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Review of Bio-Batterai as a Renewable Energy Source

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Abstrak

Penelitian ini akan mengulas sumber-sumber alami yang dapat menghasilkan energi listrik, biobaterai memanfaatkan bahan-bahan organik seperti bakteri atau enzim. Teknologi ini sangat menjanjikan sebagai sarana untuk menghasilkan energi secara berkelanjutan. Mikroorganisme digunakan dalam proses yang dikenal sebagai sel bahan bakar mikroba (MFC), yang merupakan metode yang paling umum untuk memproduksi biobaterai. Proses ini melibatkan pengubahan energi yang tersimpan dalam bahan organik menjadi energi listrik. Biobaterai terus berjuang dengan sejumlah masalah, termasuk output daya yang rendah dan masa pakai yang singkat, meskipun faktanya biobaterai memiliki sejumlah manfaat potensial, seperti kapasitas untuk berfungsi dalam kondisi alami dan pemanfaatan berbagai macam bahan organik sebagai sumber bahan bakar. Melalui perkembangan dalam ilmu pengetahuan material, teknik, dan bioteknologi, upaya penelitian dan pengembangan yang sedang berlangsung ditujukan untuk meningkatkan efisiensi biobaterai serta kemampuannya untuk ditingkatkan. Hasilnya, biobaterai memiliki banyak harapan di masa depan untuk menjadi alternatif yang layak dan berkelanjutan untuk baterai konvensional. Pada akhirnya, penelitian ini akan memberikan gambaran umum tentang persiapan dan pemanfaatan bahan alami sebagai sumber listrik terbarukan.

Kata Kunci: *Biobaterai, bahan organik, sel bahan bakar mikroba*

INTRODUCTION

The production of electricity by biobatteries, also known as "biobatteries," is accomplished through the utilization of organic compounds, such as enzymes or bacteria (Choi, 2023). These batteries represent a potentially fruitful area of research for the generation of sustainable energy because they have the potential to generate power from renewable resources and do not have a negative impact on the surrounding ecosystem. Microbial fuel cells (also referred to as MFCs) and enzymatic biofuel cells are the two primary categories of biobatteries (EBFCs) (Calabrese Barton et al., 2004). In MFCs, bacteria digest organic matter and produce electrons as a byproduct; these electrons can then be collected, stored, and used as a source of electrical energy. In electron donor fuel cells (EBFCs), enzymes play a catalytic role in the oxidation of a fuel, such as glucose, which results

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in the generation of electricity (Zhang et al., 2021). The capability of biobatteries to function in ambient conditions, without the necessity for high temperatures or pressures, is one of the most significant advantages of these types of batteries. They are also able to use a wide variety of organic materials, such as waste products and biomass, as sources of fuel in their systems. Biobatteries have yet to overcome a number of obstacles, including low power output and short lifetimes, despite the fact that they may have some advantages in the future. However, there is ongoing research being conducted with the goal of improving the efficiency and stability of these batteries, and it is hoped that in the future, they will be able to serve as a viable alternative to conventional batteries. Bio-batteries, particularly microbial fuel cells (MFCs) and enzymatic biofuel cells (EBFCs), have shown potential as a sustainable and environmentally friendly source of energy (Kižys et al., 2023). However, despite their potential advantages, bio-batteries still face several challenges that must be addressed to make them a practical option for widespread use. One of the main challenges with MFCs is their low power output (Prasad et al., 2022). The amount of energy produced by MFCs is typically much lower than that of traditional batteries, limiting their practical applications. Another challenge is their short lifespan, as the microorganisms used in MFCs can become less efficient over time or may die off entirely. In addition, scaling up MFCs to produce large amounts of electricity is challenging, and more research is needed to optimize their design and improve their efficiency. Similarly, EBFCs also face challenges, including the low stability of the enzymes used in the bio-catalytic reactions (Kim et al., 2006). Enzymes can degrade over time, limiting the lifespan and stability of the bio-battery. In addition, the efficiency of EBFCs is often lower than that of MFCs, and the choice of fuel source can affect their performance.

Despite these challenges, ongoing research and development efforts are focused on improving the efficiency, stability, and scalability of bio-batteries. By overcoming these challenges, bio-batteries hold the potential to become a viable and sustainable alternative to traditional batteries, offering a more environmentally friendly and renewable source of energy.

ANALYSIS AND COMPARISON METHODS

Microbial fuel cells are the method of producing biobatteries that is employed the vast majority of the time (MFCs) (Gao et al., 2019). Microorganisms like bacteria, yeast, or algae, which are all examples of microorganisms, are used in MFCs to convert the energy that is stored in organic matter into electrical energy. During the process, electrons will be moved from the microbial cell to an electrode, where they will be able to be collected and used to power an electrical device. In order to build an MFC, two electrodes are inserted into a container that is then filled with a solution that is rich in nutrients. At one of the electrodes, which is referred to as the anode, the microorganisms oxidize organic matter in order to release electrons. At the other electrode, which is referred to as the cathode, the electrons combine with oxygen to produce water as well as other oxidized products. Ions are able to pass through a membrane that is positioned between two electrodes, which allows the electrical circuit to be completed. It is possible for MFCs to use a wide variety of microorganisms, but this will depend on the application in question as well as the organic matter that is readily available (Obileke et al., 2021).

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Table 1. Various sources of paper with their description and discussion

No.	Paper Description	Discussion
1	From Double-Helix Structured Seaweed to S-Doped Carbon Aerogel with Ultra-High Surface Area for Energy Storage (Li et al., 2019) Year: 2018 Researchers: Daohao Li Guojing Chang Lu Zong Pan Xue Yu Wang Yanzhi Xia Chao Lai Dongjing Yang Research method: Quantitatif Journal: *Energy Storage Materials*	Research Results: Seaweed is used to enhance the capabilities of future batteries. Yang and his team produced cobalt-alginate nanofibres with durable structures similar to egg cases. The fibres can be used to boost the performance of batteries and capacitors, electrical devices that can store and release power in many electrical devices. Reason for Research Review: Can strengthen this research by providing a reference on how significant seaweed can be used as a bio-battery. Reasons for Research Review: Can strengthen this research by providing references on how significant seaweed can be used as a bio-battery.
2	Construction of Rechargeable Bio-Battery Cells from Electroactive Antioxidants Extracted from Wasted Vegetables (Hussain et al., 2021) **Year:** 2021 **Researcher:** Z. Hussain Zuhra G. Rukh A. Zada M.Y. Naz K.M. Khan S. Shukrullah S. A. Sulaiman **Research Method:** Kuantitatif **Journal:** *Cleaner Engineering and Technology*	Battery cells are made by combining electrolyte compounds from onion-radish, onion-citrus, onion-cactus, radish-radish, radish-citrus and radish-cactus. The juice from the combination of vegetables and plants was used to maximize the output voltage. Output voltage was measured before and after cell charging for different charging times, juice volumes, charging voltages and cell media pH. The effect of media was explored by changing the media properties from acidic to neutral and neutral to basic. Where the voltage of most cells in basic media was higher than neutral and basic media. Among the batteries studied, the radish-cactus battery produced a voltage of 2.13 V while the radish-onion battery produced a voltage of 1.9 V. **Reasons for Being a Research Review**: Can strengthen this research by providing a reference that vegetables and fruits can be used as basic materials for making bio-batteries.
3	Biomass Seaweed-Derived Nitrogen Self-Doped Porous Carbon Anodes for Sodium-Ion Batteries: Insights Into the Structure and Electrochemical Activity (Senthil et al., 2022)	Nitrogen self-doped seaweed-derived made carbon (SAC) as an anode material for sodium-ion batteries showed remarkable reversibility, i.e. by 303/192 mAh g^{-1} after 100/500 cycle on current density 100/200 mA g^{-1}.

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No.	Paper Description	Discussion
	Year: 2021 **Researcher:** Chenrayan Senthil Jae Woo Park Nitheesha Shaji Gyu Sang Sim Chang Woo Lee **Research Method:** Kuantitatif **Jurnal:** *Journal of Energy Chemistry*	Reason for Research Review: Provides references to illustrative schemes for the preparation of carbon bio-batteries from seaweed.
4	Fruit and Vegetables as a Potential Source of Alternative Electrical Energy (Senthil et al., 2022) **Year:** 2019 **Researcher:** Syifa Fauzia1 Muhammad Abdul Haq Ashiddiqi1 Alfiatun Wa'is Khusnul Khotima **Metode Penelitian:** Kuantitatif **Jurnal:** *PROG. INTERNAT. CONF. SCI. ENGIN.*	There are various parameters that affect the electrical properties of fruits and vegetables. Different types of fruits and vegetables produce different currents and voltages depending on their characteristics. Based on the research that has been done, it shows that pH is inversely proportional to current and voltage. In addition, the type of electrode used also affects the electrical properties. The distance between the electrodes will be inversely proportional to the current and voltage in fruit and vegetable waste. When installing bio-batteries in series and parallel can increase the current and voltage. A bio-battery with a higher voltage will result in a longer LED flash time. Reasons for Being a Research Review: Can strengthen this research by providing a reference that fruits and vegetables have the potential to be utilised as an alternative source of electrical energy.

Based on the explanation in **Table 1**, the author proposes steps to make biobatteries that can be used from recycled materials. **Figure 1** shows the use of environmentally friendly basic materials that can be developed annually. As well as the process of utilizing salt solution as an energy source which proves electrolyte solution has a good chance as a renewable energy source.

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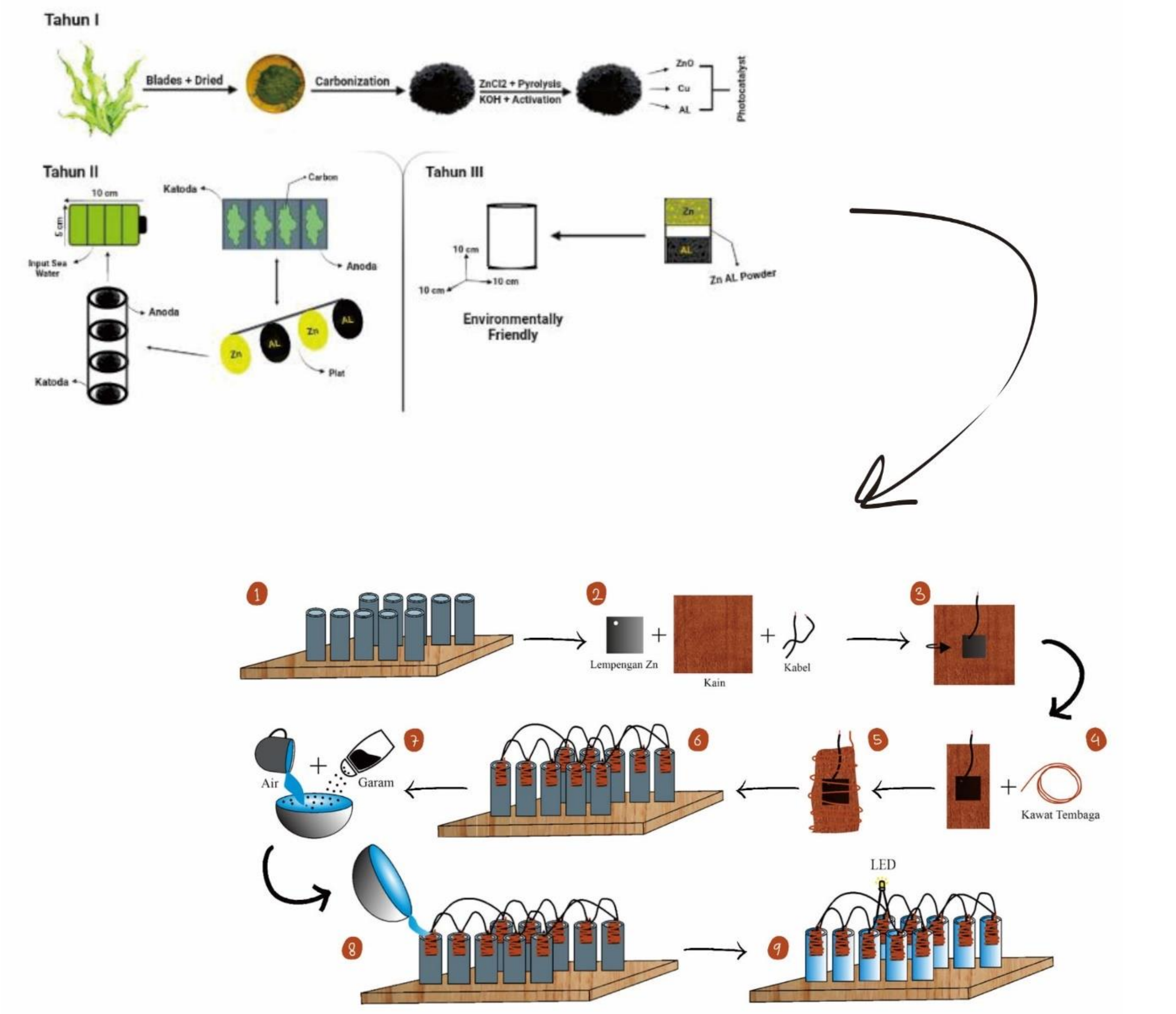

Figure 1. The schematic of the use of basic materials (first row) and the manufacturing process of electrical materials as a power source (second row)

Most of the time, the production of biobatteries is accomplished using microbial fuel cells (MFCs). In MFCs, microorganisms such as bacteria, yeast, or algae are used to convert the energy that is stored in organic matter into electrical energy. Other examples of microorganisms include fungi and algae. During the process, electrons will be moved from the microbial cell to an electrode, where they will be able to be collected and used to power an electrical device. This will be done so that the electrons can be used to power an electrical device. To construct an MFC, two electrodes are first inserted into a container before the container is subsequently loaded with a solution that is abundant in nutrients. Microorganisms are responsible for the oxidation of organic matter at one of the electrodes, which is referred to as the anode. This process allows electrons to be released. At the other electrode, which is known as the cathode, electrons combine with oxygen to produce water as well as other oxidized products. This reaction takes place because the cathode is the opposite electrode from the anode. Ions are able to traverse a membrane that is located between two electrodes, which makes it possible for an electrical circuit to be finished. It is possible for MFCs to make use of a wide variety of microorganisms; however, this will depend on the application that is being considered as well as the organic matter that is easily accessible.

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CONCLUSION

Bio-batteries show great promise as a sustainable and environmentally friendly alternative to traditional batteries. However, significant research and development are still needed to overcome the current challenges associated with bio-batteries, such as low power output, short lifetimes, and limited scalability. Advances in materials science, engineering, and biotechnology will likely play a crucial role in overcoming these challenges and making bio-batteries a viable option for practical applications. As researchers continue to improve the efficiency and stability of bio-batteries, it is expected that they will become increasingly important in the transition towards a more sustainable and low-carbon future.

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