Final Year Project Showcase
Batch 2022
Year 2026

	Department: Biomedical Engineering Program: Biomedical Engineering
1	**Project Title** Engineering and Evaluation of Bio-heal Cool Strip for Biomedical Applications.
2	**Project Idea** Conventional wound dressings frequently desiccate the wound bed, lack any antimicrobial action, and adhere painfully to healing tissue on removal. The Bio-Heal Cool Strip is a low-cost, fully natural thin-film dressing engineered to solve all three problems at once: a Polyvinyl Alcohol (PVA) matrix is loaded with Neem, Aloe Vera, Cucumber and Menthol so that a single strip simultaneously fights infection, retains moisture, and delivers an instant cooling, pain-relieving sensation turning affordable, locally available plant materials into a clinical-grade wound-care product.
3	**Process** Neem leaf, Aloe Vera and Cucumber extracts were prepared by maceration/blending and combined with a PVA solution (optimized at 16% w/v after screening four concentrations) via the Solvent-Casting technique to cast five distinct thin films: a PVA control (PS-3), PVA+Neem, PVA+Neem+Aloe Vera+Menthol (PNAC), PVA+Neem+Cucumber+Menthol (PNSC), and the full multi-extract blend PVA+Neem+Aloe Vera+Cucumber+Menthol (PNASC). Each film was then subjected to a complete physicochemical and biological characterization tests: pH testing (skin compatibility), digital microscopy (surface morphology), contact-angle goniometry (wettability), FTIR spectroscopy (chemical compatibility of the bioactives with the polymer), swelling-ratio testing (moisture-retention capacity), Universal Testing Machine tensile testing (mechanical strength/flexibility), and disc-diffusion antibacterial testing against MRSA and E. coli.
4	**Outcome** All five formulations recorded a near-neutral, skin-safe pH (6.60–6.91), confirming non-irritancy for direct wound application. Contact-angle measurements (73.8°–90.1°) confirmed a strongly hydrophilic, moisture-retentive surface, and the optimized PNASC film absorbed up to ~320% of its own weight in fluid within one minute (PNSC reached ~500%), demonstrating strong exudate-management capacity. FTIR confirmed successful, non-destructive incorporation of all bioactives into the PVA network through hydrogen bonding, with no harmful chemical interactions. Tensile testing showed a tunable, flexible film (elongation 3.75–5.6%) that stays mechanically intact yet conformable for practical handling and painless removal. Antibacterial disc-diffusion assays showed clear, dose-dependent zones of inhibition against MRSA, rising from 6 mm for the PVA control to 10 mm for the fully-loaded PNASC strip direct experimental proof that the natural bioactives translate into real antimicrobial protection.

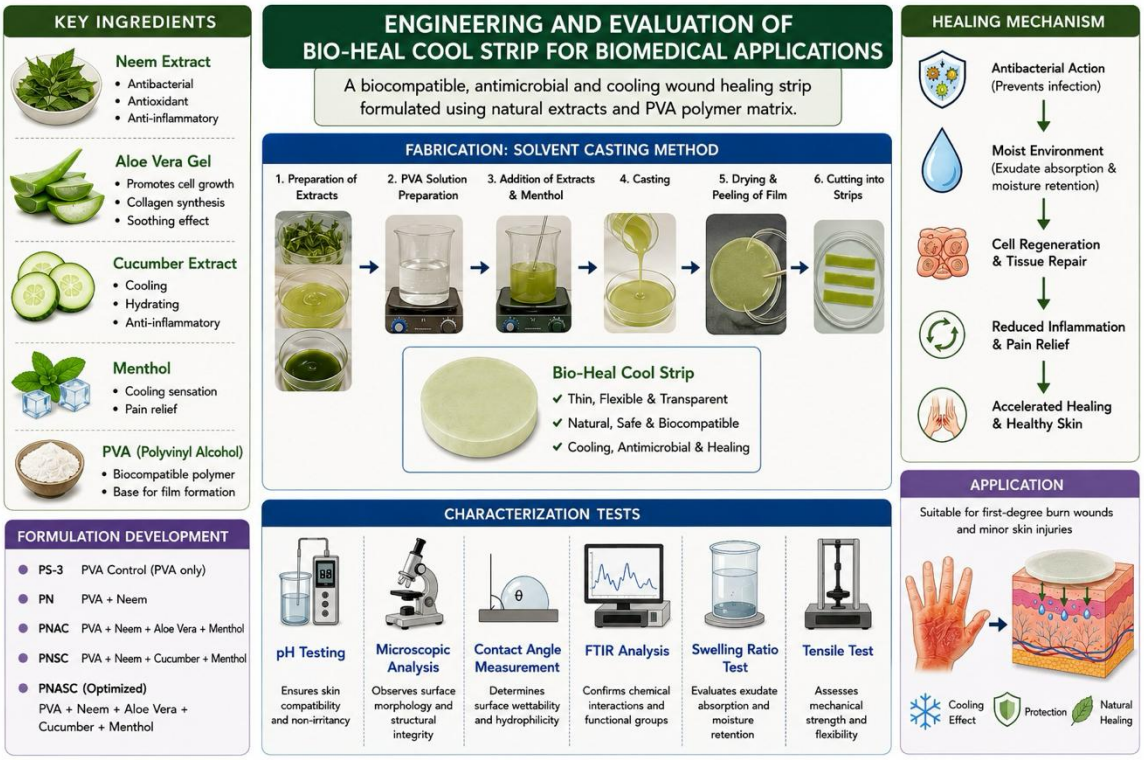
5	**Evidence (Theoretical Basis)** Burn wounds damage the epidermal barrier, accelerating fluid loss and infection risk; polymer thin films are well established in the literature as an effective way to keep such wounds moist and protected. PVA was selected as the film-forming matrix for its proven biocompatibility, non-toxicity, flexibility and controlled swelling behavior. Neem is documented for potent antibacterial, antioxidant and anti-inflammatory limonoids (azadirachtin, nimbin) active against wound pathogens such as S. aureus and P. aeruginosa. Aloe vera's acemannan polysaccharide is reported to boost fibroblast proliferation and collagen synthesis, while Cucumber's high water and phenolic content contributes cooling, moisturizing and antioxidant effects. Menthol is established to bind TRPM8 receptors, producing an analgesic cooling sensation together with anti-inflammatory and antimicrobial action. This literature base justified combining all four bioactives into a single PVA film, and the project's own pH, FTIR, contact-angle, swelling, tensile and antibacterial results empirically confirm the predicted synergy.
6	**Impact on Sustainability of Urban Regions or SDG-11 "Sustainable Cities and Communities"** The project's primary declared alignment is SDG-3 (Good Health and Well-being), but it also directly supports resilient, sustainable urban communities under SDG-11: the strip is fabricated entirely from low-cost, locally sourced plant materials (neem trees, aloe vera, cucumber) rather than imported synthetic dressings, making affordable first-aid and burn care accessible within dense urban neighborhoods and under-resourced clinics. By reducing dependence on imported wound-care supply chains and using biodegradable, non-toxic ingredients, the strip also lowers the environmental footprint of everyday urban healthcare and could be scaled into community health centers, school first-aid kits and household emergency kits city-wide.
7	**Competitive Advantage or Unique Selling Proposition** The Bio-Heal Cool Strip's core selling proposition is that it replaces multiple separate dressing types (moisture-retentive, antimicrobial, and cooling/analgesic) with a single, inexpensive, all-natural film offering simultaneous health, cost and sustainability advantages that make it attractive for community healthcare providers, pharmacies and wound-care manufacturers to invest in or license.
a	**Attainment of any SDG** (e.g. How it is achieved and why it is necessary for the region) Directly advances SDG-3 (Good Health and Well-being). Pakistan has one of the higher burn injury burdens in the region, driven by common household hazards (open-flame cooking stoves, geysers, electrical faults) and limited burn-care infrastructure outside major cities. Most public hospitals lack dedicated burn units, and imported wound dressings (hydrocolloid, hydrogel, silver-based) are expensive and largely limited to urban tertiary-care settings. This leaves rural clinics, small-town pharmacies, and lower-income households with few affordable options beyond basic gauze, which doesn't control

	infection or moisture loss. The Bio-Heal Cool Strip addresses this gap directly by using low-cost, locally available plant materials to deliver antimicrobial and moisture-retentive wound care at a fraction of the cost of imported alternative making it necessary and directly applicable to closing Pakistan's burn-care access gap, particularly for first-degree burns and minor wounds that make up the majority of household burn injuries.
b	**Environmental Aspect** (e.g. carbon reduction, energy-efficient, etc.) Composed entirely of biodegradable, plant-derived ingredients (Neem, Aloe Vera, Cucumber, Menthol) in a biocompatible PVA matrix, the strip avoids the petrochemical additives, silver/iodine agents and non-biodegradable backing layers used in many commercial dressings; its solvent-casting fabrication uses only water and minimal ethanol, minimizing chemical waste and environmental impact.
c	**Cost Reduction of Existing Product** All active ingredients were sourced locally (neem leaves, aloe vera and cucumber from local plants/markets; PVA and menthol from a local supplier) at a fraction of the cost of imported hydrocolloid, hydrogel, alginate or silver-based antimicrobial dressings, making the Bio-Heal Cool Strip a significantly cheaper alternative for treating first- and second-degree burns without compromising antimicrobial or moisture-retention performance.
d	**Process Improvement which Leads to Superior Product or Cost Reduction, Efficiency Improvement of the Whole Process** (e.g. What is the issue is current process and what improvement you suggest) The current fabrication process has two efficiency bottlenecks, both of which can be addressed without added equipment cost. First, the Neem maceration step ties up 30 hours of continuous stirring plus additional water-bath concentration time for just one ingredient, while the PVA solution, Aloe vera gel, and Cucumber extract are prepared separately in sequence meaning much of the total process time is spent waiting rather than actively processing. This can be resolved simply by running the Neem maceration in parallel with the other preparation steps (Aloe vera gel and Cucumber extraction take only minutes, and PVA dissolution ~1 hour), rather than doing them one after another, cutting total batch turnaround time significantly with no added cost. Second, casting is currently done by hand into individual petri dishes, which can cause slight inconsistency in film thickness between samples. Rather than investing in new equipoment, this can be improved at negligible cost by using a simple, reusable leveling frame or fixed-depth pouring guide (a thin spacer/mold placed on the casting surface) to standardize film thickness across every dish, and by pre-marking a fixed pour volume per dish. This tightens batch-to-batch consistency using only inexpensive, reusable tools already available in the lab, rather than machine keeping the process just as low-cost while making the output more uniform and reliable for scale-up.

e	**Expanding of Market share** (e.g. how it expands and what is the problem with the current market) The current market for wound and burn dressings in Pakistan is dominated by imported hydrocolloid, hydrogel, alginate, and silver-based antimicrobial dressings, which are costly and largely inaccessible to lower-income households, small clinics, and rural pharmacies. This leaves a significant portion of the local population underserved for even minor burns and wounds. The Bio-Heal Cool Strip expands market share by offering a locally manufactured, natural, and significantly cheaper alternative that can be distributed through existing local pharmacy and medical-device supply chains (e.g., companies like Talha Enterprise), allowing it to capture price-sensitive customers currently priced out of the imported-dressing market while still meeting the antimicrobial and moisture-retention performance standards those products offer.
f	**Capture New Market** (e.g. Niche market or unaddressed segment) Targets the currently unaddressed niche of affordable, natural, multi-functional burn dressings for low-resource households, community clinics and pharmacies in Pakistan and similar markets which is a segment largely unserved by expensive imported wound-care brands.
g	**Any Other Aspect (Please tag it like above options)** Patient Comfort and Treatment Compliance A striking but often overlooked issue with conventional wound dressings is the pain and secondary tissue trauma caused when a dried-out or adhered dressing is peeled off, which frequently discourages patients (especially children and burn patients) from complying with regular dressing changes. The Bio-Heal Cool Strip directly addresses this through its inherent hydrophilicity and swelling behavior, which keep the film moist and non-adherent to the healing tissue, allowing for gentle, pain-free removal. Combined with Menthol's immediate cooling and analgesic sensation on application, this makes the dressing more comfortable to wear and change than conventional options improving patient compliance with the full healing course, which is itself a key driver of faster, complication-free recovery and repeat product use.
8	**Target Market** (Industries, Groups, Individuals, Families, Students, etc) Please provide some detail about the end-user of the product, process, or service The primary end-users are households and families in Pakistan managing everyday minor burns and wound particularly domestic kitchen/stove burns, which are common given widespread use of open-flame cooking and are frequently sustained by women and children at home. Other key end-user groups include: low-income and rural populations who currently have little affordable access to advanced wound dressings and rely on basic gauze or no dressing at all; outdoor and industrial workers (e.g., factory, construction, kitchen

	staff) exposed to routine minor burns and cuts on the job; school-going children and students, for whom a simple, non-adhesive, pain free dressing is easier to apply and tolerate than conventional bandages; and elderly individuals with slower natural healing, who benefit from the moisture-retentive, non-adherent design that reduces pain during dressing changes. Beyond individual/household use, the strip is also intended for use by community health workers and primary healthcare clinics as a low-cost first-line dressing for first-degree burns and minor wounds, and by humanitarian/disaster-relief responders who need lightweight, shelf-stable, easy to apply dressings for mass burn/wound care in emergency settings. Pharmacies and local medical-device distribution companies would serve as the distribution channel connecting these end-users to the product, rather than being end-users themselves.	
9	**Team Members** (Names along with email address	Samia Umer (samiaumer456@gmail.com) Fatima Nasir (fatimaanasirofficial@gmail.com) Ifrah Saleem (ifrahsaleem.16@gmail.com)
10	**Supervisor Name** (along with email address)	Dr. Madeeha Sadia (madeehaoz@neduet.edu.pk)
11	**Video (If any)**	

Pictures (If any)



Graphical abstract: Bio-Heal Cool Strip formulation, fabrication and healing mechanism.