iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** X **Month of publication:** October 2026

DOI: https://doi.org/10.22214/ijraset.2026.85467

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
Issn: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue x Oct 2026- Available at www.ijraset.com

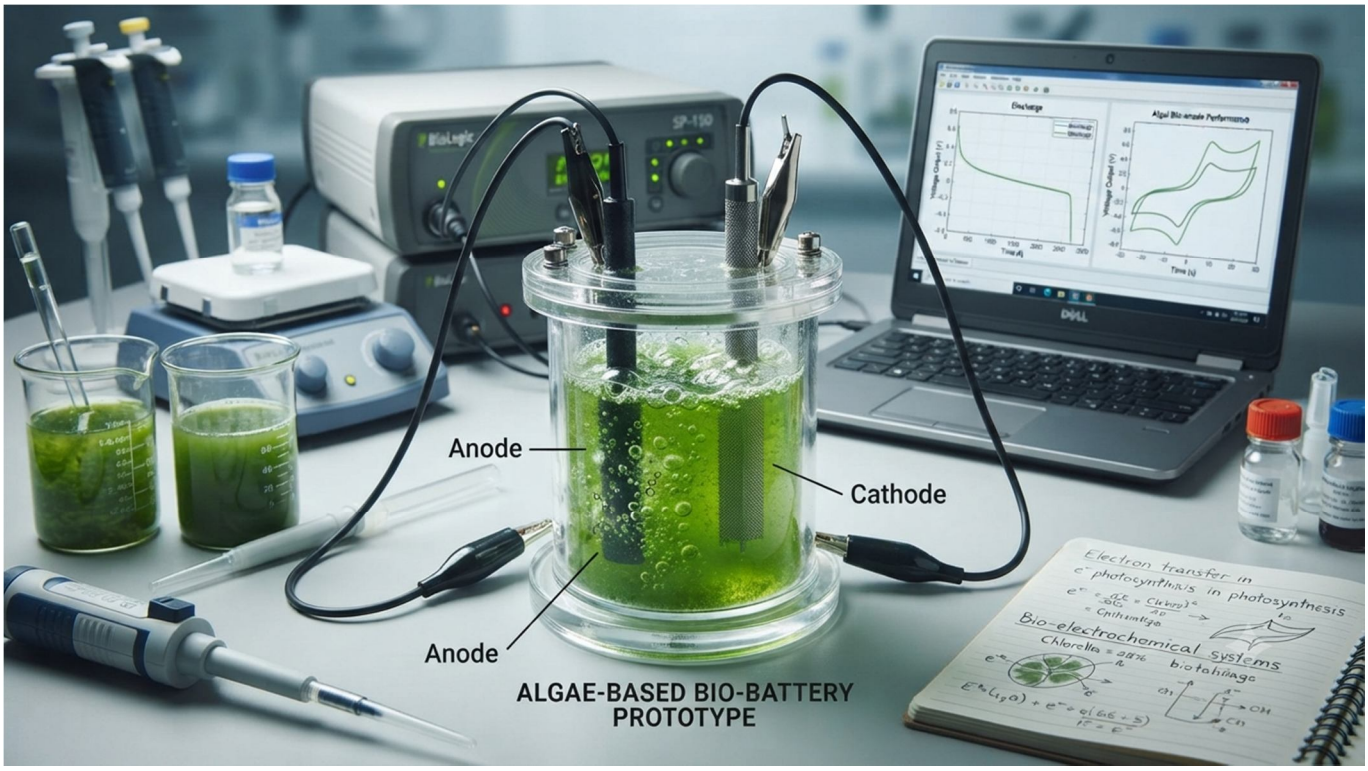
Algae as Bio-Cell with Zero Emission Next Generation Energy Source

Hiren. V. Makwana[1], Dr. Mita. J. Vakilwala[2]
[1, 2]*Keshavji Bharmal Sumaria Commerce & Nataraj Professional Sciences College Vapi,Gujrat,India.*

Abstract: ***Traditional batteries demand a lot of energy to maintain and constantly need recharging. Once discarded, the heavy metals and chemical solutions inside them can leach out and poison the environment. With roughly 745 million batteries thrown away every year, they add a massive amount of unnecessary waste to our landfills. Because energy production remains a leading driver of climate change, this project explores a greener solution: biological photovoltaic batteries (bpvs) that harness microbial photosynthesis to stay charged .based on current research, algae can serve as the core biological component for a bpv. The main goal of this project is to cut down on battery waste while creating longer-lasting, sustainable power sources. Specifically, using algae for this purpose helps tackle environmental issues by giving harvested algae a productive use, which can help prevent harmful algal blooms.***

I. INTRODUCTION

Most household batteries eventually end up in the trash, even the rechargeable ones, making them a major source of landfill waste. The toxic chemicals inside them can also leak and damage the environment. Because of these issues, finding a better, greener alternative to traditional batteries is more important than ever. This project looks at building biophotovoltaic batteries powered by algae to create a power source that is both rechargeable and truly sustainable.[2.][4.]



To see how well they stack up against standard batteries, the project tests each one's pH levels, electrical current, and potential. It also tests how the algae responds to different wavelengths of light to find the optimal conditions.[1.]

While standard batteries are known for their high power output, this research suggests that algae-based batteries actually have the potential to outperform them. Ultimately, switching to biophotovoltaic batteries offers a triple win: they help capture carbondioxide, they recharge naturally, and they even help prevent harmful Algal bloomS. [2.][4.]

When algae produce oxygen through this life-sustaining process, they also generate a steady flow of electrons. Now, a team of researchers at the university of cambridge has developed a way to tap a fraction of this energy and channel it into biocells that could one day power a variety of devices that typically rely on disposable batteries.

Within these biocells, algae are kept in a sealed case, where they produce a low-power electrical current that continues for as long as they are alive—even in the dark. While still in the early stages of commercial development, this technology could one day replace the need for energy-intensive, extractive chemical batteries.[3.]

II. RESEARCH FRAMEWORK & HYPOTHESIS

1) Research Question: What type of algae and which color light wavelength surrounding each battery will produce the greatest power output?

2) Hypothesis 1: *Spirulina* algae will generate the highest power because of its superior ability to adapt to saltwater environments with high pH levels.

3) Hypothesis 2: The algae will yield higher power when exposed to blue light wavelengths (ranging from 450 to 495 hertz), as most algae naturally rely on blue light for photosynthesis. Ultimately, if this project is successful, it can significantly reduce environmental waste in the energy sector by extending the lifespan and usability of batteries.

4) Tone & Style: Polished and natural, maintaining the exact scientific rigor of your introduction while significantly improving readability and flow

A. Experimental Design & Methodology

While this project drew inspiration from pioneering research on biophotovoltaic batteries at the University of Cambridge, it stands out by actively testing specific variables—such as algae species and light wavelength—to maximize voltage output.

III. SETUP AND MATERIALS

A total of sixteen biophotovoltaic (BPV) batteries were constructed using copper and zinc electrodes, a saltwater solution, and specific algae strains.

1) Electrodes & Solution: Copper wire was shaped into uniform springs to enhance electrical conductivity, and both the copper and zinc metals were thoroughly sanded before immersion. Equal proportions of water and salt were maintained across all setups.[5.][6.][8.]

2) Algae Samples: Eight jars were prepared for each algae type (*Spirulina* and *Nannochloropsis*), with one-fourth cup of algae added to every jar.

3) Light Wavelength Filters: Colored plastic wrappers were secured around the jars to test different light wavelengths: four jars used red filters, four used yellow, four used blue, and the rest served as algae controls. Two additional jars were set up as blank control batteries containing no algae.[2.]

IV. DATA COLLECTION & CONTROL MEASURES

1) Data Collection: Over a two-day testing window, a pH sensor, an ammeter, and a voltmeter were used to monitor the pH, current, and voltage of every jar. LabQuest recorded data across three separate trials for each setup.

2) Controlled Variables: To ensure reliability, all measurements were recorded at the exact same time each day. Consistent quantities and types of algae, identical metal electrodes, and uniform saltwater solutions were used across all tests. .[5.][6.][8.]

V. RESULTS & DISCUSSION

A. By Performance And Hypothesis Evaluation

1) Algae Species Comparison: Across the board, every *Spirulina* battery beat out the *Nannochloropsis* group when it came to average power output. On top of that, all the jars wrapped in colored light filters generated more power than the standard control batteries.

- *Hypothesis 1 (Supported): Spirulina* successfully pulled ahead with higher overall power. This makes sense given its natural knack for adapting to saltwater environments that feature high pH levels. By pinpointing the most

efficient algae strains, BPVs take a strong step toward becoming a genuinely viable alternative to conventional batteries.

2) Wavelength Impact:
   - *Hypothesis 2 (Rejected):* Blue light didn't claim the top spot for both species as expected. While it did work best for *Spirulina*, the yellow wavelength surprisingly produced the highest power output for *Nannochloropsis*. Why did this happen? Yellow light sits right between red and blue—the two colors typically associated with photosynthesis—meaning it might offer unique growth and energy benefits that researchers haven't fully recognized until now.[3.][6.]

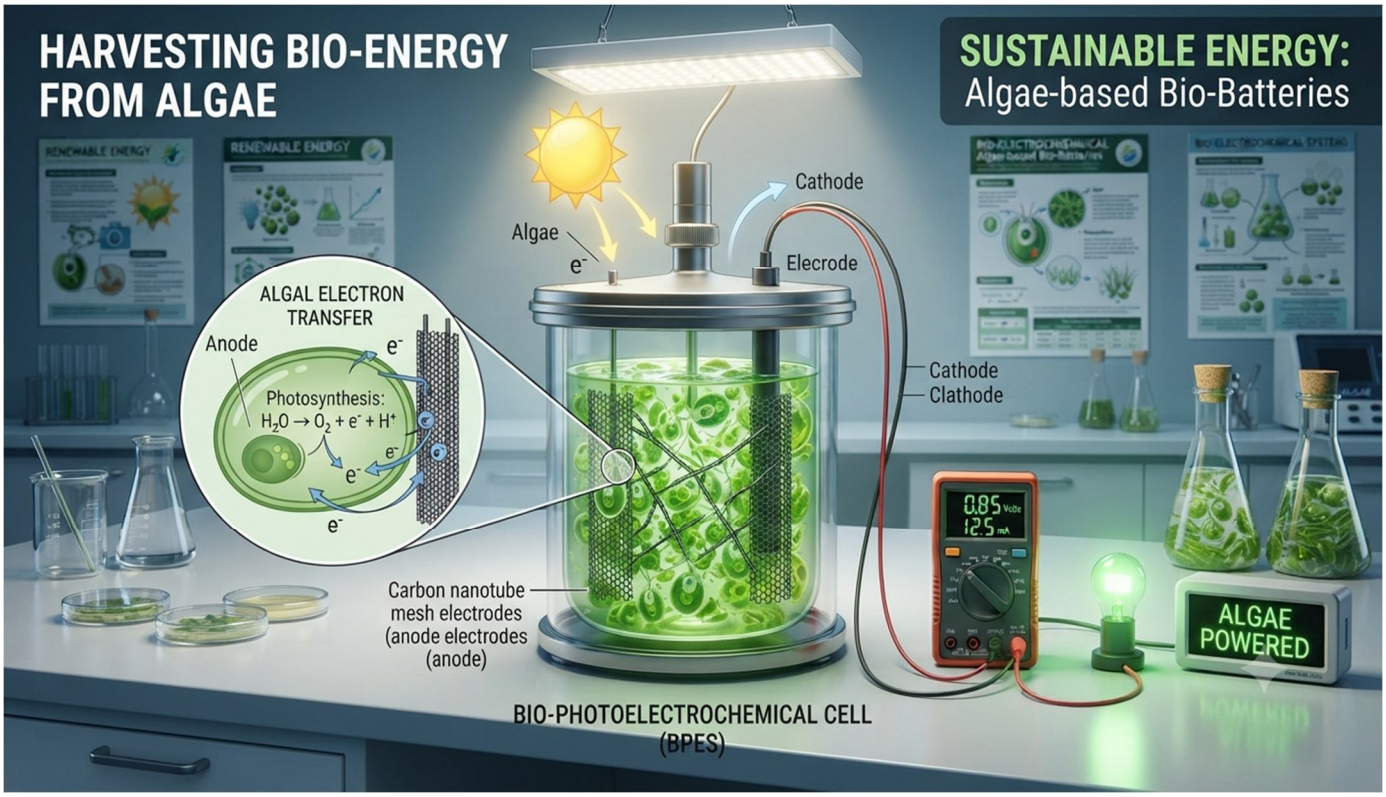
VI. VOLTAGE, BATTERY LIFE, AND PH PATTERNS

1) Voltage Output: Interestingly, the blank control battery with no algae actually hit the highest raw voltage. Even so, among the actual biological setups, the yellow-filtered jars delivered the highest voltage for both types of algae.

2) Battery Lifespan: Power stability over time was a mixed bag. While the control group experienced a slight dip in power, the algae batteries fluctuated: some picked up extra wattage while others lost steam.

3) pH Connection: A clear trend popped up showing that lower pH levels usually meant higher voltage, though there were a few outliers. For instance, the yellow *Nannochloropsis* jar didn't have a particularly low pH compared to its control, yet it still pulled ahead in voltage. On the flip side, the yellow *Spirulina* jar followed the expected rulebook perfectly, hitting both the lowest pH and the highest voltage of the algae group.[7]

VII. CONCLUSION & FUTURE IMPLICATIONS



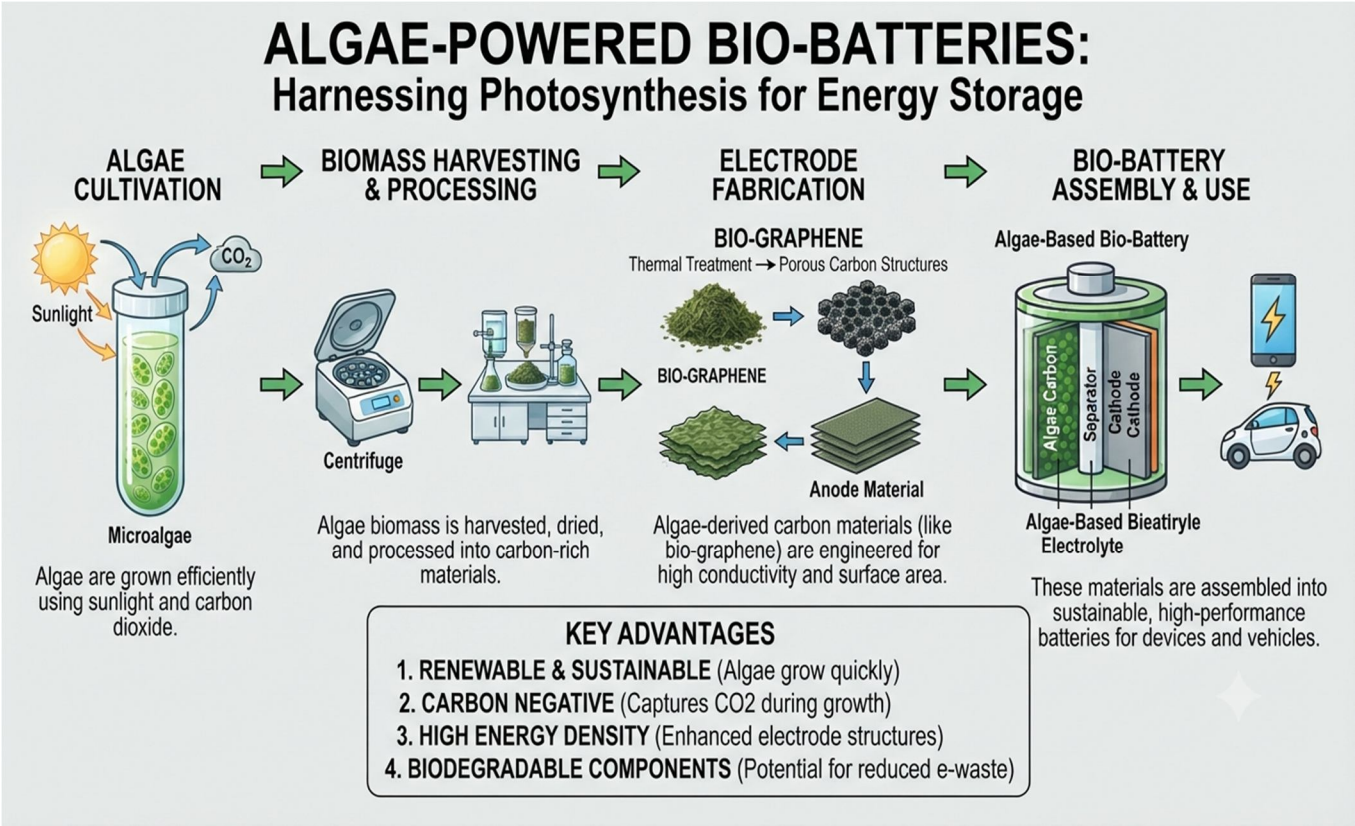
Ultimately, the findings indicate that algae-based batteries are a promising path forward, offering the potential to outlast traditional batteries while delivering even greater power. Furthermore, utilizing yellow light wavelengths to fuel photosynthesis proved to be a key factor in boosting battery output. Looking at broader research, earlier studies have shown that "lily pad"-shaped algae-coated designs can successfully link multiple cells together to scale up total power, while also continuing to generate electricity into the evening using leftover electrons from photosynthesis.[8.]

Of course, no experiment is without its challenges. A few variables proved difficult to control during testing, such as metal oxidation and potential water contamination that could harm the algae. Keeping the jars indoors protected them from unpredictable weather, but it also made it impossible to control exact natural light levels.

On a larger scale, today's ecosystems face growing stress from out-of-control algae growth, making this project's approach a double win: it taps into a renewable energy source while helping protect coastal and marine communities from harmful algal blooms. These results point toward a cleaner, greener future for energy storage. With continued research and development, biological photovoltaic batteries could soon become a viable reality.

VIII. WHATS NEXT??

Looking ahead, I want to take this project a step further by testing new types of algae and different metal combinations to see which setup yields the highest efficiency and voltage. My goal is to eventually scale down the design into a compact, portable battery that functions just like a conventional household battery.[6.]



To test its practical applications, I also plan to hook the BPV up to small everyday devices to see what kind of electronics it can successfully power. Finally, I want to put the batteries under a microscope to closely observe cellular activity and watch how the algae behaves while generating electricity.

IX. SOME CONSIDERABLE CONSEQUENCES

A. The Algae-Powered Breakthrough

Unlike traditional batteries that eventually drain and die, this photosynthesis-driven device keeps running because it continuously uses light as its energy source. Inside, it houses a non-toxic strain of algae called *Synechocystis*, which naturally harnesses solar energy through photosynthesis. The tiny electrical current produced by the algae interacts with an aluminum electrode, successfully powering a standard microprocessor.

Built entirely from common, affordable, and largely recyclable materials, the system can easily be replicated hundreds of thousands of times. This makes it an ideal power source for small devices in the rapidly expanding Internet of Things (IoT), especially in remote or off-grid locations where small, reliable bursts of power go a long way.

B. Powering the Internet of Things

Researchers at the University of Cambridge recently used this widespread blue-green algae species to continuously power a microprocessor for an entire year—and it's still going—using nothing more than ambient light and water.[12.]



As the IoT continues to grow, it needs power systems that actually generate energy on the fly rather than just storing it like conventional batteries. The IoT is a massive, expanding network of smart devices—everything from smartwatches to industrial temperature sensors—that collect and share real-time data online. With the number of connected devices projected to hit one trillion by 2035, relying on traditional power sources simply isn't sustainable.[15.]

Powering trillions of IoT devices with lithium-ion batteries would be completely impractical, requiring three times more lithium than the entire world produces in a year. Meanwhile, traditional solar panels often rely on hazardous materials that carry heavy environmental tolls.

C. Surpassing Expectations

"The system worked consistently over a long period of time—we thought it might stop after a few weeks, but it just kept going," notes Dr. Paolo Bombelli, the lead author of the study from Cambridge's Department of Biochemistry.

Because the algae naturally creates its own food through photosynthesis, it doesn't need to be fed. Surprisingly, even though photosynthesis depends on sunlight, the device keeps generating power even in the dark. Researchers believe the algae continues processing food stored during the day, maintaining a steady electrical current right through the night.

X. WHAT SHOULD BE CHANGES REQUIRED IN FRAME WORK?

A. Regeneration Of Practicality Of Design

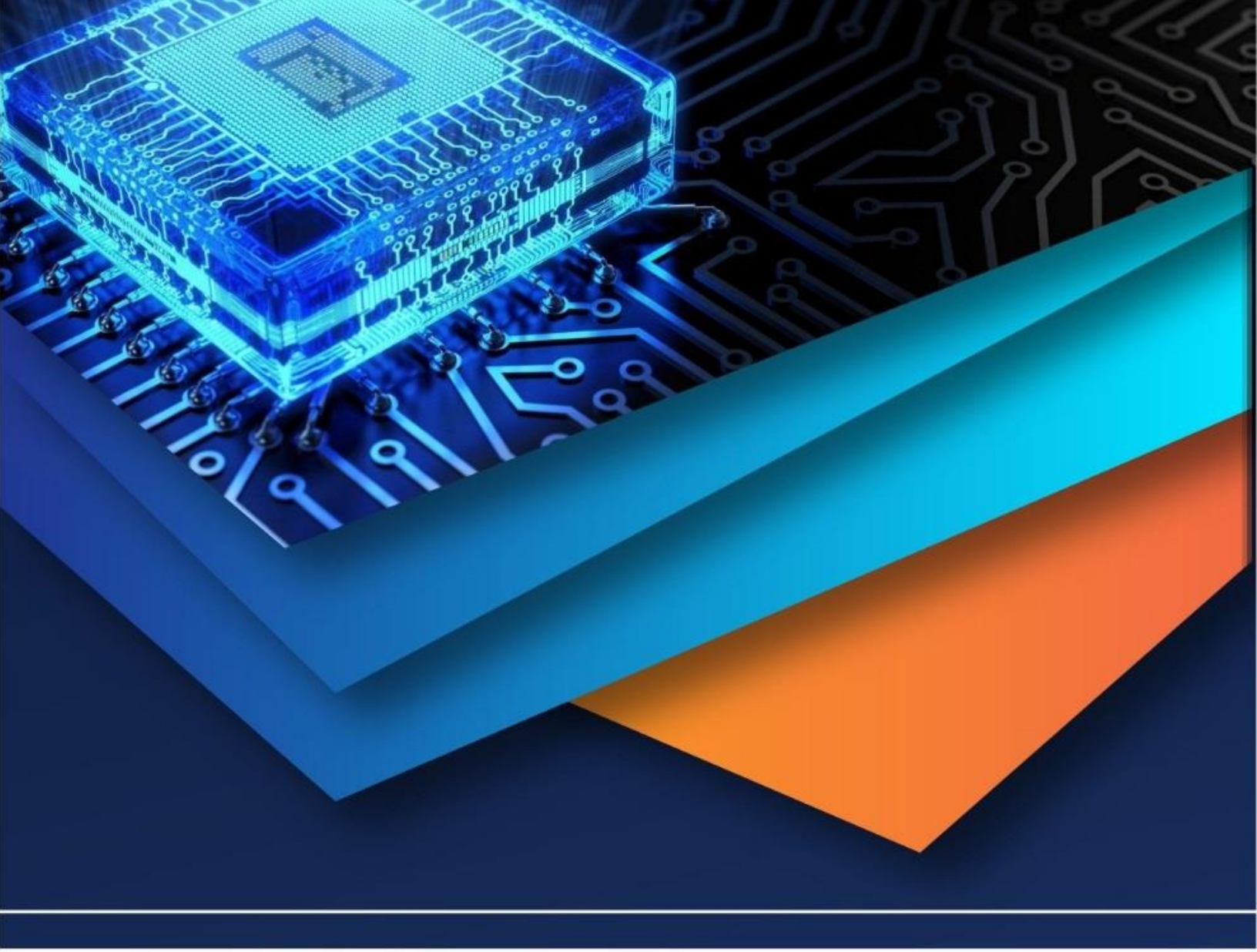
Giron taking a time of two years to design transparent, eco-friendly casings that take in both the biological needs of the algae and the scientific of a tech device: · Living Integration: A semi-permeable membrane manages gas exchange without water loss, while a filamentous electrode gives the algae a textured surface to latch onto for optimal energy transfer. · Visible Sustainability: A removable, recyclable front plate features a symbolic leaf-vein pattern, offering a transparent view of the living system to spark public curiosity. · Applicability of everytime : Working prototypes—such as a disc-shaped panel for a temperature sensor and a rectangular slab powering a clock radio—showcase how the technology can replace small disposable chemical batteries.

XI. FUTURE OUTLOOK AND VISIBILITY

Although current biophotovoltaic panels are larger than the devices they power, ongoing commercialization efforts through the spin-out company **e-Pho** aim to miniaturize the technology. Beyond mere portability, Giron suggests that keeping these living energy generators visible in architectural and public spaces can foster a deeper human connection with sustainable energy production.

REFRENCES

[1] Bhatt, A et al. (2016). How a battery works. Australian Academy of Science.
[2] Bombelli, P. (2018, January 10). Harnessing the power of algae: new, greener fuel cells move step closer to reality. University of Cambridge.
[3] Driver, A, & Bombelli, P. (2018) Biophotovoltaics Energy From Algae. University of Cambridge.
[4] Everything You Need To Know About Battery Recycling. (2022, April 1). GarbageDay.
[5] Electric Circuits: Basics of the voltage and current laws. (2015, June 12). [Video]. YouTube.
[6] Electric Potential: Visualizing Voltage with 3D animations. (2015, June 3). [Video]. YouTube.
[7] Guo, Y.H (2021). A Novel Approach to Decomposing Polystyrene. Canada-Wide Science Fair 5-page Report.
[8] Huang, A.; Sun, L.; Wu, S.; Liu, C.; Zhao, P.; Xie, X.; Wang, G.(2016) Utilization of Glucose and Acetate by Chlorella and the Effect of Multiple Factors on Cell Composition. J. Appl. Phycol., 29, 23–33.
[9] Making a battery with a zinc plate, copper plate and salt water. (2020, April 1). [Video]. YouTube. https://www.youtube.com/watch?v=_IcnnXtaQ1c
[10] Sharkey, T et al. n.d. Alternative Energy - Biological photovoltaics. Swiss Environmental Technology AG.
[11] Technology Networks. (2022, February 21). Paired vs Unpaired T-Test: Dif erences, Assumptions and Hypotheses. Informatics from Technology Networks.
[12] Tschortner, J et al. (2019). Biophotovoltaics: Green Power Generation From Sunlight and Water. frontiers in Microbiology.
[13] Woodford C. (2021) Batteries. Explain that Stuff.
[14] Wey, L. (2019) The Development of Biophotovoltaic Systems for Power Generation and Biological Analysis. Chemistry Europe.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)