SASTA OLIPHANT SCIENCE AWARDS

SOUTH AUSTRALIAN SCIENCE TEACHERS ASSOCIATION

Prize Winner

Models & Inventions

Year 7-8

Eugene Lee

Pedare Christian College

RISK ASSESSMENT FORM
Models & Inventions

This must be included with your report, log book or entry

NAME: Eugene Lee ID: 0485-003

SCHOOL: Pedare Christian College

Activity: Give a brief outline of what you are planning to do.

The purpose of this study is to understand how bacteria generate electricity and how Microbial Fuel Cells help treat wastewater and convert the energy into electricity simultaneously. A model of the wastewater treatment system using MFCs for a brewery and a farm will be created, with the sewage being discharged into the bottom soil of the wetland.

Are there possible risks? Consider the following:

- Chemical Risks: are you using chemicals? If so, check with your teacher that any chemicals to be used are on the approved list for schools. Check the safety requirements for their use, such as eye protection and eyewash facilities, availability of running water, use of gloves, a well-ventilated area or fume cupboard.
- Thermal Risks: are you heating things? Could you be burnt?
- Biological Risks: are you working with micro-organisms such as mould and bacteria?
- Sharps Risks: are you cutting things, and is there a risk of injury from sharp objects?
- Electrical Risks: are you using mains (240 volt) electricity? How will you make sure that this is safe? Could you use a battery instead?
- Radiation Risks: does your entry use potentially harmful radiation such as UV or lasers?
- Other hazards.

Also, if you are using other people as subjects in an investigation you must get them to sign a note consenting to be part of your experiment.

Risks	How I will control / manage the risk
Biological Risks	• Enclosed footwear and gloves must be worn while sampling soil. • Wash skin area that comes in contact immediately and after experiments. • Remove gloves after handling bio-hazardous material to prevent cross contamination.
Electrical Risks	• Do not put the electrodes near power plugs. • Do not disperse the fibres in the air to prevent electrical shortages. • Connect the electrodes and components correctly.

(Attach another sheet if needed.)

Risk Assessment indicates that this activity can be safely carried out

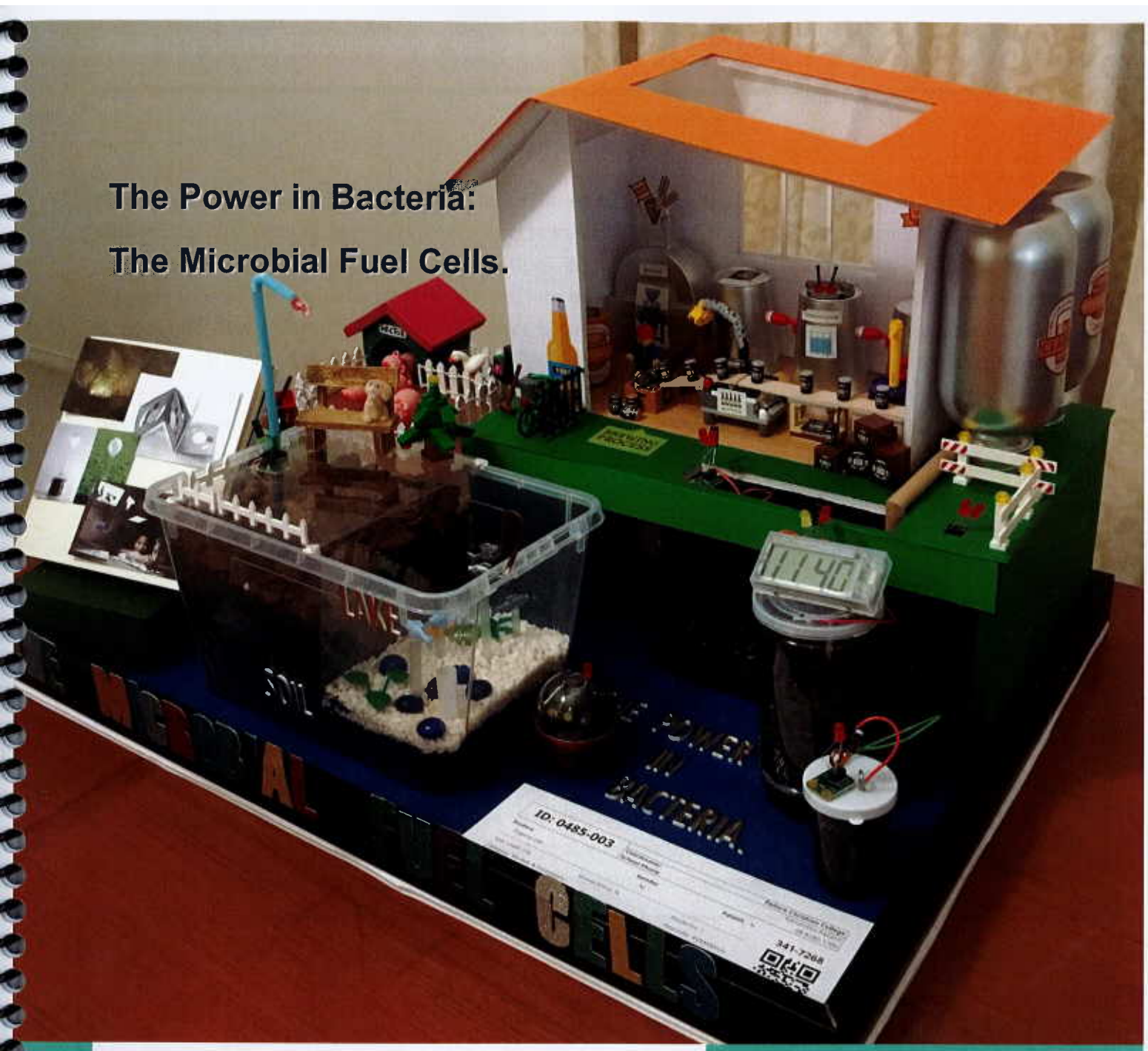
RISK ASSESSMENT COMPLETED BY (student name(s)): Eugene Lee

SIGNATURE(S): Eugene Lee

☑ **by ticking this box, I / we state that my / our project adheres to the listed criteria for this Category.**

TEACHER'S NAME: Samantha Ireland SIGNATURE: [signature]

DATE: 20/7/21



0485 - 003

Treatment of brewery industrial wastewater and generation of sustainable bioelectricity by Microbial Fuel Cells.

Word Count: 498 words.
(Headings, titles, tables, references and pictures/descriptions are excluded.)

Research Motivation

Microbes are often associated with diseases or illnesses, but also the essential players in the recycling of nutrients and providing key ingredients necessary to support life. The sewage generated by human activities have been discharged in large quantities, containing rich organic matter, including bacteria and valuable substances, which cannot be recycled into effective energy resources. Instead, additional energy is required in the treatment, resulting in a large waste of resources. Beer lovers and manufacturers often regard, "Save Water, Drink Beer" as an advertising slogan. Is this really the case? The water consumption in brewing is large, as it requires at least 7 gallons of water per gallon of beer. Due to the larger use of fresh water, a large amount of wastewater is generated accordingly. It belongs to the concentrated organic polluted wastewater, which is non-toxic but harmful. The main pollutant is easy to decompose, has good biodegradability and is suitable for anaerobic biological treatment.

Introduction

A Microbial Fuel Cell (MFC) is a bio-electrochemical system that can drive an electric current by using bacteria and a high-energy oxidant, mimicking bacterial interactions in nature. The MFCs are the devices which harness electrons naturally given off by bacteria within soil, sediment or wastewater to create an electrical circuit. The first MFCs were demonstrated in the early 20th century by Michael Cressé Potter (1858-1948).

With the rise of the concept of modern circular economy and the breakthrough of MFC technology, many scientists began to consider the innovative sewage treatment system of circular economy, which can generate electricity and reduce the toxicity of heavy metals in water and soil. If the waste had been dumped into rivers and oceans without removing the energy, the ecosystems may be damaged.

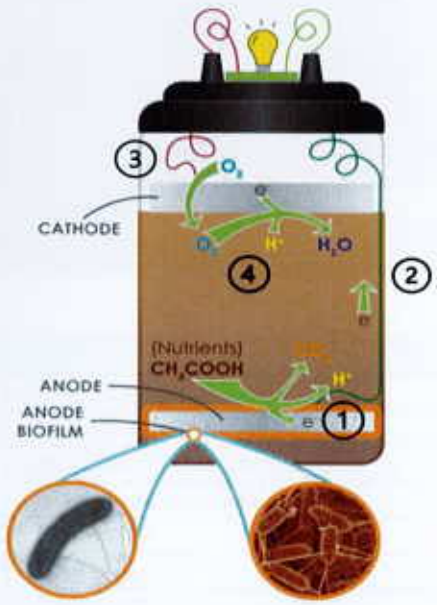


Figure 1. shows the flow of electrons through a single-chamber MFC.

https://en.wikipedia.org/wiki/Microbial_fuel_cell#/media/File:SoilMFC.png

① As the microbes around the anode munch up the nutrients in the mud, they deposit electrons onto the anode.
② These electrons travel through the wire to the Hacker board, where they power the electronics.
③ The electrons then travel back down through the wire to the cathode.
④ As the cathode, electrons interact with oxygen (from the air) and protons (from the anode) to form water.
Mechanism of Microbial Fuel Cells

Mechanism of Microbial Fuel Cells

Microbes

Anode:

$C_6H_{12}O_6 + 6H_2O \rightarrow 6CO_2 + 24H^+ + 24e^-$

Cathode:

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

$C_6H_{12}O_6 + 6H_2O \rightarrow 6CO_2 + 12H_2O$

Researchers are currently developing MFCs as a method to simultaneously treat wastewater and convert the energy into electricity. If this can be done, it may be possible for wastewater treatment to go from a process that uses a lot of energy to one that could generate energy. The MFC solves the problems of high temperature impacts on treatment efficiency, high cost and low efficiency. A model of wastewater treatment system using MFCs for a brewery and a farm will be created, with the sewage being discharged into the bottom soil of the wetland.

Materials

Equipment	
3 × Plastic Vessels with Lids	2 × Digital Clocks
6 × Carbon Felts	4 × Gloves
1 × Red Wire for Cathode	6 × Paper Straws
1 × Green Wire for Anode	1 × Cupper Sheet
1 × Multimeter	1 × Zinc Sheet
8 × Hacker Boards	1 × Silver Paint
8 × Capacitor (10μF)	3 × Plastic Cups & Bottles
8 × Resistors	1 × Scissors & 1 × Knife
1 × Soil Sample	1 × Glue
10 × LED Light	Colour Papers

Methods

1. Build the Electrodes.

2. Collect soil samples.

3. Add soil into the vessel.

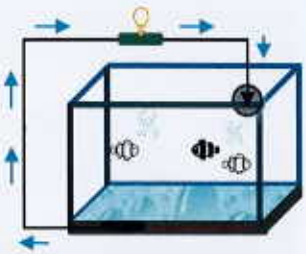
4. Set up the Multimeter.

5. Measure the voltages.

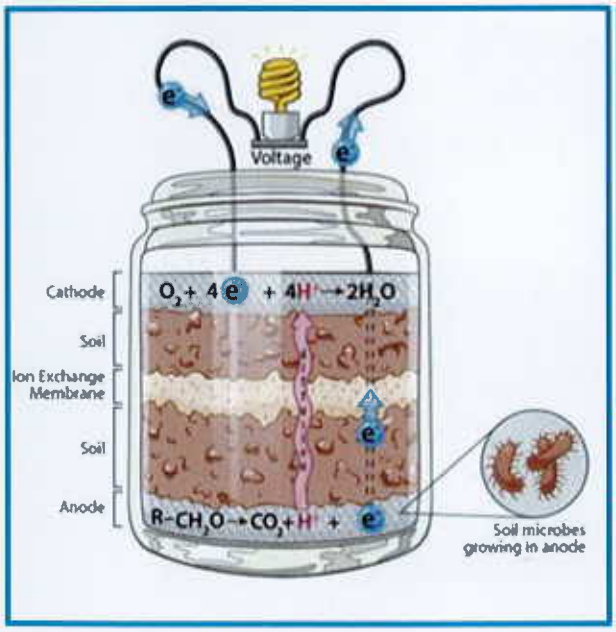
6. Setup the Hacker Board.

7. Testing

8. Design the Model.



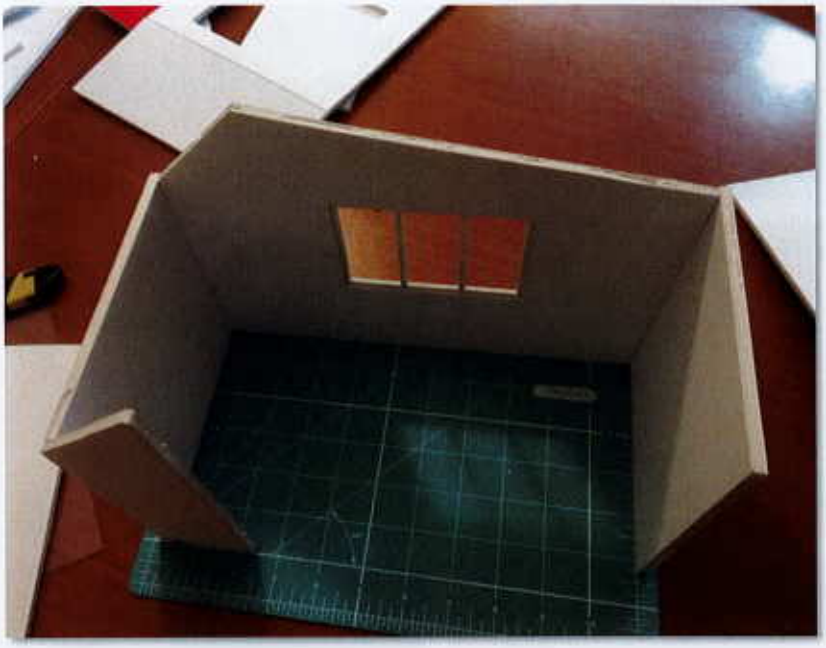
Samples



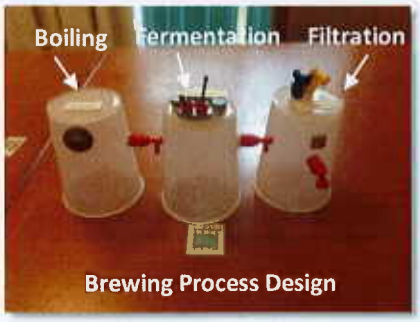
Suitable for the areas where power system installation is difficult.

Beer Factory Model Creation

External Design



Interior Design

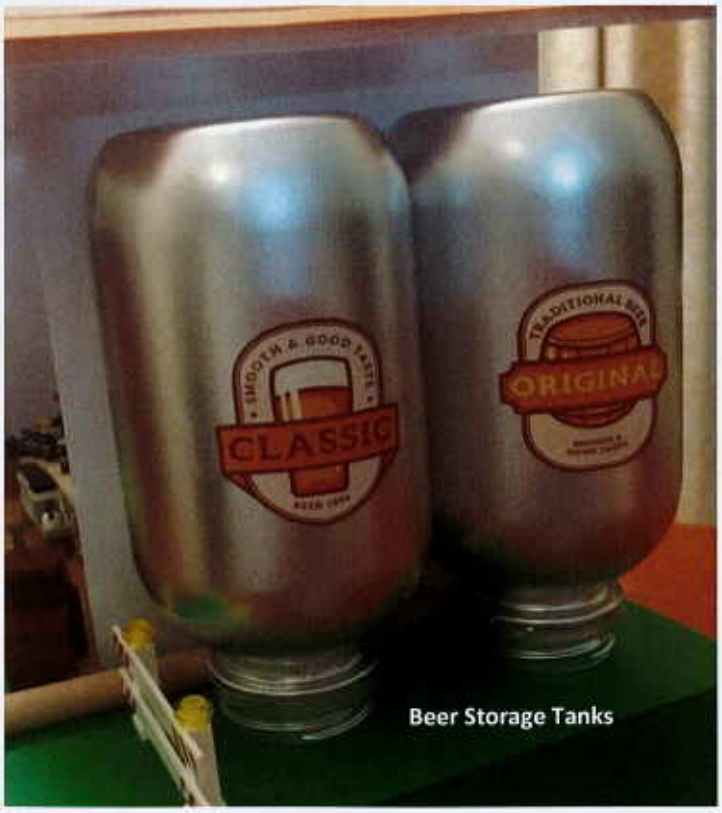



After
Before

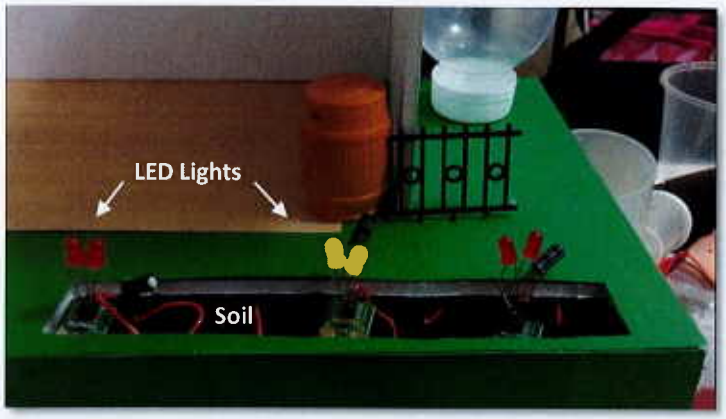

Beer Storage Tanks


Logo & Products

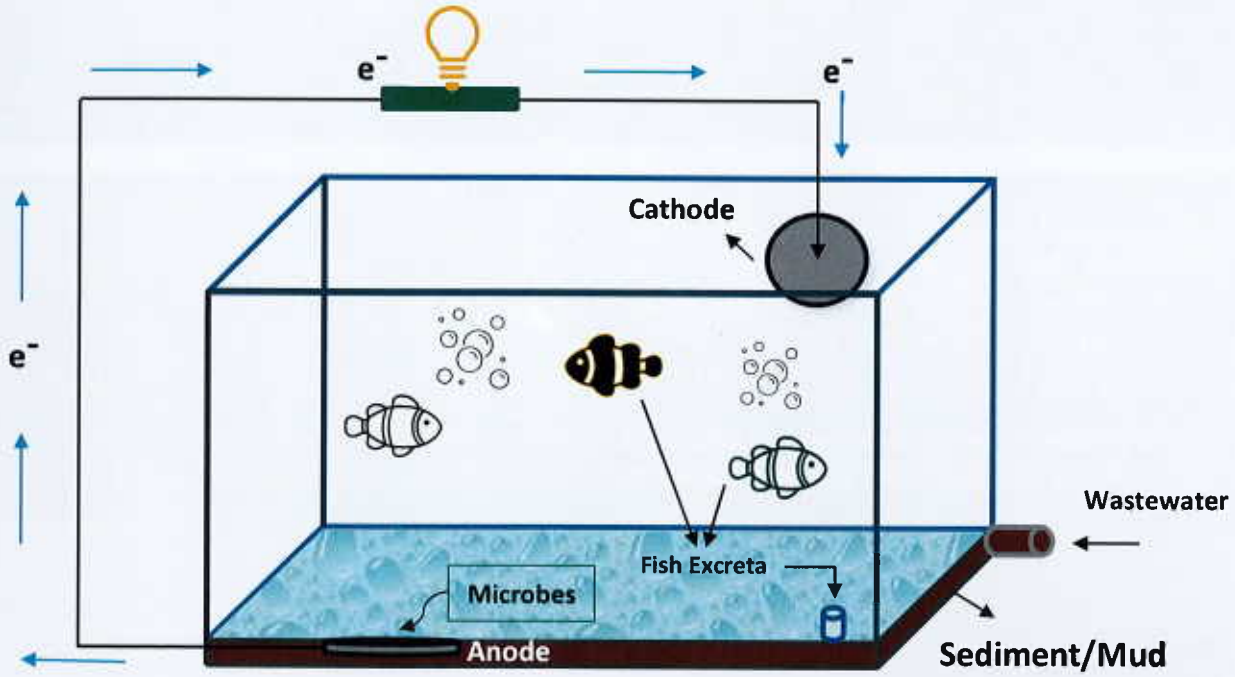

Beer Cans

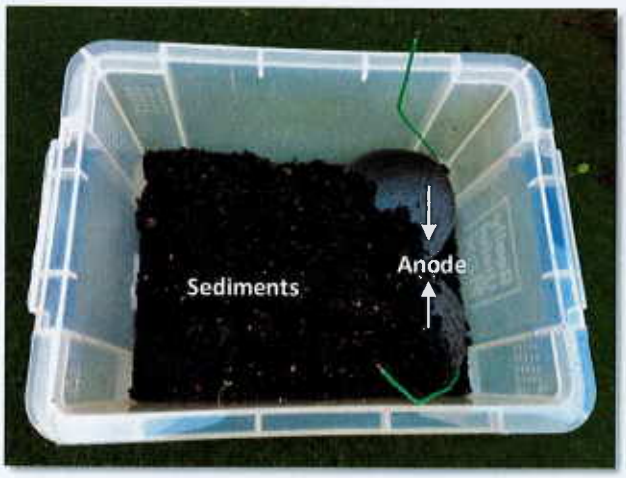

CLASSIC
ORIGINAL
Beer Storage Tanks

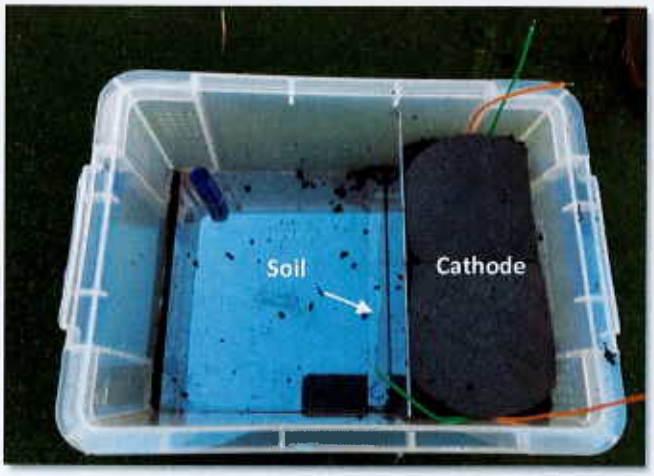

Sewage Pipes

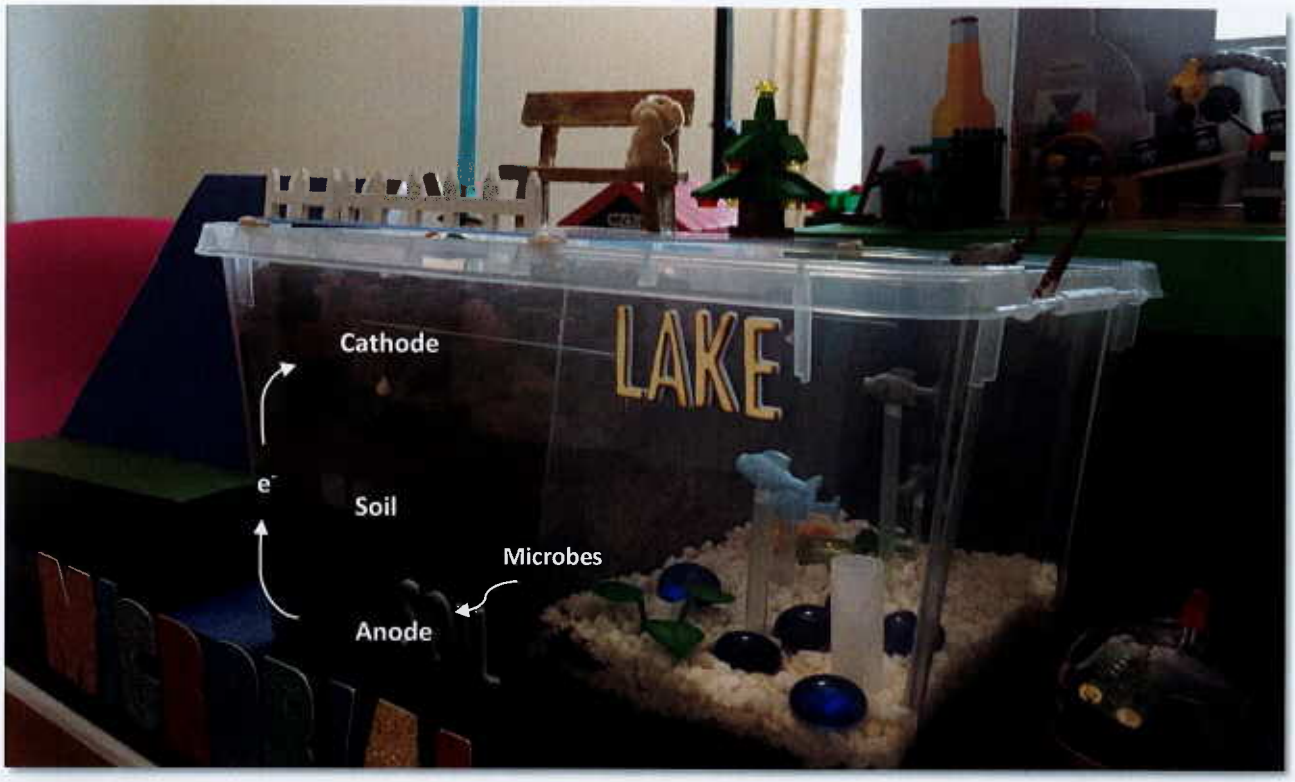


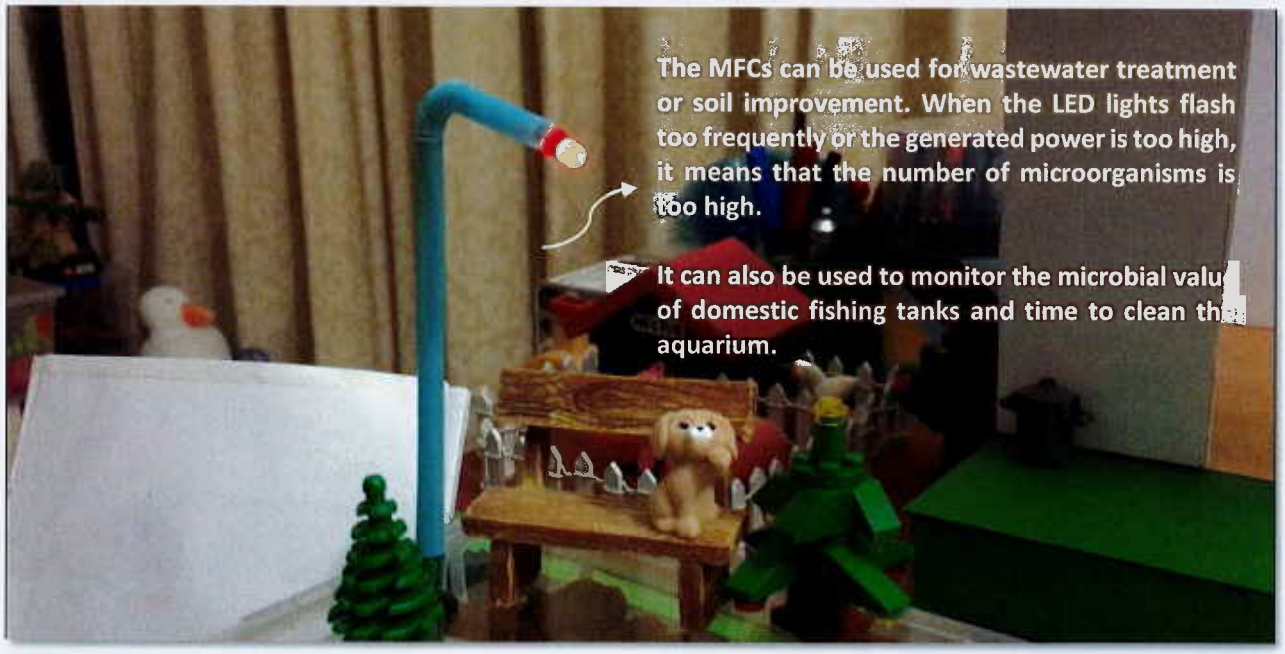
Fish Tank or Miniature Wetland Park & Lake Creation








Cathode
LAKE
e⁻
Soil
Microbes
Anode

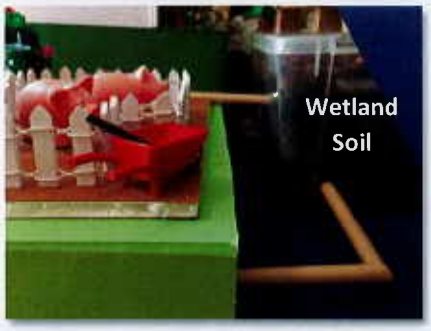

The MFCs can be used for wastewater treatment or soil improvement. When the LED lights flash too frequently or the generated power is too high, it means that the number of microorganisms is too high.
It can also be used to monitor the microbial valu of domestic fishing tanks and time to clean th aquarium.


Fish Excreta


LAKE


Fish Excreta


Farm
Wastewater Pipes


Wetland
Soil


Farm
Wastewater
Beer Wastewater
Soil
Lake
Wetland Park


Soil


Wastewater Pipes

Conclusion

The chemical energy contained in wastewater can be considered promising sustainable energy sources, which can be recovered using MFC technology by means of electro-active bacteria. The organic matter stored in the natural environment and waste is a huge source of energy resources. The MFCs can be used to support sustainable energy if the efficiency can be improved and the cost is reduced. The MFC synchronous pollution control and power generation catalytic wastewater treatment has great practical significance and potential. Using constructed wetland microbial fuel cells to treat beer production or farm wastewater has a certain feasibility. It produces electricity while treating pollutants, which makes up for the energy consumption in the treatment process and has a good application prospect for waste recycling.

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- 2021. [online] Available at: https://www.researchgate.net/publication/276043847_An_Experimental_Study_of_Microbial_Fuel_Cells_for_Electricity_Generating_performance_characterization_and_capacity_improvement
- Michael Agnew, A., 2021. The thirsty business of beer: How breweries are confronting the industry's water problem. [online] Growler Magazine. Available at: https://www.growlermag.com/the-thirsty-business-of-beer-how-breweries-are-confronting-the-industrys-water-problem/#:~:text=Water%20is%20used%20in%20every%20step%20of%20the,can%20go%20as%20high%20as%2010%20to%20one.

Images

- **BrewingProcess_1.jpg (1369×850) (usahops.org)**
- **https://en.wikipedia.org/wiki/Microbial_fuel_cell#/media/File:SoilMFC.png**
- **https://secureservercdn.net/198.71.233.68/97r.1fc.myftpupload.com/wp-content/uploads/2015/10/Fuel_cell.jpg**
- **https://www.sott.net/image/s11/232624/full/Pee_Power_Toilet_Urine_Electri.png**