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USING MICROBIAL FUEL CELL TO GENERATE ELECTRICITY AND ITS BIOBUSINESS.

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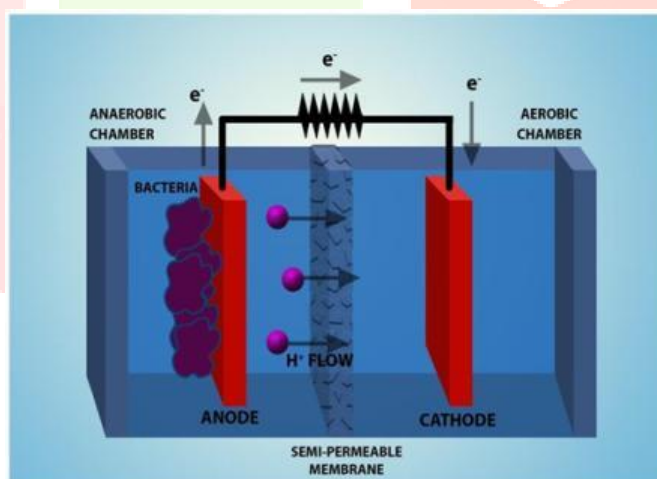
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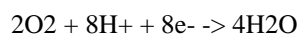
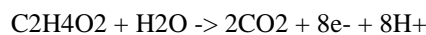
Abstract: The review paper addresses the idea to produce electricity from a typical Microbial Fuel Cell using domestic sewage water as a substrate, to optimize its output using different concentrations of mediators, namely, Neutral Red and Methylene Blue; and hence to compare the results in order to identify the best model suited for production of energy from the aforementioned source. Electricity was generated by using sewage water in anode compartment and electrolyte in cathode compartment. When electricity generated was compared between no mediators and mediators, it was clearly observed that the voltage production with mediators was much higher. The voltage produced was calculated to be 11.76% higher when mediator was used, showing its better to use mediator to obtain optimum results with sewage water. The MFC, thus created, not only produces electricity but because of it acting as a substrate, the organic material also get oxidized resulting in low BOD content (i.e. Pure and drinkable water) for human use as well as consumption. .

I. INTRODUCTION



In the present time most of the energy which we use in the form of electricity or fuels all comes from non-renewable sources of energy. As the nonrenewable resources like coal and petrol will not last forever our scientist found out many renewable resources like hydro energy, wind energy, geothermal energy and many more. Among all these energy sources Microbial Fuel Cell (MFC) is the best one because in addition to power generation it also helps in waste water treatment and pollution control.

In MFCs microorganisms are used as biocatalysts in production of electricity. Microbes are provided with nutrition and are covered in an anodic chamber in anaerobic environment. The utilization of nutrients or organic matter by microbes produces electrons. This electron is then transferred to the cathodic chamber through a membrane which divides anodic chamber and cathodic chamber. The transferred electron binds to the oxygen and proton in the cathodic chamber to produce water. This transfer of electrons produces electricity. This whole procedure of transfer of electron can be represented in form of chemical reaction –



This is the basic principle behind all the MFCs.

MATERIALS USED:

Chemicals and Reagents used :

Methylene Blue has been used as the chemical mediator. A consortium of bacteria in the sewage water is used as the biocatalyst. 2% agar agar gel and 1% KCl mixture has been used as a matrix to prepare the salt bridge which serves as the proton exchange membrane. Saline water for the acceleration of the cathode reaction has been used.

Instruments :

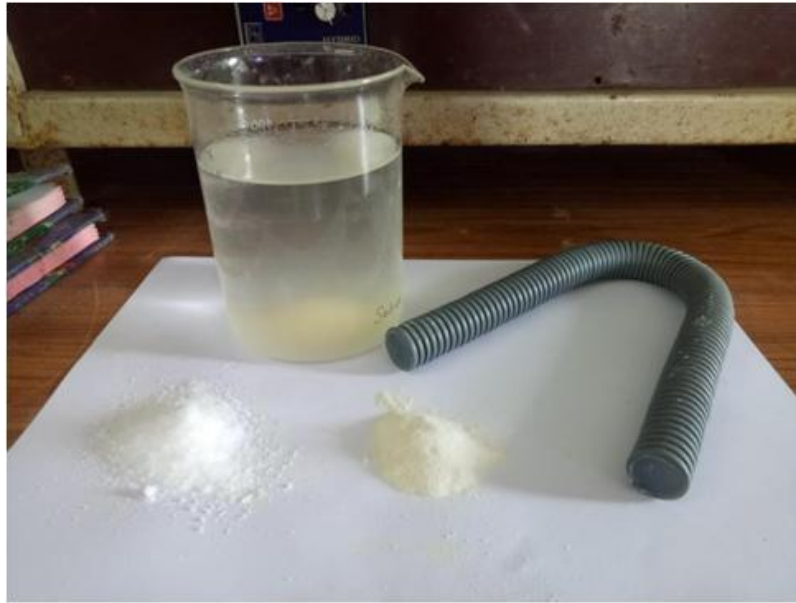
2B pencil leads have been used as graphite rods. They can be used as anode since they have good electrical conductivity, low resistance, strong biocompatibility, chemical stability, corrosion resistance, a large surface area, and economic sensibility. They have also been used as cathodes.



Preparation of Standard Stock Solutions:



KOH Solution: 28.0528 gms of KOH pellets were dissolved in water and made up to 500 ml to create 1% KOH solution to act as cathode electrolyte.



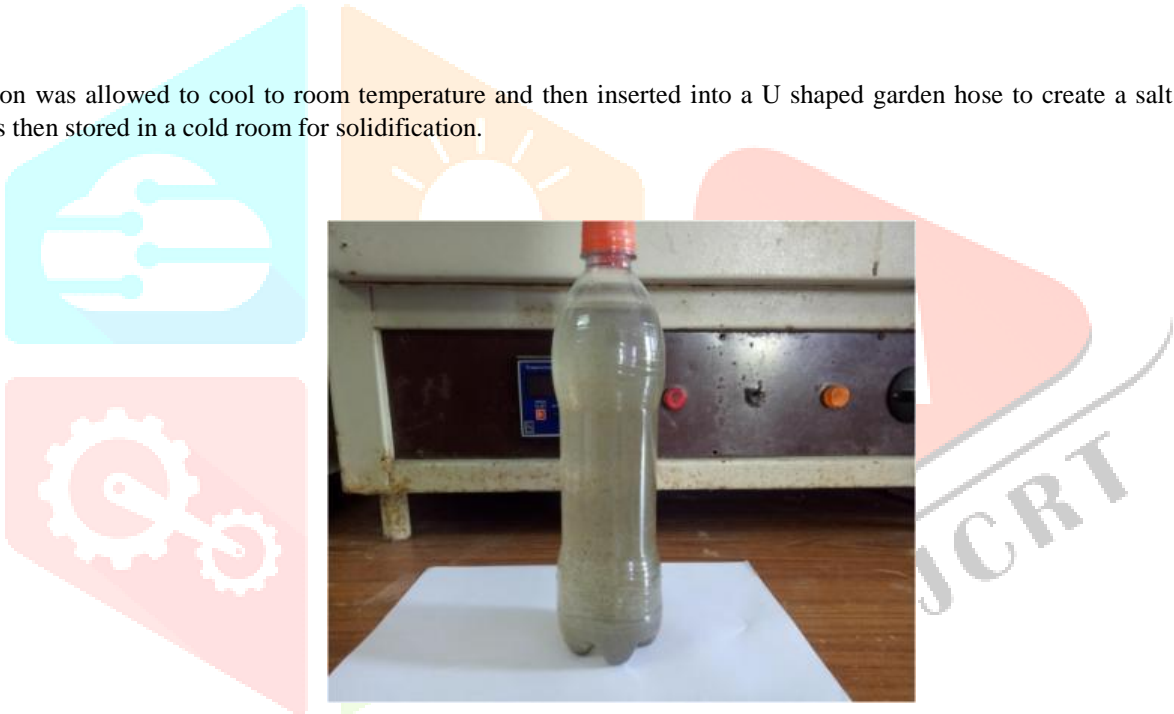
2% Agar and 1% KCl Solution: 2 grams of Agar powder and 7.45 grams of KCl was added to water and made up to 100 ml to create 2% agar and 1% KCl solution.



The salt bridge solution, was then boiled until a colorless solution was obtained.



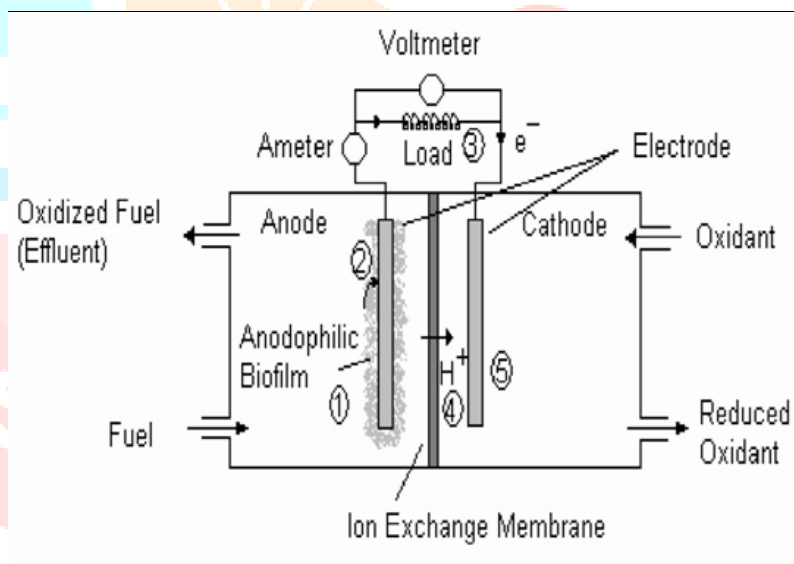
The solution was allowed to cool to room temperature and then inserted into a U shaped garden hose to create a salt bridge. The salt bridge was then stored in a cold room for solidification.



The sewage water acts as a substrate (without mediator)



Sewage water with mediator methylene blue

CONSTRUCTION AND WORKING:

Generally, the Microbial Fuel Cell is consisting of two chambers namely, Anodic chamber and cathodic chamber. Anodic chamber is provided with organic matter (generally from waste water) and anaerobic bacteria which decomposes the organic matter and produces electrons and protons along with carbon dioxide.

Anodic reaction - $C_2H_4O_2 + H_2O \rightarrow 2CO_2 + 8e^- + 8H^+$

The electron produced by bacteria is then transferred to the external load using any inorganic mediator material. From that load electrons are transferred to the cathode.

The Cathodic chamber is properly supplied with oxygen and here electron protons and oxygen all combine to form water (H_2O). The proton is transferred to the cathodic chamber through the proton exchange membrane, which divides anodic and cathodic chambers.

Cathodic reaction - $2O_2 + 8H^+ + 8e^- \rightarrow 4H_2O$



This cell works the same as an electrolytic cell but the only difference is that instead of electrolytes biomass is used for generation of electrons. This biomass can be anything, nitrate rich material from the river basin, organic matter from the sewage or even human urine. Microbes feed on these materials to produce electrons which generate electricity.



A fully functional Microbial Fuel Cell

PROCEDURE:

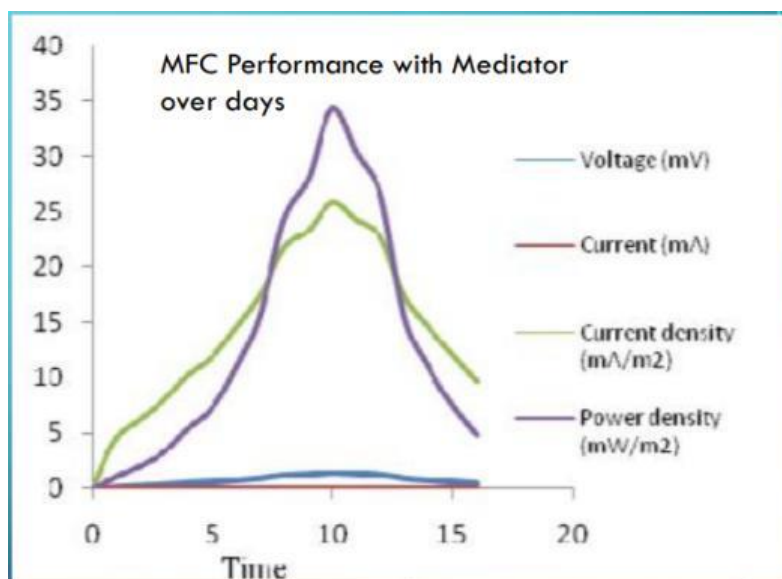
- 1) Two different MFC (Without mediator; With Methylene Blue as mediator) are operated under the same conditions and the Operating Voltage, Output Current, Current Density and Power Density are noted at equal intervals of time.
- 2) The values observed are plotted against time to find the optimum (peak) value of Current density and Power density.

3) These results are compared to find the optimum conditions of operation for the Microbial Fuel Cell (with sewage water as a substrate).



OBSERVATIONS:

Mediator	Voltage (mV)	Current (mA)	Current Density	Power Density
Without Mediator	0.68	0.068	13.229	8.996
Methylene Blue	0.76	0.076	14.785	11.237



RESULTS:

The voltage generated was calculated to be 11.76% higher when mediator was used, showing its better to use mediator to obtain optimum results with sewage water. The MFC arranged in series shows maximum readings.

APPLICATIONS OF MFC AND IT'S BIOBUSINESS:

- Sustainable energy source : Green technology
- Preserving non-renewable sources of energy. Electricity has been produced without the use of any such sources. Chemicals which are cheap and easily available have been used.
- It causes no pollution. No substances that are harmful have been used and they degrade easily.
- Electricity has been produced from sewage water, which is a waste product whose disposal causes pollution. So on the contrary, it prevents pollution. Sewage water which is disposed into rivers and other freshwater bodies can be utilised to produce electricity.
- Electricity is produced at a much cheaper rate than by the usage of coal and other non-renewable sources of energy.
- All the substances used are easily available and cheap.
- If we can add another chamber in two chambered MFCs, it is also possible to desalinate the sea water & the desalinated water can be used to irrigate farm fields in drought prone areas.
- We can manage the electricity bills of those farmers who would provide us the organic dirt.

BUSINESS MODEL CANVASS (BMC):**My First Canvas**

May 16, 2020

PROBLEM <ol style="list-style-type: none"> Most of the energy which we use in form of electricity or fuels comes from non-renewable source of energy which are depleting rapidly. The world needs sustainable, efficient, and renewable energy production Water quality is very poor in India due to excessive pollution and over-utilization of water resources Environmental issues associated with water sanitation Current wastewater treatment technologies are not sustainable needs due to rapid industrialization and population growth Existing alternatives for energy production include using renewable sources like sun, wind, water etc. are expensive Existing products are not customer friendly 	SOLUTION <ol style="list-style-type: none"> Preserving non-renewable sources of energy. Electricity has been produced without the use of any such sources. It causes no pollution. No substances that are harmful have been used and they degrade easily. Electricity has been produced from sewage water, which is a waste product whose disposal causes pollution. So on the contrary, it prevents pollution. Electricity is produced at a much cheaper rate than by the usage of coal and other non-renewable sources of energy. All the substances used are easily available and cheap. 	UNIQUE VALUE PROPOSITION <p>Our product believes in keeping the environment clean, hence it is assured that our microbial fuel cell produces zero emissions of pollutants in nature.</p> <p>Our product also helps in cutting the cost of wastewater treatment as sewage water is the primary substrate that is used in production of electricity.</p>	UNFAIR ADVANTAGE <ol style="list-style-type: none"> we are treating sewage water to generate electricity and pure water at a same time. if we can add another chamber in two chambered MFCs, it is also possible to desalinate the sea water & the desalinated water can be used to irrigate farm fields in drought prone areas. we can manage the electricity bills of those farmers who would provide us the organic dirt. 	CUSTOMER SEGMENTS <ol style="list-style-type: none"> Agriculture, food & beverage, government & municipal, healthcare sector. Customers from rural areas where there is very little or no electricity generation Customers who prefer GREEN electric consumption Production will be preferred by people staying near polluted water bodies or waste water Customers who prefer less expensive forms of similar products already available in the market
EXISTING ALTERNATIVES <ol style="list-style-type: none"> Alkaline fuel cells Direct methanol fuel cells Phosphoric acid fuel cells Molten carbonate fuel cells Proton exchange membrane fuel cells. 	KEY METRICS <p>Sales Revenue Net Profit Margin Gross Margin MRR (Monthly Recurring Revenue) Net Promoter Score Customer satisfaction</p>	HIGH-LEVEL CONCEPT <ol style="list-style-type: none"> Certain microorganisms are capable of producing bioelectricity from reductive substances. Extensive research has been conducted to improve MFC performance through the fabrication of a new stack of MFCs. Maximum generated current and power in a fabricated stack of MFCs were 6447 mA/m² and 2003 mW/m², respectively. In addition to the use of organic substances, MFCs are used for the treatment of inorganic wastes. 	CHANNELS <p>Inbound: To steer customers towards our product, we will use our website, info-graphics, white paper and video content along with search engine optimization.</p> <p>Outbound: TV and radio ads, telemarketing, display of ads and banners, newspaper and magazine ads, cold calling, pop-ups along with displaying video content.</p>	EARLY ADOPTERS <p>Understand their motivations. Innovators like to stay up with the latest trends, almost to the point of being obsessive. Become the expert. Go where your customers are. Leverage social media.</p>
COST STRUCTURE <p><u>Amount of each substance used:</u></p> <ol style="list-style-type: none"> KCl = 7.45gms; Cost in the apparatus: KOH = Rs1.40251; 6Methylene blue = Rs10; <p>274.48</p>		REVENUE STREAMS <ol style="list-style-type: none"> The global microbial fuel cell market is forecast to reach USD 19.5 Million by 2026. The microbial fuel cell solution market is gaining traction due to the increasing demand for clean drinking water. Moreover, the increasing investments by governments and other organizations for the development of cost-effective and sustainable fuel cell technologies will also drive the growth of the market. The Asia Pacific region, particularly India, Japan, and China, is forecasted to have a substantial annual growth due to the development of manufacturing hubs for cost-effective technologies, and due to the availability of less expensive labor and raw materials. 		



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LEAN CANVAS

Problems:

The world needs sustainable, efficient, and renewable energy production. Today we are witnessing a global energy crisis due to huge energy demands and limited resources.

Non-renewable energy sources are depleting and renewable energy sources are not properly utilized. There is an immediate need for search of alternate routes for energy generation. Environmental issues associated with water sanitation are not confined to developing countries alone but are the most basic human and environmental necessities all over the world. Wastewater sources are major causes for environmental pollution in surface and groundwater bodies. Current wastewater treatment technologies are not sustainable to meet the ever growing water sanitation needs due to rapid industrialization and population growth, simply because they are energy- and cost-intensive leaving latitude for development of technologies that are energy-conservative or energy-yielding.

Solutions:

- Preserving non-renewable sources of energy. Electricity has been produced without the use of any such sources. Chemicals which are cheap and easily available have been used.
- It causes no pollution. No substances that are harmful have been used and they degrade easily.
- Electricity has been produced from sewage water, which is a waste product whose disposal causes pollution. So on the contrary, it prevents pollution. Sewage water which is disposed into rivers and other freshwater bodies can be utilised to produce electricity.
- Electricity is produced at a much cheaper rate than by the usage of coal and other non-renewable sources of energy.
- All the substances used are easily available and cheap.

UNIQUE VALUE PROPOSITION OF MICROBIAL FUEL CELL:

Our product believes in keeping the environment clean, hence it is assured that our microbial fuel cell produces zero emissions of pollutants in nature. Our product also helps in cutting the cost of wastewater treatment as we sewage water is the primary substrate that is used in production of electricity.

Unfair Advantage:

- We are treating sewage water to generate electricity and pure water at the same time.
- If we can add another chamber in two chambered MFCs, it is also possible to desalinate the sea water & the desalinated water can be used to irrigate farm fields in drought prone areas.
- We can manage the electricity bills of those farmers who would provide us the organic dirt.

Customer Segments:

Customer segmentation is the process of dividing customers into groups based on common characteristics so companies can market to each group effectively and appropriately. In business-to-business marketing, a company might segment customers according to a wide range of factors. A microbial fuel cell is ideal for use in a number of complex applications such as commercial waste treatment, hydrogen generation, and water treatment among others, since it helps create electricity from a broad range of fuels. On the basis of application, the microbial fuel cell market has been segmented into wastewater treatment, power generation, biosensor, and others. On the basis of end-user, the microbial fuel cell market has been segmented into agriculture, food & beverage, government & municipal, healthcare, and others. Apart from that, customers from rural areas where there is very little or no electricity generation, who prefer GREEN electric consumption, who prefer less expensive forms of the products already available in the market. It is also possible that production will be preferred by people staying near polluted water bodies or waste water.

Existing Alternatives:

- Alkaline fuel cells
- phosphoric acid fuel cells
- Methanol fuel cells
- Molten carbonate fuel cells

Key metrics :

- Sales Revenue
- Net Profit Margin
- Gross Margin
- MRR (Monthly Recurring Revenue)
- Net Promoter Score

High level concept:

- Certain microorganisms are capable of producing bioelectricity from reductive substances.
- Extensive research has been conducted to improve MFC performance through the fabrication of a new stack of MFCs.
- Maximum generated current and power in a fabricated stack of MFCs were 6447 mA_m⁻² and 2003 mW_m⁻², respectively.
- In addition to the use of organic substances, MFCs are used for the treatment of inorganic wastes.

Channels – (for customer reach):

Inbound: To steer customers towards our product, we are planning on using our website, infographics, using a white paper that is an in-depth, well-researched piece of educational content, creating video content that explains the working of our product along with search engine optimization.

Outbound: TV and radio ads, telemarketing, banner and display ads, billboards, newspaper and magazine ads, cold calling, pop-ups along with displaying contextual ads

Braunstorm Customer Segments:

Types of adopters for new products:

INNOVATORS

The youngest group of consumers

Most risk-taking

More educated than others

Usually, wealthier than other consumers

Access to other innovators and resources

Early Adopters:

Progressive Educated Thought leaders;

people value their opinions

Well connected in the community

Early Majority:

Have a low-risk appetite

Usually better than average social status but not thought leaders

Average to above average education

Connected to early adopters

Late Majority:

The older group of consumers

More skeptical about product adoption

Usually, lower social status and prosperity as compared to the other categories

Laggards:

The oldest group of consumers

Usually, value traditional methods

Highly averse to change and risk

Rarely seek opinion outside their own social set

Customer satisfaction

Cost Structure:

Amount of each substance used:

1 Agar agar powder = 2gms

1 KCl = 7.45gms

1 KOH = 28.05gms

Cost in the apparatus:

1 KOH = 1.4025

1 KCl = 0.2235

1 Agar agar = 11.6

1 Methylene blue = 10

1 Multimeter = 250

1 2B Pencil leads = 1.25

1 Total = 274.48

Revenue Streams:

- The global microbial fuel cell market is forecast to reach USD 19.5 Million by 2026.
- The microbial fuel cell solution market is gaining traction due to the increasing demand for clean drinking water.
- Moreover, the increasing investments by governments and other organizations for the development of cost-effective and sustainable fuel cell technologies will also drive the growth of the market.
- The Asia Pacific region, particularly India, Japan, and China, is forecasted to have a substantial annual growth due to the development of manufacturing hubs
- for cost-effective technologies, and due to the availability of less expensive
- labor and raw materials.

Our Website:

Link to the site: <https://bioenergenbb.wixsite.com/home>

Conclusion:

The generation of electricity was done by using sewage water. Electricity was generated by using sewage water in anode compartment and electrolyte in cathode compartment. When electricity generated was compared between no mediators and mediators, it was clearly observed that the voltage production with mediator was much higher. The voltage produced was calculated to be 11.76% higher when mediator was used, showing its better to use mediator to obtain optimum results with sewage water. Moreover, plastic water bottles was used to encourage the theme of the project i.e. Recycling. The MFC not only produces electricity but because of it acting as a substrate, the organic material also get oxidized resulting in low BOD content (i.e. pure and drinkable water). The MFC arranged in series shows maximum readings. The electricity will be produced throughout the year since waste and xenobiotics are readily available. MFC will lead to the clean up of wastes and xenobiotics. So, it can be used as an alternative to bioremediation. Also, it offers low cost electricity from waste materials.

Plagiarism Report Link:

<https://drive.google.com/file/d/1Rdn3D4i81PFZVOJetbNulTxfala-HxE/view>

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