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Survey-Based Analysis on Solar Energy Awareness and Designing of Bio-photovoltaic Cell using Algae-A Green Energy Initiative

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Abstract: ***The conventional source of energy which is being used extensively for a long time in such a way that their known reserves have been depleted to a great extent. Furthermore, fossil fuels are being consumed at an alarming rate, resulting in global warming and severe climate change. In this paper, analysis has been presented for a field survey ofa mixedgroup of people (students, educationists, industrialists, etc.). The survey covered a variety of topics related to low-cost electricity generation, including solar energy awareness, usage, and benefits. It also covered the knowledge of alternative energy sources.In this paper, we have also presented low-cost electricity generation using bio photovoltaictechnology. We have presented here the working prototype of the Bio-photovoltaic cell successfully designed using Chlorella culture. We optimized the growth of chlorella on various parameters, Temperature,PH, salinity, and light intensity.***

Keywords: Bio-Photovoltaic Cell, Microbial Fuel Cells, Proton Exchange Membrane, Algae, Chlorella Vulgaris

1. Introduction

Due to overpopulation and unsustainable lifestyle choices, humanity is facing a major crisis for energy generation. It has been reported that even if the new energy policies are implemented globally, still by 2040, the energy demand will increase by 32%. [1] With rising energy demand and diminishing fossil fuel reserves, alternative energy generation technologies have sparked a lot of attention recently. [2] The method of harvesting solar energy has drawn renewed interest. Traditional fossil fuels are the primary contributor to greenhouse gas emissions; they pose a significant political risk and are rapidly depleting. Solar energy, on the other hand, is essentially carbon-free, abundant, and accessible worldwide. Through the process of photosynthesis, nature has shown that solar energy can be harnessed. Plants use just about 0.25 percent of the energy in the sunlight that falls on them in the photosynthetic production of biomass, which is not a highly energy-efficient process. [3] Bio-photovoltaic cells are a new source that is growing in popularity. Biological photovoltaic (BPV) devices are solar cells that generate renewable energy through the photosynthetic activity of living microorganisms like algae and moss.[4] Algae are incredibly easy to cultivate, requiringonly sunlight, carbon dioxide, and water thus offering a remarkably simple way of producing energy. [5] Bio-photovoltaic cell is less costly as compared to photovoltaic cell employing silicon. It is a clean and reproducible way for energy production with negative carb on foot prints. Numerous experiments have been conducted on this across the globe and are emerging as a serious alternative source.[6] The working of BPV devices is based on the idea of converting light energy into electrical energy using photosynthetic microorganisms. Microbes in the presence of light split water molecules. The generated protons and electrons are harvested through a bio-electrochemical system[7]. This is accomplished by inserting the algae within one of the two electrode-containing chambers of the BPV cell (anodic chamber). A membrane separates the two chambers, allowing only protons to flow through. The electrons produced, on the other hand, flow via the external circuit and recombine with the proton and oxygen to form water in the other chamber (Cathode chamber) [8].

We focused our study on the photovoltaic cell using algae for sustainable energy conversion and effective utilization of the solar energy spectrum.Algae are incredibly easy to cultivate, requiringonly sunlight, carbon dioxide, and water thus offering a remarkably simple way of producingenergy [9]. Microalgae have been identified as a potential source of raw material for chemical energy production among all photosynthetic organisms due to their rapid growth rates. Microalgae may be consistently produced in semi-continuous and continuous culture for long periods of time, resulting in maximum annual productivity and, as a result, improved solar efficiency usage. Furthermore, micro-algal cells have a minimal structural material content, allowing for the use of the entire biomass for nutrition or other economic purposes. Chlorella Vulgaris unicellular, spherical in shape, green algae, contains the highest source of chlorophyll content.[10] In this paper, we have done the field survey to know the awareness about the alternate energy source for low-cost electricity generation.The analysis has been done for the same. Also, we have presented an alternative source of energy for low-cost electricity generation. We have designed a prototype of a Bio-photovoltaic cell using Chlorella algae as it multiplies rapidly through photosynthesis, requiring only carbon dioxide, water, sunlight, and a small number of minerals to reproduce.[11] Chlorella Vulgaris has been chosen because of its fast growth rate and easy maintenance and handling. It acts as a biocatalyst for the generation of current. [4]

Preparation of the survey questionnaire

Forthe surveytwoquestionnaires,one for common people and another for the industrialists were prepared toassess the awareness of the people and industry towards the use of

alternate sources ofenergy such as solar energy.For the survey, common people, residential societies, andschools of Delhi were visited. The various schools, colleges, and industries were covered for the survey. Based on the survey, results were analyzed and pie charts wereprepared shown in Fig 2 and Fig 3.

Selection of Algae for construction of prototype bio-photovoltaic cell

The basis for the selection of algae would be suitable for being used in a bio-photovoltaic cell.–fast growth, easy maintenance, less waste generation, better performance and efficiency, andeconomical. Single-cell Chlorella species were chosen. Its better growth and ability to generate important by-products made it a clear winner amongst other competent [10]. Chlorella culture was obtained from Blue-Green Algae Centre, Indian Agricultural Research Institute,PUSA and Grown in our laboratory in the Plant growth chamber under conditions standardized-light(1000 lux), pH(8.2-8.7), temperature (16-27^{o}C), mixing, and aeration and salinity (20-24gm/L). The experimental conditions were optimized for the growth of *Chlorella* which has been used asa test organism for the construction of Bio-photovoltaic cells.

2. Result and Discussion

Conclusions of the Survey

Figure 1 and Figure 2 below presents Survey results. A field survey of mixed people (students, educationists, industrialists, etc.) was conducted covering different aspects of solar energy like its awareness, usage, and benefits. About 71% of the people knew about the government's initiative to reduce carbon emissions.

In Delhi and NCR regions more than 49% of the people consume 300kWh and aboveelectricity in a month which depicts how much electricity we are wasting and as nowadays the cost of electricity is so high, so we can consider that they are giving a large partof their income towards this energy consumption. Only 14% of the people consume 100-200kWh electricity in a month while the rest are average consumers (between 200-300kWh).

The next question was very beneficial as it discussed how many people are aware ofalternate energy sources by which we can take a step towards green energy. Only asmall portion 25% area ware of solar energy which brings a great surprise that people are not aware of a source that is emerging so quickly and has been established verysuccessfully in most of the countries across the globe. 36% of the people answered that they haven't even heard of the term solar panels which shows that there is less awareness amongst people and a large population of 35% of people who knew about itwasn't installing it because of its cost of installation.While the remaining population who had installed solar panels weren't benefitted from these. Only 40% voted that it is of use and 30% voted against it due to its maintenance cost and that period is too long to recover the cost of installation.

The less awareness was also a reason due to which 66% of people are not using somevery useful household solar appliances such as solar geysers, solar cookers, etc. 10%knew about solar cookers and are using them, while the ratio for solar geysers and solar heaters was only 5% and 4% respectively.

Analysis of data on various initiatives in the area of photovoltaic

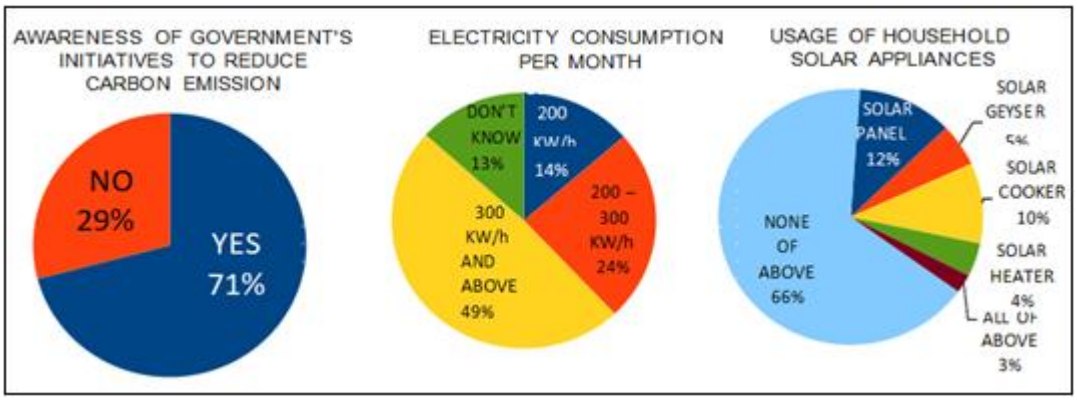

Figure 1

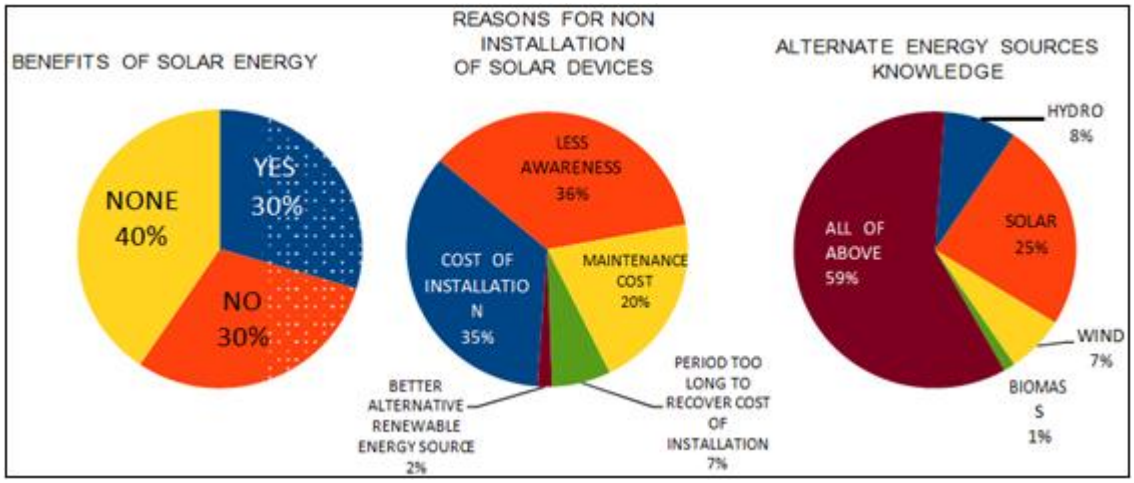

Figure 2

Growth and inoculation of algae under optimum conditions

The cultures procured from Blue-Green Algae Centre,(IARI), PUSA were grown in our laboratoryin the Plant growth chamber as shown in Fig 3. The experimental conditions were optimized for the growth of Chlorella, which has been used asa test organism for the construction of BPV. The optimization of Various parameters was done in a plant growth chamber in our laboratory. The optimized Parameters for Chlorella Vulgaris obtained are as follows [12]: Temperature (oC) in the range of 16-27 oC,optimized at 20oC.Salinity (g/l) in the range 12-40 g/l, optimized at 20 g/l. Light intensity (lux) in the range of 1,000-10,0000 lux, optimized at 5,000 lux and pH value in the range of 7-9 has its optimized value of 8.2. All these parameters were optimized for beet performance of Chlorella Vulgaris s for maximum power generation.

Figure 3: Chlorella Vulgaris Cultures Grown in our laboratory in the Plant Growth Chamber

Designing of Prototype of Bio-Photovoltaic Cell

After optimization of algae cultures, the prototype was constructed with a proper selection of electrodes and a proton selective membrane. Nafion (117) is found effective as a membrane forproton exchange membrane (PEM) fuel cells by permitting hydrogen ion transport while preventing electron conduction. For the construction of the prototype, two glass chambers were joined through the Nafion membrane. One glass chamber contains Chlorella Vulgaris and the other contains distilled water. Electrodes were inserted in both chambers and they were connected externally through a multimeter as shown in Fig. 4,thereby completing the circuit for the flow of electrons between the chambers. The voltage thus obtained can be measure through a multimeter. Zinc and copper were used as cathode and a node respectively. Successful working of the constructed prototype is shown in Fig 4 and it generated a moderate amount of voltage.

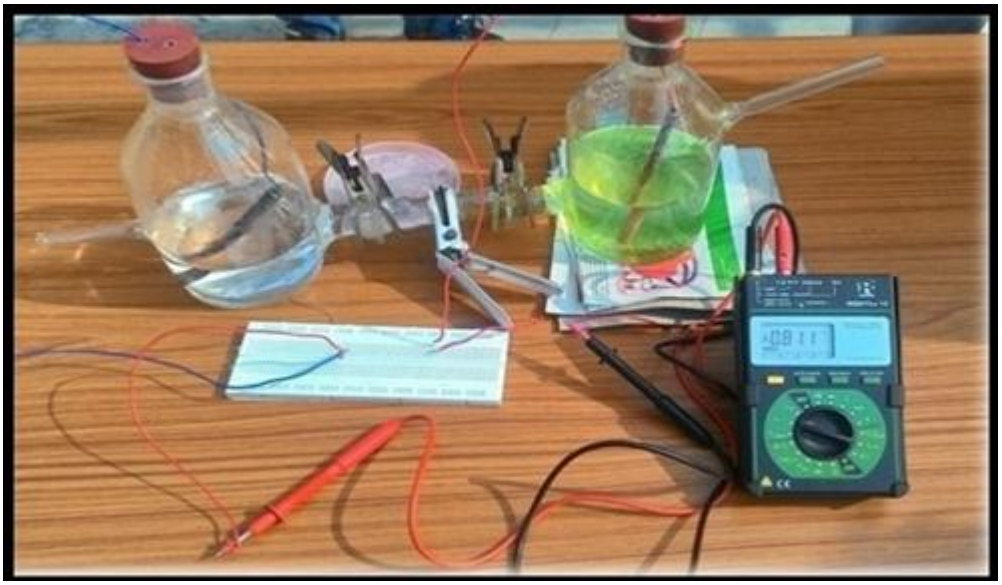

Figure 4: Working of Prototype of Bio- photovoltaic Cell

3. Conclusions

The survey analysis shows that more awareness needs to be given to people to save our planet from various crises such as global warming and protecting many species on the earth getting distinct. Further, the research work exploits the potential of Bio-Photovoltaic cell as a sustainable, efficient, and renewable energy production source. Wepresent bio-photovoltaic cell, a concept that exploits bio-energy sources, like algae and blue-green algae to convert solar energy into electrical energy. The major concept with which we started is to design adevice that can meet the demand for a small light weight power source to provide power in remote areas, on roads (street lighting), highways, and emergency exits.Bio-photovoltaic cells may be the only technology capable of providing power at that scale.These cells could be used more easily and are relatively safer than photovoltaic. They havethe potential to be less expensive than photovoltaic because they don't require preciousmetal catalysts and use the most effective configuration than the traditional design. Algaeand blue-green algae can utilize sunlight and carbon dioxide to convert solar intoelectrical energy.A distinctive property of bio-photovoltaic is that of being able to self-assemble and self-repair. **The development of biofuel cells is a multi-disciplinaryendeavor.**

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