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Water lily (*Eichhornia crassipes*) generation of electricity through photosynthesis

Generación de electricidad del lirio acuático (*Eichhornia crassipes*) por medio de fotosíntesis

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Abstract

Generate electricity through the photosynthesis of the water lily; releasing electrons at their roots, to be collected by the anode (copper wire) and cathode (metallic foil) conductors, to transport them through copper conductors and be able to use them, in light energy, in a 3-volt led. Plastic containers on average have a higher voltage, compared to metal containers, on average they reached 0.747 volts, R6 was the one with the highest voltage production and the lowest 0.518 volts on average was R4. The voltage produced by metal containers, which did not reach the maximum values of plastic containers, the highest average is R7, with a voltage of 0.576 volts and the lowest of all averages is 0.216 volts R10, On 09/17/2019 at 4:45 PM, the highest average voltage of 7.11 volts was recorded.

***Eichhornia crassipes*, photosynthesis, renewable energy**

Resumen

Generar electricidad por medio de la fotosíntesis del lirio acuático; liberando electrones en sus raíces, para ser recolectados por los conductores ánodo (alambre de cobre) y cátodo (lámina metálica), para transportarlos por conductores de cobre y poder utilizarlos, en energía lumínica, en un led de 3 volts. Los recipientes de plástico, en promedio tienen un mayor voltaje, comparado con los recipientes metálicos, en promedio llegaron a 0.747 volts, el R6 fue el de mayor producción de voltaje y el de menor 0.518 volts, en promedio el R4. El voltaje producido por los recipientes metálicos, los cuales no llegaron a los valores máximos de los recipientes de plástico, el promedio mayor lo tiene el R7, con un voltaje de 0.576 volts y el menor de todos los promedios es de 0.216 volts el R10, el día 17/09/2019 a las 16:45 se registró el mayor voltaje promedio de 7.11 volts.

***Eichhornia crassipes*, fotosíntesis, energía renovable**.

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Introduction

The United Nations (UN) comments on encouraging signs that energy is becoming more sustainable and widely available. Access to electricity in the poorest countries has started to accelerate, energy efficiency continues to improve, and renewable energy is achieving excellent results in the electricity sector. Despite this, greater attention needs to be paid to improving access to clean and safe cooking fuels and technologies for 3 billion people to expand the use of renewable energy beyond the electricity sector and increase electrification. in sub-Saharan Africa.

Worldwide there are 7.5 billion inhabitants, and 16% of this population lacks electricity service, which is why they use fossil fuels to heat and light their homes (Zapien Rodríguez *et al*., 2019, 2019, p. 1).

Worldwide, according to the International Energy Agency, photovoltaic solar energy represents no more than one percent of supply, and yet it is certainly an unstoppable trend. Since 2016, it is the world's fastest growing source of energy. So much so that the manufacture of photovoltaic cells already consumes 40% of the planet's tellurium production, 15% of the silver and a large part of the quartz. It also consumes a considerable part of the indium, zinc, gallium and tin production. And it is a demand that does not seem to stop growing (Jiménez, 2019).

(Espinoza, *et al*., 2020), comment that in recent decades there has been a considerable global increase in the urban population, industrial productivity, energy demand, waste generation and the emission of greenhouse gases due to conversion of energy. The agricultural, forestry, textile and food sectors generate large amounts of waste and its environmental impact has become a matter of great concern in societies around the world. Current efforts are related to maximizing the efficiency of combustion and energy-related processes in general through the use of industrial waste and the reduction of particles.

The problem is that, despite attempts to design recyclable cells, the vast majority of the industry is in another race. In growing the installed photovoltaic without thinking about these types of problems. For their part, governments also do not have in mind to tighten regulations (focused as they are on reducing emissions as soon as possible) (Id, 2019).

The main problem of most alternative sources is energy storage: it is difficult to store on a large scale and must be consumed immediately (Arismendi Romero, 2011, p. 28).

(Carrasco, 2020), affirms that the spatial growth of cities occurs progressively, depredating the soil and the ecosystems around it, which is why each government must have a development plan normatively.

Solar energy

“Solar energy has been used by civilization for millennia, initially for its thermal effect for drying food and residential heating. The first applications of solar energy for the production of electricity date from the beginning of the 20th century, using concentrating solar systems for the production of steam and electrical energy (Shuman, 1916)” Apud. (Nobre *et al*., 2019).

"Sunlight is available in a limited time during the day, it has to be converted and stored to be used. The two alternatives are photochemical conversion and storage of solar energy”, which consists of the direct conversion of solar energy into electricity, generating high fuel sources such as molecular hydrogen from water (Rimichi Flores, December 2019).

The first complex of proteins responsible for photosynthesis in all photosynthetic organisms that use oxygen is known as Photosystem II (PSII). To a certain extent, PSII can be considered to be the basis of life as we know it today, because thanks to photosynthesis, plants make their food and produce the oxygen that we breathe. (Id., 2011, p. 27).

The photosynthesis of carbohydrates is one of the most complex processes that exists in nature, where from CO2 and water, these organic molecules are formed with the emergence of 3200-3500 million that is present dioxygen evolution. The first photosynthesizing cyanobacteria years and from there all the O2 in the Earth's atmosphere has been formed from this process (A and R, 2013, p. 9).

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Plants are indisputably pioneers of solar energy, they have been subjected to millions of years of evolution, all of them make use of the sun to generate their own food, they operate with an efficiency close to 100%, which means that for each photon of Captured light produces the same number of electrons. (Mata González, Dimas Reséndiz, Machuca Pulido and Medina Juárez, 2017, p. 6).

"If we put the efficiency of the plants into a balance, with that of a photovoltaic cell whose efficiency ranges between 14 and 18%, it can be said that we have had the best energy capture system, however, during photosynthesis the plants use that energy released to generate sugars that plants use to boost their growth. These electrons in the form of sugars are deposited in curl deposits as a consequence of the deposition curl, there they are stored as hydrocarbons that, by organic decomposition, microorganisms decompose these chains formed by carbons that when there is a molecular separation there is a release of energy that can be captured. It is clear that for this stage the generation efficiency has dropped, however it is still a 100% clean generation ". (Id., 2017, p. 6).

> "Oxygenic photosynthesis is carried out through the sequential action of Photosystem II (PSII) and (PSI) reaction centers through scheme Z. Both pigment-membrane protein complexes are found in cyanobacteria, algae and plants." (Nguyen and Bruce, 2014).

(Blanco, 2020), comments that there are different types of solar energy systems that can be implemented in the house, either from passive systems, which allow us to heat the house due to its orientation with respect to the sun, passive lighting using the same bioclimatic architecture techniques and active solar energy capture systems through photocells.

Water lily Eichhornia crassipes

This South American species is the most serious aquatic weed in the world. It grows very quickly. It is common in Mexico and causes problems in lagoons, dams, and irrigation canals. (CONABIO, 2020).

The cost of managing water hyacinth in the world is so high, both for the economy and for the ecology, that it is necessary to provide economically and environmentally sustainable control methods in order to offer long-term solutions against the infestation of this weed. (Martínez Jiménez).

It is estimated that it covers approximately 40,000 ha. Virtually all lakes in Mexico have problems with this species; for example, it covers approximately 7000 ha of Lake Chapala. (Id., 2020).

(Rosas, 2020), explains that the problem is that thanks to the misuse of the oxidation plants that do not put them into operation, either due to lack of training and human resources, as well as a budget by the H. City Council , solid waste is not treated properly and therefore ends up in one of the 2 sections of the lagoon, contaminating the other section through the filtration of contaminated water, for which they produce large amounts of the sacate plant, water lily and lettuce. (Valderrama and Cortés, 2020), explain the implementation of bacteria as an experimental model for wastewater treatment, which allows, to a great extent, to understand the role that these microorganisms can play in an environment.

Aquatic systems are also being affected by the presence of IAS in the APRN Valle de Bravo. For example, the giant reed (Arundo donax) and the water lily (Eichhornia crassipes) modify the habitat of aquatic species and affect water quality. The water lily invades the vessels of the dams that make up the Cutzamala System and is often dispersed in lagoons and intermountain natural wetlands, affecting the quality of the water. Water and competing for light and nutrients with native vegetation (CONANP, 2012), (Apud. PNUD México, 2019).

Objective

In this research a prototype is proposed, to generate electricity, through the photosynthesis of the water lily; releasing electrons at their roots, to be collected by the anode (copper wire) and cathode (metallic foil) conductors; to transport them through copper conductors and to be able to use the energy in the form of light energy in a 3 volt led.

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Materials

For the project, water lily obtained from the Miguel Alemán Dam, from the Municipality of Valle de Bravo, State of Mexico, Mexico, six recycled plastic containers of different volumes, five metal containers, recycled metal cans, brand copper wire were used. Recycled condumex gauge 10 and gauge 12, 2 m long, 11 square metal recycled plates measuring 10 cm by 10 cm, lead solder, non-potable water in the area, 3.0 volt led, electric soldering iron, truper brand multimeter model TU-830.

Methodology

The methodology, which is quantitative, quasi-experimental, was collected in a 20-liter container for water lily from the dam in the municipality of Valle de Bravo, State of Mexico, Mexico.

The cathodes were designed, with a metal plate, welded to a copper wire and a copper wire mesh as anode, and copper wire as a conductor, to later start with experiments with other materials; Recycling was used, of plastic containers to contain the water, water containers made of metal cans, of different volumes.

Copper wire for the connections, in the series circuit; the metallic plates were soldered with the copper wire. A circular coil for the anode was built with copper wire of approximately 2 meters in length, non-potable water was added to each container, placing water lily in approximately equal proportion, until eleven prototypes were built to verify the voltage produced, the voltage was measured individual of each container; as well as the total produced by the series circuit; with a multimeter, on different days and times for a long time.

The circuit was connected in series, the total voltage of the circuit was measured, connecting a 3-volt led spotlight, the reduction of the voltage obtained and that produced by the eleven containers on different days and hours was measured.

Experimental prototype

The process of obtaining the data was experimental and direct observation, the plant extracted from the dam of Valle de Bravo, State of Mexico, Mexico was dosed, in figure 1, the type of water lily is appreciated, with its leaves and Spread roots, with non-potable water from the local plumbing, the recycled plastic container in different sizes was used. In figure 2, the prototypes for the cathodes were built, with metal plates they were drilled to weld a copper wire as a conductor and a circular and elicoidal section was built with copper wire for the anode. In figure 3, the placement of the anodes and cathates, which are separated by a smaller plastic container, were placed inside the bottom of the plastic container, they were placed to receive the electrons, which the water lily will deposit in their roots and subsequent bacteria will deposit on metals. In figure 4 you can see the metal container which will serve as cattate and the plastic container as an insulator inside the copper wire that will be the anode.

Figure 1 Plastic container, containing water and the Water Lily collected from the Valle de Bravo dam, State of Mexico, Mexico
Source: Self made

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Figure 2 Construction of the anodes and cathodes with copper wire in a circular elicoidal shape for the anode and metal plates for the cathode, welding copper wire
Source: Self made

Figure 3 Plastic container with the metal plate and copper wire used as anode and cathode
Source: Self made

Figure 4 Condumex brand 10-gauge copper wire, 2 meters long, to be used as the anode and the metal tin as the cathode.
Source: Self made

The voltage measurements produced by the containers were made with a digital multimeter, trupper brand model MUT-830, Figure 5. On different days and hours, the voltages in millivolts, produced by the different plastic and metal containers, connected in series, were measured. , Figure 6. The final prototype, the total voltage, produced by the plastic and metal containers, was measured, measured in volts, of the entire circuit connected in series Figure 7. A 3-volt led was placed, to the circuit connected in series, to measure the resulting voltage of the series connected circuit Figure 8.

Figure 5 Truper multimeter model MUT-830, used to measure the voltage of the containers.
Source: Self made

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Figure 6 Measurement of the voltage of a plastic container in millivolts
Source: Self made

Figure 7 Measurement of the voltage of the series circuit, of the eleven vessels
Source: Self made

Figure 8 Voltage measurement connecting a 3-volt led to the series circuit
Source: Self made

Results

As can be seen in the results of table 1, the plastic containers on average have a higher voltage, compared to the metal containers, on average they reached 0.747 volts the R6 was the one with the highest voltage production and the one with the highest 0.518 volts in average the R4.

Voltage Measurement (v) Plastic Containers						
	R1	R2	R3	R4	R5	R6
	0.776	0.802	0.493	0.727	0.784	0.770
	0.728	0.654	0.502	0.334	0.738	0.750
	0.673	0.603	0.558	0.402	0.710	0.707
	0.734	0.775	0.595	0.603	0.773	0.756
	0.703	0.768	0.560	0.529	0.773	0.758
	0.601	0.618	0.565	0.561	0.742	0.721
	0.748	0.680	0.622	0.504	0.760	0.759
	0.746	0.729	0.593	0.484	0.763	0.757
Average Voltage (Volts)	0.714	0.704	0.561	0.518	0.755	0.747

Table 1 Individual voltage of plastic containers and average voltage
Source: Own elaboration with data from measurements in the field

In the results obtained from Table 2, the behavior of the voltage produced by the metal containers can be observed, which did not reach the values of the plastic containers, the highest average is R7, with a voltage of 0.576 volts and the lowest of all the averages is R10 with 0.216 volts, a hypothesis that arises from these results is the lack of sunlight in the containers, due to its low voltage produced.

Voltage Measurement (v) Metal Containers					
	R7	R8	R9	R10	R11
	0.342	0.373	0.625	0.263	0.694
	0.930	0.237	0.523	0.238	0.420
	0.288	0.391	0.489	0.320	0.362
	0.604	0.671	0.599	0.217	0.571
	0.575	0.669	0.620	0.052	0.573
	0.606	0.611	0.593	0.215	0.567
	0.639	0.598	0.493	0.140	0.550
	0.625	0.581	0.593	0.285	0.543
Average Voltage (Volts)	0.576	0.516	0.567	0.216	0.535

Table 2 Individual voltage of metal containers and average voltage
Source: Own elaboration with data from measurements in the field

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According to what is observed in Table 3, it can be inferred that there is an average tendency to decrease the voltage, produced by the series circuit of the eleven vessels, when connecting a 3-volt led, reaching an average of 6,538 volts, by reducing the voltage to 2,609 volts on average. The day the highest series circuit voltage was measured was September 17, 2019 at 4:45 PM. This indicates that the circuit generated a greater amount of voltage 7,110 volts, since the measurement time was very long of 13 days, compared to the last measurement day, September 4, 2019, which was a voltage produced on average of 4,930 volts.

S voltage threshold (v)	Total voltage of measurement in multimeter (v)	Voltage difference (v)	Voltage reduction by connecting a 3 v led	Date	Time
6.649	7.110	0.461	2.620	17/09/2019	16:45
6.054	4.930	-1.124	2.570	04/09/2019	13.11
5.503	7.030	1.527	2.580	03/09/2019	16:59
6.898	7.030	0.132	2.630	03/09/2019	10:48
6.580	6.590	0.010	2.630	02/09/2019	15:21
6.400	6.350	-0.050	2.600	28/08/2019	17:32
6.493	6.760	0.267	2.620	27/08/2019	14:35
6.699	6.500	-0.199	2.620	26/08/2019	10:44
6.410	6.538	0.128	2.609	Average voltage (volts)	

Table 3 Voltage summation of the eleven containers, measurement of the total voltage of the eleven containers with a multimeter, difference of the total summations of the eleven containers, voltage reduction by connecting a 3-volt led type bulb, date of the voltage measurements of the containers , time of individual and total measurements of metal containers and average voltage
Source: Own elaboration with data from measurements in the field

Conclusions

The results obtained in the measurement of the individual and series voltages of the containers, on average, are notably increased in plastic containers; This indicates that better conductors for the anode and cathode can be sought, such as aluminum, zinc or copper; Comparing results of research carried out with terrestrial plants, this experiment allows to take advantage of the energy of aquatic plants, such as the water lily and to generate clean energy compared to solar cells, although it is in a prototype stage, it is intended to be more efficient the future series circuit and store the energy, to be used as direct current.

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