPSW3, EPSP1, EPSP2, and EPSP3. The purification of EPS involved inoculating isolated endophytic fungi into a broth medium at 25°C for 32 hours on a shaking incubator and EPS precipitation using 95% ice-chilled ethanol. The purified EPS were processed for quantification of total carbohydrate content and bioactivity through α-amylase, α-glucosidase, and HBRCs membrane stabilization assay. The results indicated that EPSW1 inhibited α-amylase, showing an effective IC50 value of 265.75 µg/mL, while EPSP2 inhibited α-glucosidase with an IC_{50} value of 441.87 µg/mL. In terms of in vitro anti-inflammatory activity, EPSP1 significantly stabilized HRBCs membrane, with an EC50 value of 8.75 µg/mL, followed by EPSW1 (155.17 µg/mL). Furthermore, the study assessed in vivo anti-inflammatory activity through a carrageenan-induced paw edema model in mice. Simultaneously, the in vivo antidiabetic activity was investigated in Balb/C mice by inducing diabetes via a 1% alloxan injection. Three concentrations (400 mg/kg, 200 mg/kg, 100 mg/kg) were tested for each activity. At 400 mg/kg, EPSP1 showed the highest anti-inflammatory impact (91.37%) while EPSW2 at the same concentration displayed a significant

74.85% reduction in blood glucose levels in alloxan-induced diabetic mice. In conclusion, the study emphasizes the potent bioactivity of EPS from wheat and Parthenium, showcasing therapeutic benefits, including anti-diabetic and anti-inflammatory properties.

Keywords: Endophyte, Exopolysaccharides, Anti-diabetic, Anti-Inflammatory, Wheat, Parthenium

Fractionation of antioxidant polysaccharides in cress seed coat mucilage by size exclusion chromatography

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Elevated levels of reactive oxygen species (ROS) pose severe threats to the intracellular environment in terms of oxidative stress, and their continuous overproduction causes various clinical disorders. Antioxidant compounds combat oxidative stress in cells and are therefore useful in the management of various clinical disorders. Plants are an important source of bioactive compounds, especially mucilage containing polysaccharides have been extracted from plants and studied for various biomedical applications. *Lepidium sativum*, commonly known as garden cress, whose seeds release mucilage upon soaking in water. The aim of the current study was to extract polysaccharides via size-exclusion chromatography (SEC) from the seed coat mucilage of garden cress and to evaluate the bioactive fraction(s). The mucilage was extracted by soaking cress seeds in distilled water. The collected mucilage was then precipitated with 75% ethanol. The ethanol precipitated fraction was further fractionated through Bio-Gel P-10 (90 µm-180 µm). A total of 60 (2 ml each) fractions were collected tested for the presence of carbohydrates. The results revealed the presence of pentoses, hexoses, uronic acids and unsaturated uronic acids. Among all the screened samples for their antioxidant potential through DPPH assay, significant EC_{50} value was shown by fraction F23 as its EC_{50} was 37.93 µg/mL, followed by fraction F52 (58.04 µg/mL) and fraction F53 (66.04 µg/mL), respectively. Selected SEC fractions of ethanol precipitated polysaccharides extracted from cress seed coat mucilage were then screened for H_2O_2 radical scavenging activity. Each fraction was screened at three different concentrations, including 50, 100 and 200 µg/mL. The results obtained showed that fraction F53 was the most effective fraction at 200 µg/mL as it scavenged the $H_2O_{\cdot 2}$ free radical by 81.9%±0.24, followed by fraction F18 (76.54%±0.65) and fraction F23 (76.4%±1.96). *In vitro* lipid peroxidation assay was performed on mice tissue samples where F52 fraction was the most effective one having IC_{50} value of 34.17 µg/mL, followed by F20 having IC_{50} value of 57.18 µg/mL. Our results concluded that water-soluble polysaccharides extracted from cress seed coat mucilage can be used as potential and effective natural antioxidant compounds.

Keywords: Endophytes, Exopolysaccharides, Wheat plant, Bioactive compounds

Assessing farmers' perception of environmental impacts, carbon absorption and emissions associated with tobacco cultivation

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Tobacco cultivation has significant environmental consequences, including deforestation, soil degradation, water contamination, and increased carbon emissions. These effects contribute to the larger carbon emissions and pose long-term ecological and socio-economic challenges. This study aims to explore farmers' perceptions of the environmental impacts and the carbon absorption as well as emissions associated with tobacco cultivation. The study employed a questionnaire-type approach of randomly selecting tobacco farmers in three villages each from two Districts i.e. Swabi (Yarhussain, Yaqubi and Sudher) and Charsadda (Shodag, Kooz Behram Dheri and Hisara Nehri) and interviewed to gather insights of tobacco farming impacts. Quantitative data were also collected on the absorption and emissions of carbon during the crop cultivation phase in these areas. The results revealed that the farmers generally acknowledged tobacco's high input demands, such as fertilizers and pesticides, limited awareness on the negative environmental consequences, such as soil degradation, water pollution, and long-term ecological harm. Deforestation due to wood burning for tobacco curing was the widely recognized issue. More than 75% of the respondents agreed on this issue, yet most farmers prioritized short-term economic gains over environmental considerations. Quantitative analysis indicated that tobacco cultivation resulted in considerable carbon emissions, primarily due to wood burning during the curing process, which accounted for over 98% of total emissions. Fertilizers and pesticides contributed to smaller amounts. Conversely, the carbon absorption potential of the tobacco crop during the growing period was considerably lower, leading to a net positive carbon footprint. Emission levels varied within the villages, as Sudher and Shodag exhibiting the highest carbon emissions due to intensive curing, while Yaqubi and Kooz Bahram Dheri reported lower, though still significant, emissions. The study highlights the significant environmental footprint of tobacco farming in the region and more awareness and sustainable practices to mitigate its ecological impacts is needed.

Keywords: Farmer's perception, environmental impacts, carbon emissions absorption, tobacco

Synthesis, characterization and electrochemical application of Ag-Zn bimetallic nanoparticles for sensing of Eriochrome black t (EBT)

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The current article reports the synthesis of Ag-Zn bimetallic nanoparticles (BNPs) through a simple, eco-friendly chemical reduction method and their

application in electrochemical sensing of Eriochrome Black T (EBT), a hazardous dye discharged from textiles and industries. Various physio-chemical techniques such as UV-Vis Spectroscopy, Zeta Sizer, Scanning Electron Microscopy (SEM), Fourier Transform Infrared Spectroscopy (FTIR), Energy Dispersive X-Ray Spectroscopy (EDX) and X-Ray Diffraction (XRD) were used to confirm BNPs morphology, composition and structure. The electrochemical studies using Cyclic Voltammetry (CV) and Electrochemical Impedance Spectroscopy (EIS) revealed high sensitivity, stability and reproducibility of the sensor toward EBT dye detection. The study demonstrates Ag-Zn BNPs as a promising low-cost and reliable sensing material for environmental monitoring of toxic dyes in wastewater.

Bioremediation of Polluted Water using Indigenous Microorganisms: An Effective Approach for Sustainable Environment

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Water is a gift of nature, and no life form is possible without safe water but unfortunately due to increase industrial development and population rate, this natural gift is contaminated into several ways and hence the availability of safe drinking water to everyone has become an important need of current scenario. Pakistan has become a water deficit country due to depleting ground and surface water resources, prevailing droughts and shift of fresh water from agriculture to more pressing domestic as well as industrial uses. Due to continuous increase in population and industrialization, most of the sources become contaminated and unsafe for daily usage. Hence, the combination of polluted water consumption and poor hygiene practices results in illnesses which not only contribute to high child mortality and morbidity but also result in high health costs for treatment. Solid waste management system exists in Pakistan but only in large cities like Lahore and Karachi. However, in other cities like Peshawar, 04 sewage plants were in which only one sewage plant is currently operational. There are several reasons for malfunctioning of these plants, including the plants were established at unfeasible locations, several vast ponds made for water treatment had already been filled with garbage and lack of funds. Currently world is moving towards green technology where biological materials are used instead of chemicals for bioconversion of compounds. The scientific community of Pakistan is also focusing on utilization of indigenous microorganisms and their metabolites for bioremediation of toxic waste materials into usable form. This will result in the generation of more effective and sustainable environments with availability of safe drinking water to consumers.

Immobilization of Fungal Glucoamylase Using Calcium Alginate Beads

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Enzymes have remarkable advantages over chemical catalysts but their use on industrial scale is vulnerable due to decrease in their stability, efficiency and due to harsh environmental conditions. Current study is a challenge to increase the stability and efficiency of glucoamylase by its immobilization through entrapment method. For this purpose, glucoamylase was produced from previously isolated specie of *Aspergillus niger* and immobilized on sodium alginate by an entrapment method. Various parameters were used namely sodium alginate concentrations, calcium chloride concentrations, beads surface area, optimization of pH and temperature, reaction time, substrate concentration and reusability of enzyme were optimized and associated with the free enzyme. The maximum immobilization yield was obtained at 4% concentration of sodium alginate, 0.3M calcium chloride concentration and 4 cm beads diameter. The optimum pH for immobilized and free enzymes were 4 and 5 correspondingly, temperature remained 50 °C and 60 °C and reaction time was 10 minutes. Thus, it can be expected from current findings that sodium alginate immobilized glucoamylase can be used to produce commercially important products and efficiently for hydrolysis of starch.

Co-application of *Parthenium* Biochar and Nitrogen Fertilizer Effectively Mitigates Cadmium Toxicity during Tomato Growth

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Environmental contamination by cadmium (Cd), a highly toxic heavy metal, poses significant health risks to plants and humans. Biochar (BC) has been effectively used to promote plant growth and productivity under Cd stress. This study presents an innovative application of BC derived from the invasive weed *Parthenium hysterophorus* to promote plant growth and productivity under Cd stress. Our study includes detailed soil and plant analyses, providing a holistic perspective on how biochar and urea amendments in the form of nitrogen influence soil properties, nutrient availability, and plant physiological responses. To address these, we established seven treatments: the control, Cd alone (5 mg kg^{-1}), BC alone (5 %), N alone (3 g kg^{-1}), BC with Cd, N with Cd, and a combination of biochar and N with Cd. Cd stress alone significantly reduced plant growth indicators. However, the supplementation of BC, N, or their combination significantly increased shoot length, root length, and fresh shoot biomass, respectively. This improvement is attributed to enhanced soil

properties and improved nutrient absorption. The BC–N combination also enhanced Cd tolerance by improving total chlorophyll content compared to the control, respectively. Similarly, these treatments significantly ($p < 0.05$) boosted the activity of antioxidant enzymes such as catalase, peroxidase, and superoxide dismutase respectively, thereby mitigating oxidative stress as a defensive mechanism. The Cd tolerance was improved by BC, N, and their combinations, which reduced Cd content in the shoots (by 60.5 %, 38.9 %, and 51.3 %), roots (by 47.5 %, 23.9 %, and 57.6 %), and grains (by 58.1 %, 30.2 %, and 38.3 %) relative to Cd stress alone, respectively. Conclusively, converting invasive *Parthenium* weed into BC and combining it with N offers an environmentally friendly solution to manage its spreading while effectively mitigating Cd stress in crops.

Keywords: Cd tolerance; Antioxidant activity; chlorophyll content; Cd accumulation

Genetic Evaluation of Chickpea Germplasm to Find Climate Resilient Material Under Semiarid Conditions

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Water scarcity impacts agricultural yields and endangers food production in arid and semi-arid areas. Chickpea, a vital legume crop, is very sensitive to drought stress, leading to poor yields and negative physiological effects under these conditions. The present study assessed 14 chickpea genotypes for drought tolerance. Plants were grown in pots with limited irrigation, receiving only a single supply before sowing. The experimental procedures included measuring eight agronomic and physiological traits: the number of branches per plant, total plant biomass, chlorophyll concentration, number of pods per plant, number of seeds per pod, weight of 100 seeds, relative water content (RWC), and cell membrane stability (CMS) of chickpeas. The lines revealed significant differences at the genotype level concerning the biomass of the plant, the number of pods per plant, and the RWC as affected by drought. The four major principal components contributed to the total variance under normal conditions, while the three were associated with drought stress. Plant biomass with the number of branches per plant and RWC had the highest eigenvector value under stress. Findings from correlation analysis exhibited different trait associations under drought and control conditions. Heritability estimates revealed the presence of genetic potential for drought resilience, whereby characters like relative water content and cell membrane stability appeared to be strong

predictors of drought tolerance. The research thus inferred that adequate genetic variation is available in the tested genotypes to be used in breeding programs towards the development of drought-tolerant chickpea cultivars. Such findings provide critical inroads into the physiological and agronomic responses of chickpea against drought stress and give way to sustainable production under water-limited conditions.

Keywords: Genetic Variability, Chickpea Germplasm, Climate Resilience, Drought.

Mitigation of drought stress in sunflower (*Helianthus annuus* L.) by nickel application

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Sunflower (Helianthus annuus L.) is moderately drought tolerant crop since water stress reduces its achene yield. Nickel (Ni) is considered a phytotoxic element at its higher concentration while its low concentration has been proved to have beneficial effects on the growth, and physiological water use efficiency of sunflower. Studies were conducted to assess the impact of Ni on growth and yield of sunflower hybrid (ORISUN-648) under drought conditions. Two foliar applications of nickel sulfate ($NiSO_4$) were made at vegetative growth and flowering phases of crop growth at its 0 ppm, 1.5 ppm and 3.0 ppm concentrations under fully irrigated and restricted irrigation regimes. The results revealed that water stress significantly reduced the leaf area index, crop growth rate, head diameter, total dry matter, and achene yield of sunflower crop. But significant improvement occurred in leaf area index, crop growth rate, 1000-achene weight and achene yield of sunflower by foliar application of 3 ppm NiSO4 solution under droughted environment. However, its plant height was not improved by different Ni foliar application treatments suggesting Ni may not have substantial effect on vertical growth of sunflower crop. But, significant improvement (29%) in total dry matter of sunflower by foliar application of Ni under drought conditions suggests its positive role in drought amelioration in sunflower.

Keywords: Crop growth rate, Drought tolerance, Foliar application, Leaf area index, Nickel sulfate

Optimization of Spinach Growth via Seed Priming and Foliar Treatment with Moringa Leaf Extract

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The extensive use of synthetic chemicals in crop cultivation poses environmental risks and deteriorates food quality. Consequently, natural alternatives are recommended to safeguard the environment, enhance food nutritional value, and reduce contamination. Moringa oleifera is cultivated for its leaves and seeds, which serve as fresh vegetables, green manure, plant biostimulants, and natural pesticides. This study aimed to evaluate the impact of moringa leaf extract (MLE) as a plant growth enhancer on the development and quality of spinach grown in pot culture during 2023. To assess the effects of application methods and extract concentration, two levels of seed priming (4% and 8% MLE) and two levels of foliar spraying (4% and 8% MLE) were tested, including their combinations and a control group. The pot experiment was designed as a completely randomized design with three replications per treatment. Data was collected on various growth metrics (such as shoot and root lengths, fresh and dry weights, and root-to-shoot ratios), physiological responses (including relative water content, membrane stability index, chlorophyll levels, photosynthetic and transpiration rates, and stomatal conductance), biochemical functions (i.e., soluble carbohydrates, total and crude protein, fats, organic acids, antioxidant enzymes such as ascorbate peroxidase, catalase, dehydroascorbate reductase, glutathione peroxidase, glutathione reductase, superoxide dismutase, along with non-enzymatic molecules like ascorbate, glutathione, and phenolics), and ionic/nutrient concentrations (sodium, chloride, nitrogen, phosphorus, and potassium). All data were statistically analyzed using Analysis of Variance with Statistix 10 software, and treatment differences were compared using the least significant difference test at a 0.05 probability level. The results revealed that combined treatment of seed priming and foliar spraying at 8% MLE proved most effective for enhancing spinach growth and physiological performance. The findings provide valuable insight into the most effective bio-stimulant and application method for improving spinach growth and quality, benefiting organic kitchen gardening and sustainable agriculture practices.

Keywords: Spinach, Growth, Seed Priming, Foliar Application, Moringa Leaf Extract.

Effectiveness of Various Bio-stimulants in Promoting Maize Growth under Salt Stress

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The use of large amounts of synthetic chemicals in plant cultivation harms the environment and reduces food quality. Therefore, natural alternatives should be used to protect the environment, increase food quality, and decrease food contamination. The Moringa oleifera tree is cultivated for its leaves and seeds which are used as a fresh vegetable, green manure, plant biostimulant, and biopesticide. Plant growth regulator (PGR) is a substance that regulates or modifies the physiological processes of plants, impacting their growth, development, or maturation. These can be natural plant hormones (phytohormones) or synthetic compounds. Therefore, the present research aimed to investigate the effect of moringa leaf extract (MLE) and seaweed extract (SWE) a PGR as biostimulators to enhance growth of maize grown in a pot culture under normal and salt-affected soils during 2025. To examine the effects of MLE and SWE, the present study included MLE at 4% and SWE at 4% alone as well as in combination with control. The pot experiment was conducted using a completely randomized design with three replications of each applied treatment. Data was collected on various growth parameters (such as: shoot and root lengths, shoot and root fresh and dry weights as root to shoot ratio), physiological responses (like relative water contents, membrane stability index, chlorophyll contents, photosynthetic and transpiration rates as well as stomatal conductance), biochemical functions (i.e., water soluble carbohydrates, total and crude proteins, fat, organic acids; as well as enzymatic antioxidants including ascorbate peroxidase, catalase, dehydroascorbate reductases, glutathione peroxidase, glutathione reductase, superoxide dismutase; and non-enzymatic molecules including ascorbate, glutathione, phenolics) and ionic/nutrients concentration (e.g., sodium, chloride, nitrogen, phosphorus and potassium). All the obtained data were analyzed statistically using the Analysis of Variance following Statistix 10 statistical package and difference among the treatment means were compared by the least significant difference test at 0.05 probability. The results revealed that combined treatment of 4% MLE and 4% SWE proved most effective for enhancing maize growth and physiological performance both under normal and salt-affected soils.

Keywords: Bio-stimulants, Maize Growth, Soil Salinity.

Effectiveness of Bio-stimulants in Promoting Sunflower Growth under Salt Stress and Optimal Soil Conditions

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The widespread use of synthetic chemicals in agricultural production negatively affects the environment and lowers the nutritional quality of food. Hence, natural alternatives are recommended to preserve the ecosystem, improve food quality, and minimize contamination. Moringa oleifera is cultivated for its leaves and seeds, which are utilized as fresh vegetables, green manure, plant biostimulants, and eco-friendly pesticides. Plant growth regulators (PGRs) are compounds that regulate or modify the physiological activities of plants, influencing their growth, development, or maturation. These regulators may be either naturally occurring plant hormones (phytohormones) or artificially synthesized substances. Therefore, this research aimed to assess the influence of moringa leaf extract (MLE) and seaweed extract (SWE), a plant growth regulator, as biostimulants to enhance the growth of sunflower cultivated in pot culture under both normal and salt-affected soils during 2025. To evaluate the effects of MLE and SWE, the experimental treatments consisted of 4% MLE, 4% SWE, their combined application, and a control group. The pot experiment was implemented in a completely randomized design (CRD) with three replications for each treatment. Measurements were recorded for several growth indicators including shoot and root lengths, fresh and dry biomass of shoots and roots, and root-to-shoot ratio. Physiological parameters included relative water content, membrane stability index, chlorophyll content, photosynthetic and transpiration rates, and stomatal conductance. Biochemical assessments involved water-soluble carbohydrates, total and crude proteins, lipids, organic acids, enzymatic antioxidants such as ascorbate peroxidase, catalase, dehydroascorbate reductase, glutathione peroxidase, glutathione reductase, superoxide dismutase, along with non-enzymatic antioxidants including ascorbate, glutathione, and phenolic compounds. Concentrations of ions and essential nutrients such as sodium, chloride, nitrogen, phosphorus, and potassium were also analyzed. All gathered data were statistically processed using Analysis of Variance (ANOVA) with the Statistix 10 software package, and differences among treatment means were tested with the least significant difference (LSD) method at a 0.05 significance threshold. The results revealed that the combined treatment of 4% moringa leaf extract and 4% seaweed extract was the most effective approach for enhancing the growth and yield of sunflower crop under both normal and saline soil conditions.

Keywords: Evaluation, Moringa Leaf Extract, Sunflower, Growth, Saline Conditions.

Seed priming improves germination and seedling growth of oat (*Avena sativa* L). Under salt stress environment

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Oat is an important winter fodder crop grown all over the world. Poor oat seed germination is a problem in salt-affected soils. Seed priming is a technique that can improve germination and promote early seedling establishment by overcoming salt stress. It helps in imparting the initial vigor to the seedlings which is essential for better seedling performance. The experiment was conducted in Agronomy Lab., College of Agriculture, University of Sargodha, using CRD factorial having seven priming treatment and five salt stress levels and replicated thrice. The seeds were soaked in solution of salicylic acid 0.4mML-1, ascorbic acid 1.50mML-1, gibberellic acid 0.3mML-1, polyethylene glycol 15%, potassium 1%, calcium chloride 1% and in distilled water for 12 hours, no priming was kept as control. After that, seeds were planted on petri dishes, and salt stress was given using NaCl solutions of 40, 60, 80, and 100 mM-1. The data regarding seed emergence and seedling growth was recorded according to standard protocol and statistically examined using Fisher's analysis of variance method, Tukey's honestly significant difference test (HSD) was used to compare treatment means at 5% probability level. Data showed the significant effects of priming and salt stress treatments on seed germination and seedling characteristics of oat. Highest germination (82.83%), speed of germination (10.52), mean daily germination (3.16%), lowest time to start germination, mean germination time (0.81%) and highest shoot length (4.78cm), seedling root length (5.14cm), seedling vigor index (825.68), seedling fresh shoot weight (31.58mg), seedling fresh root weight (28.43mg), dry shoot weight (13.97mg), dry root weight (12.69mg) and seedling roots number (13.27) were recorded when seed were primed with salicylic acid only without salt stress but priming of salicylic acid improves tolerance under salt stress of 40 mM-1 and all germination and seedling parameters were also improved.

Keyword: Growth promoters, NaCl, priming, germination, seedling, salt tolerance

Exploring genetic potential of rice accessions for salinity tolerance at seedling stage using phenotypic and molecular markers

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Rice (*Oryza sativa* L.) is a staple food of about half the population on earth. It is salt sensitive crop and most of the rice growing area in Pakistan is saline to saline sodic soil. Therefore, there is a need to screen our existing rice germplasm for its salinity tolerance. Glasshouse studies were conducted to evaluate advanced rice breeding lines against salinity. The 15 rice lines including two commercial rice varieties (Super Basmati and KSK282) were grown in hydroponic system and were evaluated for both morphological as well as molecular levels. Four salinity levels i.e. 0 dSm^{-1}, 4 dSm^{-1}, 8 dSm^{-1} and 12 dsm^{-1} NaCl. This displayed enough genetic variation in rice genotypes for salinity tolerance under reported salinity levels. Furthermore, ten DNA based SSRs markers named as RM1287, RM10800, RM3412, RM10, RM10793927, RM140, RM7075 and RM7414 were used to locate Saltol QTL (located on chromosome 1) which creates salinity tolerance/resistance in rice cultivars. Results showed that Genotype OPS-132 performed really well in both physical assessment (performing moderate tolerant to SES examination of genotypes against salinity) as well as molecular level (8 out of 10 markers showed positive band in OPS-132). OPS-132 also performed better than check varieties in all aspects and suggested that this genotype should be include in rice hybridization program to develop salt tolerance cultivars.

Keywords: Hydroponic, KSK 282, *Oryza sativa*, Saltol QTL, SSRs

Unraveling environmental challenges: The role of microbes in biodegradation of polyvinyl chloride for sustainable waste management

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Plastic pollution is the most important global concern as it severely threatens living organisms in ecosystem. Traditional approaches like land filling and incineration to manage plastic waste are not effective because these methods are also associated with adverse effects. Environmental biotechnology offers an eco-friendly strategy that is utilization of microbes for the biodegradation of waste plastic. This study focuses on the isolation of plastic degrading bacteria from various ecological niches. Among all isolated strains, two strains with maximum potential of plastic degradation were selected for characterization and optimization studies. The bacterial isolates, named DS3 and MPW3, were identified as species of *Bacillus* and *Micrococcus*, respectively. The plastic sample used in this study was a type of PVC plastic, specifically plastic food wrap. An effect of two key physical parameters such as temperature and pH on the rate of plastic biodegradation was studied. Biodegradation analysis was done using weight loss method. Growth density and amount of dissolved CO_2 after biodegradation were also determined It was observed that both strains optimally

degraded plastic wraps at 35˚C, pH 7.0 after 3 weeks of incubation. This study offers valuable insights for the *in-situ* degradation of plastic waste.

Keywords: Biodegradation, microbes, optimization, plastic film, weight loss

The Impact of Winter Weather and Environmental Factors on the Incidence and Severity of Chest Infections in Children in Upper Dir

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Chest infections remain a major cause of morbidity among children worldwide, particularly in low-resource settings. This study aimed to assess the impact of winter weather and environmental factors on the incidence and severity of chest infections among children in Upper Dir, a mountainous district of Khyber Pakhtunkhwa, Pakistan. Data were collected from 249 child patients presenting with respiratory complaints during the winter season using a structured questionnaire. Variables included demographic information, environmental exposures, heating methods, household ventilation, clinical symptoms, frequency of infections, and access to healthcare. The findings revealed an alarmingly high burden of illness, with nearly all children experiencing recurrent chest infections during winter. A slight male predominance (59%) was observed, and children under five years were identified as the most vulnerable group. Indoor environmental conditions emerged as the strongest determinant: all households relied on wood stoves for heating, and none had proper ventilation, leading to prolonged exposure to indoor smoke. Clinical features were dominated by cough, fever, shortness of breath, and chest pain, consistent with acute lower respiratory tract infections such as pneumonia and bronchitis. Socioeconomic challenges, including poverty and low maternal education, further increased risk. Healthcare access was extremely limited, with most families traveling two or more hours to reach the nearest facility, often delaying treatment. This study concludes that winter chest infections in children of Upper Dir are primarily driven by indoor smoke exposure, poor living conditions, and lack of timely healthcare. It recommends introducing cleaner household heating methods, improving ventilation, strengthening community health education, and expanding rural healthcare services. Addressing these root causes could significantly reduce the burden of respiratory illness and improve child health outcomes in the region

Assessment of Applied Organic Fertilizers in Boosting Growth and Yield of Spinach

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Organic amendments have gained significant interest due to their potential to enhance soil fertility, increase soil organic carbon content, and boost crop yield and productivity. This study aimed to evaluate the impact of farmyard manure, poultry manure, compost, and biochar on improving the growth and quality of spinach cultivated in pot culture during 2023. To assess the effects of these organic inputs, treatments included farmyard manure, poultry manure, compost, and biochar applied at rates of 0.5% and 1%, alongside a control. The pot experiment was arranged in a completely randomized design (CRD) with three replicates for each treatment. Measurements were taken on various growth indicators such as shoot and root lengths, fresh and dry weights of shoots and roots, and root-to-shoot ratio. Physiological parameters measured included relative water content, membrane stability index, chlorophyll concentration, photosynthesis and transpiration rates, as well as stomatal conductance. Biochemical assessments covered water-soluble carbohydrates, total and crude proteins, fats, organic acids, and enzymatic antioxidants including ascorbate peroxidase, catalase, dehydroascorbate reductase, glutathione peroxidase, glutathione reductase, superoxide dismutase, plus non-enzymatic antioxidants like ascorbate, glutathione, and phenolic compounds. Ionic and nutrient concentrations (sodium, chloride, nitrogen, phosphorus, and potassium) were also analyzed. All collected data were statistically evaluated using Analysis of Variance (ANOVA) via Statistix 10 software, and treatment means were compared by the least significant difference (LSD) test at a 0.05 significance level. Results indicated that among the organic amendments tested, 1% biochar was the most effective in promoting spinach growth and enhancing physiological attributes, closely followed by 1% compost. The findings offer valuable insights into the effectiveness of different organic amendments as practical and cost-effective strategies for improving spinach growth and quality, supporting organic farming and sustainable urban horticulture initiatives.

Keywords: Appraisal, Organic Amendments, Growth, Spinach.

Comparative Study of Raw and Magnetic Biochar for Heavy Metal Adsorption: A Case of *Parthenium hysterophorus* L. Biomass

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Since last two decades due to most of the anthropogenic activities the environment became polluted which pollute directly or indirectly water which has very alarming effects. To decrease this pollution, there are lot of techniques which are used for the removal of pollutants but most of them are very costly, and they need special management. In modern scientific era the use of biochar is

considered as one of the most reliable and effective technique which play the most important role as bio-adsorbent for the removal of different pollutant like pesticides, organometallic compounds and heavy metals. In the present study biochar is produced from Parthenium hysterophorus L. biomass and modified with iron chloride before and after production to produce magnetic properties and investigate the adsorption properties of modified and non-modified biochar. The batch adsorption experiment of four heavy metals (Cr, Cu, Cd and Pb) demonstrated that the adsorption of heavy metals on modified biochar was lower. Raw biochar adsorbed Cr, Cu, Cd and Pb 20%, 100%,90%,98% at pH 7 respectively. Modified biochar absorbed Cr, Cu, Cd and Pb 90%, 60%,65% and 58% at pH 7 respectively. And comparatively the adsorption capacity of post modified biochar was slightly higher than the pre modified biochar. But the adsorption of anions were three times higher on modified biochar than raw biochar i.e. Chromium (HCrO3–). Magnetic modification of biochar is more efficient for the removal of anions than cations.

Immunoinformatics-guided universal chimeric multi-epitope subunit vaccine against Marburg virus disease: tackling Marburg and Ravn virus co-infection through *in silico* design and validation

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Marburg Virus Disease (MVD) is a life-threatening hemorrhagic fever, caused by two viruses—Marburg virus (MARV) and Ravn virus (RAVV)—that belong to the family Filoviridae. MVD represents a significant threat to public health owing its high mortality rate and the lack of approved vaccines. In this study, immunoinformatics tools were used to identify antigenic and conserved regions in viral glycoproteins, enabling the design of a chimeric multi-epitope subunit vaccine to reduce MVD-related mortality. Epitopes for cytotoxic T lymphocytes, helper T lymphocytes, and B lymphocytes were predicted, and three highly conserved, immunogenic, and antigenic epitopes for each type were selected from both viruses. The selected epitopes were assembled into a chimeric multi-epitope vaccine construct using suitable adjuvants and linkers to enhance its immunogenicity. The designed vaccine construct demonstrated high antigenicity, non-allergenicity, solubility, and favorable physicochemical properties. Computational modeling of the vaccine's three-dimensional structure and molecular docking analysis with Toll-Like Receptor-4 indicated a strong interaction, suggesting robust immune activation potential. Furthermore, codon optimization and *in silico* cloning confirmed the efficient expression of the vaccine construct in the *Escherichia coli* K-12 strain. Immune simulations prognosticated the induction of primary and secondary arms of immune responses, such as interleukins, cytokines, and antibodies, predicting the ability

of the vaccine to induce protective immunity. Although these encouraging in silico results form a solid basis, additional in vitro and in vivo experiments are indispensable to complete the validation of the safety, immunogenicity, and protective efficacy of this vaccine candidate, opening the door to future achievements in vaccine research.

Keywords. Marburg Virus Disease (MVD), Epitopes, Toll-Like Receptor-4, Vaccine

Seroprevalence of Hepatitis B and C in Females of Dargai, District Malakand and its respective causes.

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Chronic diseases such as hepatitis B and C virus (HBV and HCV) claim the lives of thousands of people globally every year. Several factors, including virus genotypes, the stage of infection, overall health, age, and gender, have been established as significant determinants in the progression of these infections, the prognosis of the disease, and the response to treatment. In the study, a total of 44 samples were analyzed for hepatitis. Out of these, 17% were tested for HBV, with 11 (64%) individuals testing positive, while 6 (35%) tested negative. Notably, the findings indicated a higher likelihood of females testing positive for HBV. Regarding HCV, there were 27 positive cases in the overall sample, constituting 20 (47%) individuals, while 7 (14%) tested negative for HCV. The study observed a significant age-related pattern in the prevalence of HBV, with no cases reported in the 1 to 10-year age group. However, as patients aged, the occurrence of HBV increased, with individuals aged 20 to 30 years showing 18 positive cases. Furthermore, one 38-year-old female tested positive for HBV. In the case of HCV, the infections were more prevalent among individuals aged 52 to 60 years. These findings shed light on the varying rates of HBV and HCV infections with respect to age and gender, emphasizing the importance of understanding these demographic factors in the context of hepatitis research and management.

Keywords: chronic diseases, Hepatitis B and C, infection stage, prevalence, treatment response, viral genotypes. Hepatitis B; Hepatitis C; Seroprevalence; Females; Dargai Malakand; Public Health; Risk Factors; Blood Transfusion; Liver Disease; Pakistan

Enhanced Production of Alpha amylase using *Bacillus subtilus*

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Bacillus subtilis being one of the most widely utilized species due to its capacity to produce various enzymes on a commercial scale. Among these, α-amylase (EC 3.2.1.1) holds particular importance for applications in the textile, detergent, food and beverage industries. In this study, α-amylase-producing

Bacillus subtilis was isolated from rice field soil, and its enzyme characteristics and kinetics were systematically investigated under different physical and chemical conditions. Using starch as the main carbon source and peptone and yeast as nitrogen sources increased the synthesis of alpha amylase synthesis. The medium was incubated for different fermentation time (24 hours to 96 hours at a different temperature between 30°C and 60°C with an initial pH of 7.0. The enzyme showed its optimal activity after 24h hour of fermentation time at 40°C at optimum pH (7.0). These findings suggest that the α-amylase from *Bacillus subtilis* possesses favorable characteristics such as stability of enzyme, rapid catalytic reaction and enhanced activity under optimized fermentation conditions. Such properties highlight its potential for diverse industrial applications, particularly in processes requiring efficient starch hydrolysis.

Keywords: *Bacillus subtilis*, α-amylase, enzyme kinetics, starch hydrolysis, thermal stability, pH optimization, industrial enzymes

Molecular Screening of NBS-LRR Class Blast Resistant BR Genes in Rice Varieties of Sindh, Pakistan

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Rice blast disease is caused by a devastating fungus, Magnaporthe Oryzae, which causes major yield loss in the rice crop not only in Pakistan but also all over the world. Magnaporthe oryzae possesses a unique characteristic of retrotransposons that enables it to produce multiple strains within a single cropping season. This rapidly evolving pathogen is highly difficult to manage with conventional methods like chemical control because it does not produce efficient results for a longer period of time. In addition to this, a resistant cultivar with a single R gene is also not a promising solution. However, a broad-spectrum resistant cultivar with multiple number of blast resistant genes can be developed that can be an efficient solution for this disease. Hence, this study was designed to gain insights into the resistance spectrum of commercially used rice varieties of Pakistan. For this purpose 5 BR gene with functional markers of i.e., Pita, Pib, Pit, Pi54, Pik-p and one PR gene i.e., RCC2 was studied using Polymerase Chain Reacton (PCR) method in 23 rice germplasm i.e., Dilrosh, Sarshar, Jajai 77, Shandar, IR 09, JP 5, IR 06, Sada Hayat, Basmat 198, Supreme Basmat, Basmat 383, Fakhr e Malakand, Basmat 385, KSK 133, DR 82, KS 282, DR 83, Shua 92, Shua, Kangani torh, Khushbo 95, KSB 282, and Kanwal 95. The results revealed that the PR gene RCC2 was ubiquitous in all the studied rice varieties, whereas Pi54, Pita, Pik-p, and Pib genes was collectively present in only Jajai 77, which is a wild type variety. Moreover, Basmat 198 variety was found with only one broad-spectrum gene i.e., Pita. However, the Pita gene was predominant in 22 out of 23 rice varieties. In addition to that, most of the varietes were naturally present with the 3 BR gene, i.e., Dilrosh, IR 09, IR06, Shua 92, DR 83, DR 82, Kangani torh, KS 282,

KSK133, Fakhr e Malakand, Khusnoo 95, Basmat 385, Shandar, JP5, Sada hayat, Sarshar, Supreme Basmat, and Shaheen Basmat. However, Sarshar, Kanwal 95, Basmat 370, and basmati 383 was found with 2 BR genes. The result depicts that Pakistani rice germplasm is naturally abundant with the broad-spectrum blast resistant and pathogenesis related genes that are highly useful in breeding programs. A successful gene pyramiding can be done in various commercial rice varieties to increase their resistance status. This study served as the frst step towards the resistant spectrum of rice crop for rice blast disease.

Mutational analysis of Monkeypox virus P2L-KPNA2 binding interface and identification of small molecule inhibitors to rescue the host immune system

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Mpox is a re-emerging zoonotic disease caused by the Mpox virus (MPXV), which poses a significant global health concern due to its increasing outbreaks and potential for severe complications in humans. The MPXV P2L protein is a key virulence factor that facilitates immune evasion by interfering with karyopherin-α2 (KPNA2)–mediated nuclear import of interferon regulatory factor 3 (IRF3). To explore the emergence and functional consequences of mutations in this protein, we analyzed 90 P2L protein isolates against the reference sequence (NP_536451.1). Multiple sequence alignment identified 13 isolates with amino acid substitutions, including novel variants harboring multiple mutations such as P11S, E25D, D112F, and R119K. Computational stability analysis using I-Mutant 2.0, DynaMut2, mCSM, SDM, and DUET revealed that several substitutions, particularly E25D, M43C, A55T, and R119K, were consistently predicted to destabilize the protein. Further structural and functional assessments indicated that mutations such as D112F and V153F disrupted DNA binding, altered transmembrane topology, and modified key post-translational regulatory sites. Structural modeling of mutant proteins demonstrated conformational deviations from the wild type, with root-mean-square deviation (RMSD) values ranging from 1.26–1.72 Å, underscoring mutation-induced alterations in protein folding. Molecular docking revealed that specific mutants, notably WJG54236.1 (P11S, E25D, D112F), exhibited enhanced binding affinity with KPNA2 compared to the wild type, accompanied by increased hydrogen bond and salt bridge interactions at the binding interface. These findings suggest that emerging mutations in P2L not only compromise protein stability but may also strengthen its inhibitory interaction with KPNA2, thereby amplifying MPXV's immune evasion capacity. Collectively, this study highlights critical structural and functional impacts of novel P2L variants and provides a foundation for understanding their role in MPXV pathogenesis and therapeutic targeting.

Keywords. MPOXV, Immune Evasion, Mutation, Amino acids. of interferon regulatory factor 3 (IRF3).

Marker-assisted screening of wheat (*Triticum aestivum* l.) Genotypes for stripe rust resistance

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Yellow rust, caused by *Puccinia striiformis*, is a major disease contributing to significant wheat yield losses around the world including Pakistan. Genetic resistance is the key- explain. This study assessed agronomic and molecular traits associated with yellow rust resistance in 38 wheat genotypes using SSR markers. Five key agronomic parameters; plant height, spike length, grain per spike, grain weight per spike and 1000-grain weight were evaluated. The genotypes Wadaan-17, NIA-Zarkhaiz and PR-155 showed maximum plant heights. PR-155, Pirsabak-19 and Wadaan-17 had the longest spikes. Taskeen-22, Paseena-17 and Abdul-Bari 24 produced the highest number of grains spike^{-1}. Taskeen-22, Tarnab Rehber, and Wafaq-23 exhibited the highest grain weight spike^{-1}. For 1000-grain weight, the highest values were recorded for NIFA Lalma-13, Tarnab Rehber, and Pirsabak-21. Yellow rust resistance was assessed using the Average Co-efficient of Infection (ACI) and Relative Resistance Index (RRI), with genotypes showing a broad range of disease severity. Resistant genotypes exhibited ACI values between 0-9.67%, while susceptible genotypes from 21%- 36%. The RRI values ranged from 0-9, with resistant genotypes scoring between 8.5-9.0, while susceptible genotypes scored between 0-3.8. Molecular analysis using six SSR primers linked to Yr genes identified four markers (*Yr5, Yr15, YrSP, Lr46*) with distinct bands, confirming the presence of yellow rust resistance genes. The *Yr5* primer exhibited the highest molecular frequency (86.84%), while *Yr15* had a lower frequency of 44.7%. The study highlights the importance of combining yellow rust resistance and high yield traits for developing wheat varieties to address food security challenges.

Key words: wheat, *Triticum aestivum*. L, yellow rust, agronomic traits, molecular markers, ACI, RRI.

Recent trends and future of information and communication tools (ICT) in agricultural extension services in selected districts of Khyber Pakhtunkhwa

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Information and Communication Technology (ICT) enhance the per acre yield of crops through new and advance information processes. It is link between the agriculture extension department and farmers. Extension workers help farmers to adopt improved agricultural practices and rural development. These

technologies enabled the farmers to acquire information in urgency and empowered farmers in taking timely decision in challenging situations. In addition, farmers can inquire about profitable agricultural markets and enquiring about highest price for their produce. Hence, the objective behind the study was to investigate recent trends and future of these information and communication technologies in respect to extension activities of Khyber Pakhtunkhwa. Three districts of Khyber Pakhtunkhwa namely Mardan, Swat, and Haripur were selected by using multi stage sampling technique. Therefore, farmers of these three districts were the population of the study. In total, 400 farmers of these three districts were selected as sample size and data were gathered by pre-tested and finally validated interview schedule and then analyzed by Statistical Package for Social Sciences (SPSS). Maximum (34.5%) of the total respondents have age between 36 and 45 years and almost26% of the sampled respondents had not acquired any formal education. More than one fourth (29.5%) of respondents had landholding of 6 to 10 acres, about 64.5% of respondents were owner cultivator, and 87.5% respondents have agriculture as major income source. Less than half (i.e. 40%) respondents have the farming experiences ranging from 21 up to 30 years and 55% of overall respondents were familiar with ICTs, 56.2% of sampled respondents had mobile, nearly 22.5% respondents had a ICT tool i.e. telephone, about 52.8% of them possessed television, and the 9.8% owned radio. Majority of respondents (68.5%) stated about extension agents as their source of farming information followed by fellow farmers (59.5%), internet (27.5%), and mobile (17.5%). The results indicated that 30% of the respondents reported mobile, 18.8% reported internet whereas 10.5% reported television as useful ICT tool in emergency. Almost half of the respondents were uncertain regarding encouraging effects of ICTs whereas 14.2% of farmers agreed regarding promising effects of ICT tools on agricultural productivity. The findings further revealed that 38.8%, 27%, 45.5%, and 31.2% of total farmers agreed about usefulness of ICTs in building awareness, providing new information, providing weather updates and providing emergency news, respectively. Moreover, 44.5%, 22.2% and 18.8% of the sampled respondents reported non-availability of ICT tools, unawareness and lack of training respectively while 14.5% of the respondent's reported language used as the problems faced in using ICT tools. Chi-square analysis revealed that both age of the sample respondents and their literacy status have significant association with their ownership and knowledge of ICT tools. Similarly, statistically highly significant difference was found regarding farmers' perception regarding effect of mobile, telephone, television and radio on agricultural production. These results conclude that younger and literate respondents in research area were familiar with ICTs. Hence, it is recommended that extension department is essential to build awareness on the usage of ICTs about the farmers. The extension department needs to launch an ICT program in order to communicate agricultural information to the farmers. Content of the information needs to be transmitted in local language so that illiterate or less literate farmers could utilize it. Department of extension should aware farmers

about existence of tele centers established in the provincial directorate so that they can be benefitted from this service.

Linking tree diversity and structural attributes to forest ecosystem functions

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Understanding the drivers of nutrient cycling and leaf trait variation in Himalayan forests is critical for predicting ecosystem resilience under climate change. This study investigated the roles of tree diversity and stand structure in regulating soil nitrogen and mean leaf area in high-elevation forest ecosystems. Results showed that species richness and Shannon diversity had weak but statistically significant effects on soil nitrogen ($R^2 = 0.04–0.05$), while evenness and all structural metrics (DBH, height, crown dimensions) exhibited no influence. Correlation analyses revealed a complete decoupling of diversity and structure, with strong within-dimension associations but negligible cross-links. Pie-chart analysis suggested biodiversity explained 92.7% of the explained variation compared to 7.3% for structure, yet overall explanatory power remained low ($R^2 = 0.048$), emphasizing dominant abiotic controls such as atmospheric deposition and geological substrates. Structural equation modeling confirmed biodiversity as a weak but significant predictor (β = 0.22), while structure showed no effect. In contrast, canopy architecture emerged as the primary determinant of mean leaf area, with crown width exerting the strongest influence (β = 0.81), followed by tree height (β = 0.15). Diversity metrics showed no relationship with leaf traits, confirming complete independence of compositional and architectural axes. These findings suggest that nitrogen cycling is primarily governed by abiotic factors, with limited modulation of biodiversity, whereas canopy structure strongly influences functional leaf traits. The study challenges lowland biodiversity–ecosystem functioning paradigms and highlights the need for conservation and modeling approaches in mountain forests that emphasize structural integrity alongside biodiversity preservation.

Assessment of Cadmium, Copper, and Lead Contamination in Agricultural Soils of Malakand Division, Pakistan

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Agricultural soil contamination by heavy metals poses a significant threat to food security, ecosystem health, and human safety. This study presents a comprehensive assessment of the contamination levels of cadmium (Cd), copper (Cu), and lead (Pb) in the agricultural sector of Malakand Division, KP, Pakistan. Soil samples were systematically collected from cereal, paddy, and orchard fields across three districts: Swat (Landaki), Lower Dir (Chakdara), and Malakand (Batkhela). The samples were acid-digested (HNO_3-$HClO_4$) and

analyzed using Atomic Absorption Spectrometry (AAS) for heavy metal quantification, alongside potentiometric pH and Walkley-Black organic matter (%OM) analysis. The results revealed neutral to slightly alkaline soils (pH 7.22–7.67) with %OM ranging from 0.47% to 1.45%. Critically, the analysis identified severe contamination for Cd and Pb, with concentrations frequently exceeding national and international safety guidelines. A cereal sample from Swat district showed an extreme Cd concentration of 15.58 mg/kg, vastly surpassing the FAO/WHO (0.3 mg/kg) and Pakistani (0.5 mg/kg) limits. While Cu levels remained within safe limits (FAO/WHO: 100 mg/kg), Pb exceeded the Pakistani permissible limit (50 mg/kg) in several instances. A comparative spatial analysis indicated that Swat district was the most contaminated, exhibiting the highest levels of Cd and Pb, thereby representing the greatest potential risk to agricultural sustainability and public health in the region.

Keywords; Soil Contamination, Heavy Metals, Health Risk Assessment

POSTER ABSTRACTS

Identification of markers associated with agronomic traits in synthetic hexaploid wheat

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Wheat, the world's most consumed cereal, became a staple food following its cultivation during the Neolithic Revolution when agriculture replaced hunting and gathering. In recent decades, wheat's genetic diversity has declined, but synthetic hexaploid wheat offers a way to reintroduce traits from wild relatives. Though less agronomically appealing, it provides valuable resilience to biotic and abiotic stresses. Genome-wide association studies (GWAS) have identified genes linked to quality, stress resistance, and yield traits, enabling the detection of marker-trait associations in various crops. In this study, agronomic data for 55 genotypes were collected under both drought and well-watered conditions, followed by genotyping with 4,449 DArT markers. Population structure was analyzed using STRUCTURE software, and marker-trait associations for traits like root dry weight, shoot dry weight, root-shoot ratio, and chlorophyll content were identified using the GAPIT R package. The agronomic data revealed that some synthetic hexaploid wheat (SHW) genotypes outperformed check varieties under both drought and well-watered conditions. Five DArT markers; wPt-667820, wPt-3677, wPt-2652, wPt-666656 and wPt-731831 highly associated with root dry weight under drought stress and one marker wPt-731269 for root dry weight under well-watered conditions. Two markers wPt-667820, wPt-743102 were in association with shoot dry weight under well-watered condition. For root shoot ratio under drought 3 markers; wPt-2416, wPt-2559, wPt-731831 were found associated. For chlorophyll content we found four markers wPt-5184, wPt-2741, wPt-664603, wPt-664811 and two markers wPt-733067, wPt-4242 were found associated with chlorophyll content under well-watered condition. These markers require further validation before they can be used to identify the targeted traits. It is recommended that genotypes exhibiting strong drought resistance be incorporated into breeding programs to enhance resilience in wheat cultivation.

Key words: GWAS, DArT, Synthetic Hexaploid Wheat, Structure, GAPIT