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From Freshwater to Petri Dish:
DISCOVERY OF ANTIBACTERIAL FRESHWATER MICROALGAE STRAINS

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RESEARCH AND INDUSTRY CONTRIBUTION

This research provides significant academic, scientific, and institutional value to UiTM Cawangan Selangor (UCS), strengthening its position as a centre for environmental biotechnology and natural product discovery. By utilising campus freshwater ponds as a primary source of microalgal resources, the study highlights UCS as a living laboratory for sustainable bioprospecting and innovation. The successful isolation and characterisation of local microalgal strains contribute to the university's research portfolio, supporting high-impact publications and the potential development of intellectual property. Furthermore, the establishment of axenic cultures creates a valuable biological repository for future research, academic training, and industrial collaboration.

Beyond research outputs, this study enhances interdisciplinary learning by integrating biotechnology, microbiology, and pharmaceutical sciences. It provides students and researchers with practical exposure to real-world scientific processes, from environmental sampling and culture isolation to metabolite extraction and bioactivity screening. In addition, the findings open opportunities for collaboration with industry partners, particularly in the nutraceutical, pharmaceutical, and biotechnology sectors. By demonstrating the value of locally sourced microalgae, UCS is positioned to contribute meaningfully to Malaysia's growing bioeconomy while supporting sustainable development initiatives.

Opportunities for collaboration with industry

The journey began at the freshwater ponds of UCS, Puncak Alam, an ecologically dynamic system that supports abundant microalgal communities. Shaped by fluctuating environmental factors such as light intensity, nutrient availability, and water depth, these ponds provide an ideal natural microhabitat for microalgal growth, adaptation, and metabolic diversification.

Multiple sampling points across the ponds were accessed by researchers from the Marine Pharmaceutical Research Group (MaReG) at the Faculty of Pharmacy using a canoe. This approach enabled access to otherwise unreachable areas and facilitated a more comprehensive exploration of the aquatic ecosystem. As sampling progressed, the surrounding environmental conditions were systematically recorded, recognising their critical role in shaping microalgal distribution and physiology. Key physicochemical parameters, including pH, salinity, oxidation-reduction potential, electrical conductivity, turbidity, and dissolved oxygen, were measured using a Hanna multiparameter probe. In parallel, light intensity, temperature, and weather conditions were documented to provide a contextual framework for interpreting microalgal community dynamics.

36 SAMPLES

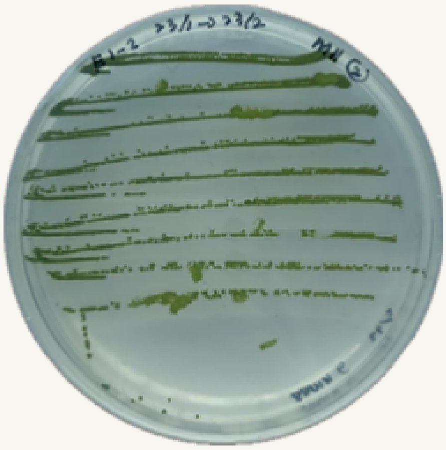
32 ISOLATES

25 AXENIC CULTURES

Water samples were collected from multiple locations across three distinct plots at two depths: near-surface (approximately 4 cm) and deeper water (approximately 100 cm), capturing both spatial and vertical heterogeneity. In total, 36 samples were obtained and transported under cold conditions to the MaReG laboratory, marking the transition from environmental bioprospecting to controlled experimental investigation.

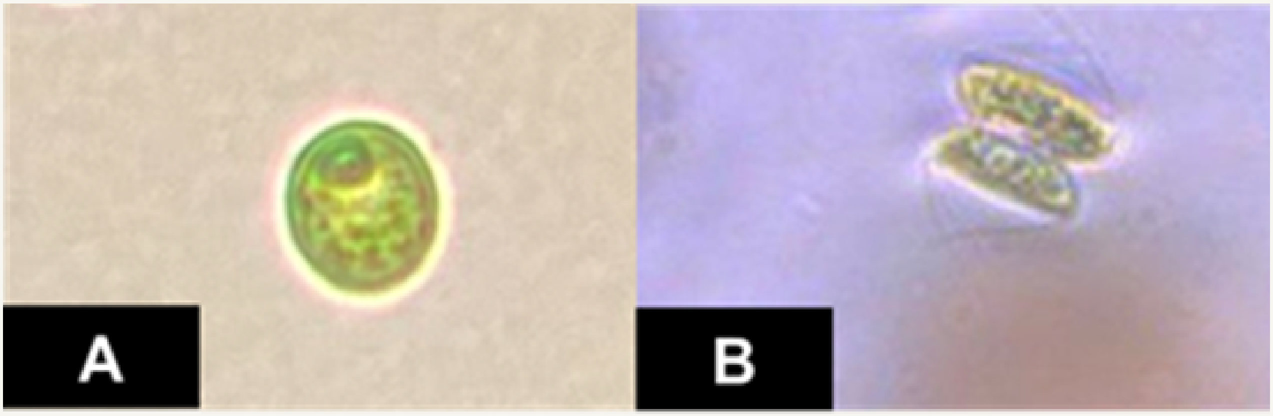
Upon arrival in the laboratory, samples were subjected to centrifugation and subsequently inoculated onto Bold's basal medium (BBM) agar. The cultures were incubated under continuous illumination, promoting the emergence of discrete colonies, each representing a distinct microalgal isolate. A total of 32 isolates were successfully obtained; however, achieving axenic cultures required careful optimisation due to microbial contamination.

To address this, antimicrobial agents were strategically employed. Ampicillin at 1 mg/mL was used as an antibacterial agent, while amphotericin B at concentrations ranging from 2.5 to 6 µg/mL was used as an antifungal agent to suppress contaminating microorganisms while preserving microalgal viability. Through iterative optimisation, 25 axenic cultures were successfully established, providing reliable strains for downstream analyses. These purified isolates were subsequently cultivated to generate sufficient biomass, then methanolic extracted to recover bioactive metabolites.

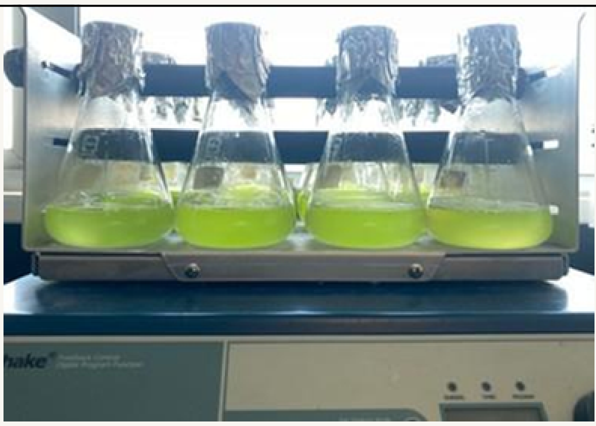


Preliminary antibacterial screening revealed that several isolates exhibited inhibitory activity against Gram-positive pathogens, including *Bacillus* sp., *Micrococcus luteus*, and *Staphylococcus aureus*, underscoring their potential as sources of bioactive compounds for biotechnology, pharmaceutical, and cosmetic applications.

Microscopic examination further revealed the morphological diversity of the isolates. Distinct cellular structures and configurations provided initial taxonomic insights that, when combined with literature-based identification, enabled tentative genus-level classification. Representative observations indicated that the isolates were predominantly *Chlorella* sp. (A) and *Scenedesmus* sp. (B), both of which are widely recognized for their metabolic versatility and bioactive potential.



The value of these microalgae lies in the wide range of beneficial substances they produce. These include carotenoids such as β-carotene and lutein, which act as antioxidants and help protect cells from damage. Other compounds, such as phenolics and fatty acids, are known for their antimicrobial, anti-inflammatory, and heart-protective properties (1). Microalgae also produce polysaccharides that may support the immune system, as well as proteins and peptides with potential health benefits (2). In addition, chlorophyll-related compounds can help in detoxification and protect cells from stress (3). Interestingly, many of these substances are produced when microalgae are exposed to environmental stress, making natural habitats like the UCS ponds rich sources of biologically active compounds.



Beyond their biochemical diversity, microalgae play a significant role in biotechnology as sustainable platforms for producing natural products, including pigments, biofertilizers, and functional food ingredients. Their cultivation supports environmentally friendly systems and has been widely applied in wastewater treatment, carbon capture, and environmental remediation. These attributes underscore the value of microalgae as versatile and eco-efficient bioresources for industrial applications. In addition, species such as Chlorella have already been commercialized as nutraceuticals due to their high nutritional value and associated health benefits (4).

In the pharmaceutical sector, microalgae are gaining attention as promising sources of new therapeutic compounds. Their antibacterial properties suggest potential for developing alternative strategies to combat infections, particularly amid rising antibiotic resistance. Furthermore, certain microalgal metabolites have shown potential in supporting wound healing and may contribute to anticancer research, although further studies are required to confirm their clinical applicability (5,6).

In the cosmetic sector, microalgae are increasingly recognized for their skin-enhancing properties. Their antioxidant compounds help protect the skin from damage caused by pollution and ultra violet (UV) exposure, both of which contribute to premature aging. Microalgal extracts have also been associated with improved skin hydration, enhanced collagen support, and a smoother overall appearance. In addition, their anti- inflammatory and antimicrobial properties make them suitable for products targeting sensitive or acne-prone skin. As a result, microalgae are now widely incorporated into skincare formulations, including creams, serums, masks, and sunscreens (7).

Building on this foundation, the present study extends beyond biodiversity exploration to position local microalgal strains within a broader trajectory of biotechnological innovation. Through systematic isolation, screening, and characterization, it advances the identification of high-value strains with promising bioactivity profiles. In doing so, the study reveals the untapped potential of freshwater microalgae within UiTM Cawangan Selangor, highlighting their relevance across multiple sectors, including biotechnology, pharmaceutical, and cosmetic industries. Ultimately, this work aims to bridge environmental discovery with industrial application by identifying robust, scalable, and stable microalgal candidates, thereby transforming local biodiversity into a foundation for sustainable and globally relevant solutions.


FROM FRESHWATER TO PETRI DISH
Discovery of Antibacterial Freshwater Microalgae
Freshwater Ponds: A Natural Research Lab
Sampling
Culturing
Isolation
Extraction
Screening
25 Axenic Microalgae Isolates Obtained
Effective against Gram-positive bacteria
Microalgae Identified:
Chlorella sp. & Scenedesmus sp.
Bioactivity & Bioactive Compounds
Antibacterial & Antioxidant
Anti-Inflammatory
Anticancer Potential
Benefits
Enhancing research, student training, & industry collaboration.
Scientific Advancement
Capacity Building
Industry Partnership
Sustainable Impact
APPLICATIONS
BIOTECHNOLOGY
Sustainable bioresource production
Wastewater treatment
Carbon capture
Biofertilizers & biostimulants
PHARMACEUTICALS
Antibacterial & antioxidant agents
Anti-inflammatory compounds
Anticancer potential
Drug discovery & development
COSMETICS
Natural antioxidants & anti-aging
Soothing & anti-inflammatory skincare
Skin barrier protection
Eco-friendly & sustainable ingredients
Microalgae: A Sustainable Resource for Biotechnology, Pharmaceuticals & Cosmetics

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