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Design of Water and Oxygen Extraction from Atmospheric Air and Microalgae

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ABSTRACT

The purpose of this study is to develop a low-energy for water generation and Spirulina microalgae cultivation. The integrated model was designed to perform three main functions: use condensation and dehumidification to draw out water from ambient air, utilizing the water that was extracted, and cultivate Spiriola spp. The system integrates sensors and IOT system to monitor air quality, manage purification processes, and optimize water and oxygen production. The research methodology study involves installing an end-open tube collector, sensors, and operating the system to collect and collect the data from air-to-water conversion efficiency under varying conditions. The study involves designing a solar-powered system with a desiccant wheel, developing theoretical models to predict performance, and validating these models through experimental testing and data analysis. The IOT data confirmed stable environmental factors such as 78% humidity, pH around 7.5, and oxygen concentration near 20.90%, validating the system's sustainability and effectiveness. The results of the study are that the integrated model is a high-efficiency, low-power, and renewable method suitable for urban and semi-urban environments.

Keywords: - *Water Extraction, Oxygen Generation, Atmospheric Air, Cultivation of Ardunio Microalgae, Liquid Tree.*

1.INTRODUCTION

1.1 Background

In the face of rising environmental challenges, innovative solutions are crucial for addressing both air pollution and resource scarcity. Our project represents a pioneering approach to environmental sustainability by integrating air purification, water generation and Oxygen generation. By taking inspiration from "Liquid Tree" which is created In Serbia to counter air pollution and From Hyderabad where they experimented Air to Water conversion, by combing this two Project in one and doing it in Low budget is the final aim for this project.

1.2 Solid Waste Management in Rural India

This project begins with the collection of air from urban or industrial sources. Using advanced filtration and chemical processes, we aim to extract and convert harmful pollutants into clean, usable water. This water then serves as a vital resource for cultivating microalgae, a versatile and highly efficient organism known for its rapid growth and ability to thrive in various conditions.

Researchers and experts have paid considerable attention to the nutritional profile of microalgae, that is made up of a variety of unicellular photosynthetic organisms. Its amazing composition includes important nutrients such as proteins, vitamins, and minerals. Its abundant nutritional content highlights the potential of microalgae as a sustainable food source and emphasizes the significance of this food source in tackling global issues related to malnutrition and food security.

1.3 Need for Civil Engineering

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The design of water and oxygen extraction from atmospheric air and microalgae is necessary in civil engineering, specially in case of urban development environmental management. Nowadays ,due to population grows rapidly and climate change, There is shortage of water also because of pollution in urban cities oxygen level is reduced. So this system helps for energy producing and reducing carbon footprints.

This system also improves the wastewater quality and air quality. By cultivating microalgae in urban designs such as rooftop garden it improves air quality and increases aesthetic interest. This technology makes a huge goal in environmental management and makes them a great future of civil engineering.

1.4 Aim of Project

To design system for extracting water from atmospheric air and oxygen from microalgae and increase environmental efficiency.

2. LITERATURE REVIEW

2.1 Literature:

All the research paper gave a brief idea about the building concept and analysis method which can be implemented in our project and gives better results.

2.2.1 Literature Review:

George, (2023), "Liquifying Urban Lungs: Assessing the Air Purification Potential of Photobioreactor Liquid Trees in Highly Polluted Cities.'' The research methodology proposed involves the study focuses on lab and field tests to assess CO2 absorption and oxygen release. Field implementation was also observed in urban settings, specifically Belgrade. Limitations include sunlight requirements, species selection, and costs.

Niranjan and Rakesh N, (2021), " Design of a Water and Oxygen Generator from Atmospheric Pollutant Air Using . The methodology involves designing a system that utilizes atmospheric pollutant air to generate water and oxygen. The system integrates sensors and IoT technology to monitor air quality, manage purification processes, and optimize water and oxygen production.

Agrawal, et al, (2023), " Experimental investigation of atmospheric air to water generation based on both ends open evacuated tube collector solar air heater". The research methodology study involves installing an end-open tube collector, calibrating sensors, and operating the system to collect and analyze data on air-to-water conversion efficiency under varying conditions. Data is then analyzed to evaluate performance and efficiency.

Kushwaha, et al (2024)," Solar-powered water generation from atmospheric air using desiccant wheel: Theoretical and experimental investigation". The research methodology study involves designing a solar-powered system with a desiccant wheel, developing theoretical models to predict performance, and validating these models through experimental testing and data analysis.

Bergmair, et al (2014), " System analysis of membrane facilitated water generation from air humidity". The research methodology study involves a system analysis of a proposed unit that uses water vapor s to extract water from humid air. The method focuses on using membranes to separate water vapor from other atmospheric gases, reducing energy requirements significantly.

Joshi, et al (2017), " Investigations on a Portable Fresh Water Generator Using a Thermoelectric Cooler.' The study experimentally investigates a thermoelectric fresh-water generator (TFWG) that condenses moisture from ambient air using thermoelectric cooling. A prototype was fabricated with ten thermoelectric modules, and the impact of an internal heat sink, electric current, air flow rate, and humidity on water generation was analysed.

Benemann, et al (1987), " Microalgae Biotechnology." The study compares microalgae mass cultures with agriculture and industrial fermentations, highlighting advantages in using microalgae in specific conditions

Kazbar, et al, (2019), " Effect of dissolved oxygen concentration on microalgal culture in photobioreactors'' This study studies the impact of high dissolved oxygen concentrations (CO_2) on biomass productivity, The specific rate of cofactor regeneration (JNADH2) was recalculated to enhance a kinetic growth model, which was then used to find the performance differences between photobioreactor geometries.

Nag-Jong Kim, et al, (2001), " A theoretical consideration on oxygen production rate in microalgal cultures' The study models oxygen production rates in high-density microalgal cultures using light penetration and photosynthesis data. The model's estimates matched experimental results and were used to determine optimal photobioreactor operating parameters.

Cattani., et al (2021), " Water Extraction from Air: A Proposal to Compare Air Water Generators Efficiency.'' The study proposes a new indicator called WET (Water Energy Transformation) to standardize the evaluation of air-to-water generators' efficiency. This indicator is designed to compare different AWG machines by calculating energy performance.

3.METHODOLOGY

3.1 General:

In the first case the group decided on the topic of the project under the guidance of the professor.
As the topic is decided group started to research on the topic on various platform and collected information. After that we searched for research papers by different authors regarding the project and studied them, after enough of data is collected, we are going to start work on working model.

As the project is multidisciplinary, we asked for help from other department, and they're going to give help us regarding electronics components.
In model first we are going to capture air through using Dehumidification, it will work as air conditioner which will cool down air and convert it in water. And for temperature we are going to use Temperature and Humidity sensor it will observe air humidity and water temperature.

3.1.1 Air Pollution Sensor

By Applying other Air pollution Sensor will collect air quality data. Air Pollution Sensor is used to detect the pollutant in the air. Also helps to detect carbon dioxide, Temperature, Humidity, Carbon monoxide, Ozone etc. present in air. It is important for air purifier and fresh air system. The Laser Scattering principle is used to detect pollutant in air also NDIR non-dispersive infrared principle for carbon dioxide and Electrochemical principle for ozone

3.1.2 ESP 32 to collect data:

ESP 32 is used to provide Wi-Fi and Bluetooth connection for embedded devices. It consists of a single core Ten silica Xtensa LX6 microprocessor. It has over than 240 MHz rate for high data processing speed. It is used commonly in mobile devices, wearable tech and IoT applications. Internal memory of ESP 32 – ROM: 448 KB, SRAM: 520 KB. Functions of ESP 32 are mainly Networking, Data processing, P2P connectivity etc.

3.1.3 LCD:

LCD screens are arrangements of small segments called pixels. It is used to show information. Such displays have many layers where two panels are made with glass material free of sodium which play an important role. The panels consist of Flutes, and they are placed parallel on each panel. It will give level and how much Oxygen is Microalgae Producing. We will note down the values which we will get from LCD 12C Module. After all the installation experimental comparative studies will be done and after comparing the results, this study will get a conclusion.

3.1.4 Model Detailing:

The model structure is made up of Fiber Material. The size of the tank is 1ft in width and 2ft in length 1.5ft in height. Tank's edge is joined with the help of silicon tape.

3.1.5 Microalgae:

The microalgae used in the project is Spirulina. Spirulina is dried biomass of cyanobacteria that can be consumed by humans and animals. Spirulina is a multicellular blue-green microalgae with bacteria. Microscopic characteristics of spirulina are a mass of unicellular filaments or trichomes, each of variable length are 100-200 microns and diameter are close to 8-10 microns. Spirulina cultivation helps in water contamination and overconsumption, soil erosion and deforestation. After Water is generated, group is going to observe for it total 1 week and we will note observation for cultivation process. Microalgae is rapid growth plant. It grows very fast, and the total life of plant is four weeks, and it needs nutrition for fast growth, microalgae have rapid growth and its CO_2 absorption, and it produces Oxygen, so group are going to use it for oxygen production. In that water, the group is going to cultivate microalgae and cultivate it for 4 weeks and maintain it throughout time. As Microalgae absorb Co_2 and releases O_2, the Oxygen will dissolve in water, we will extract oxygen.

3.1.6 pH sensor:

The pH sensor is the tool that is used for water measurements. This type of sensor can measure alkalinity and acidity in water. It ranges from 0 to 14.

3.1.7 Temperature sensor:

A temperature sensor is a combined circuit sensor that measures the temperature and provides output voltage that is linearly proportional to temperature. It is used in applications like fridges, ovens, water temperature etc.

3.1.8 Humidity sensor
Humidity sensor records the relative humidity of the environment in which it is placed. They measure both moisture and temperature in the atmosphere. It shows humidity as a percentage of the ratio of moisture and temperature to the amount of air held at temperature.

3.1.9 Oxygen sensor
The AO-03 is an oxygen sensor used to measure oxygen concentration. Application of this sensor is in various industries like mining, steel production and air purification. This sensor has typically less than 15 seconds.

3.2 Experimental study:
Our group is going to run the two experimental processes in our study. The first part is extraction of water and later part is cultivation of microalgae and oxygen measurement.

3.2.1 Water extraction process:
The project uses condensation and dehumidification to extract water from air. A fan directs air to a Peltier module, which cools it to form water droplets collected in a beaker. The module runs on 12V from a rechargeable battery powered by solar or electricity. An air pollution sensor monitors atmospheric quality.

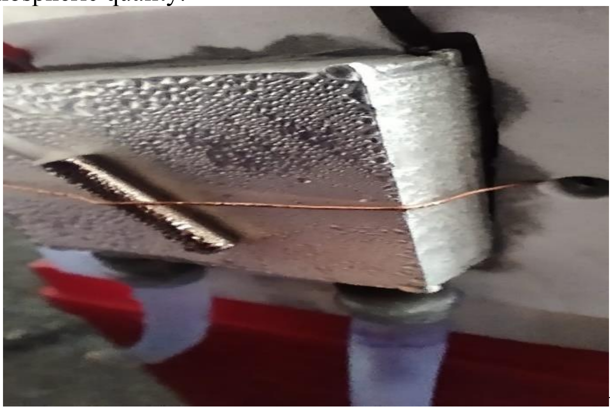


Fig.1. Extracted Water from Peltier Module

3.2.2 Cultivation of Microalgae and Oxygen Detection
The cultivation of microalgae began by placing flower stems in water, which led to algae growth after three days but died due to lack of nutrients. The group then purchased 200 ml of spirulina microalgae and 50 ml of nutrients from a farming company. The algae require 20g of nutrients weekly, containing sodium bicarbonate, potassium, and magnesium. They added the microalgae to 1 liter of water, and it doubled in volume within 10 days.

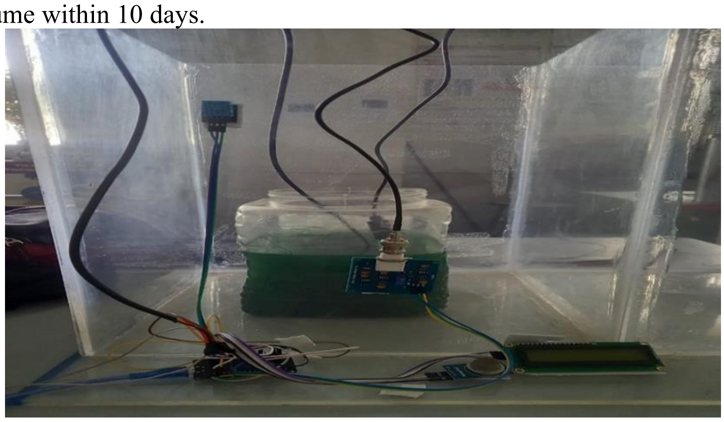


Fig.2. Cultivation of Microalgae for Oxygen Detection

3.4 Experimental Process:
For our project model firstly, we gave order of fiber material tank of size 1ft in width and 2ft in length 1.5ft in height with having partition for two compartments at fish aquarium shop for model's structure. In the first compartment we place water extraction part and second oxygen measurement.

3.4.1 Water extraction process:
For the water extraction process we purchased a Peltier module kit, and we fitted it on one side of water extraction compartment. Peltier module works as when air passes through it and gets cooled and extract water.

3.4.2 Cultivation of microalgae and oxygen detection process:
For growing microalgae, we are deeper some flower's stem in bottle having some amount of water. Microalgae grow after 3 days we noticed that microalgae need nutrition without nutrition it cannot survive. Then we ordered nutrition and spirulina microalgae from farming company. Then in one jar we put 1 liter of water and add 200 milliliter microalgae and 50 milliliter of nutrition in it. After one week we added extra one liter of water and the same quantity of nutrition in it for microalgae cultivation. Then we put this jar on another compartment of tank and provide pH sensor, humidity sensor and temperature sensor, oxygen sensor for readings shows on display. After that we put all that reading in the Thingspeak app for running the code successfully.

4. RESULT AND DISCUSSION

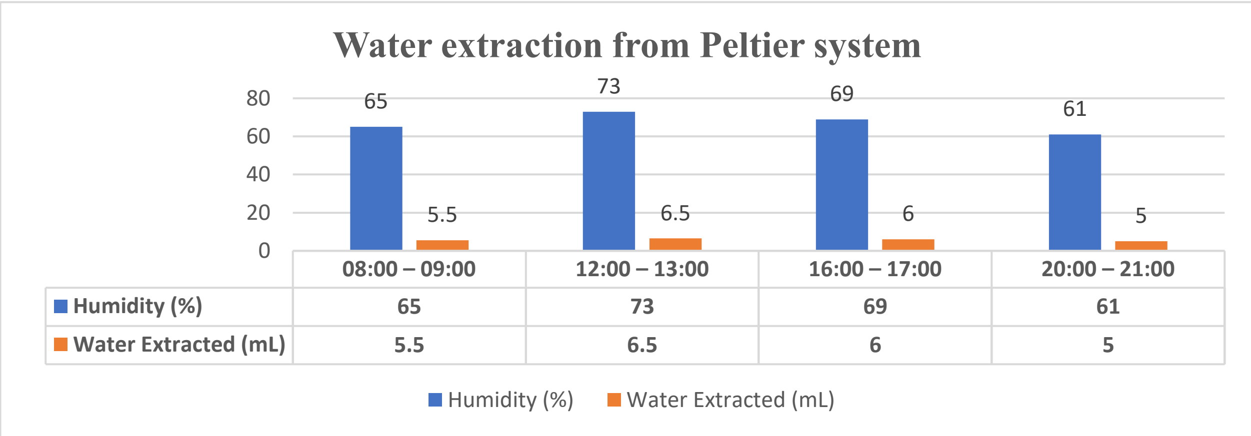
The integrated model was designed to perform three main functions are use condensation and dehumidification to draw out water from ambient air, utilizing the water that was extracted, cultivate Spirulina microalgae and use Internet of Things-based sensors to measure environmental factors and the generation of oxygen. The data collected over a period included are Air Quality, Humidity (%), Temperature (°C), pH of microalgae water Dissolved Oxygen (DO) in mg/L and O2 (%).

4.1 Water Extraction Discussion

The water extraction was achieved via a Peltier-based dehumidification system. At humidity above 60%, the system produced measurable dew condensation. Average water collected per 1 hour is 5–7 mL from Peltier system, depending on atmospheric conditions. Power consumption is 12V, supported by battery backup for sustainability as shown in table no. 4.1. This system effectively demonstrates a low-energy, renewable method for water harvesting suitable for urban and semi-urban environments.

Table No. 4.1 Water extraction from Peltier system with time interval

Sr. No.	Time Interval (Hr)	Humidity (%)	Water Extracted (mL)
1	08:00 – 09:00	65	5.5
2	12:00 – 13:00	73	6.5
3	16:00 – 17:00	69	6
4	20:00 – 21:00	61	5



Graph No. 1 Water extraction from Peltier system with time interval

4.2 Oxygen generation from micro algae

The use of Spirulina microalgae significantly increased oxygen production and biomass. Over the course of three months, the culture process successfully increased from one liter of microalgae solution to five liters, exhibiting rapid growth and optimal environmental conditions. Dietary supplements (such as potassium, magnesium, and sodium bicarbonate) are widely utilized. The optimum temperature range is between 24 and 30 degrees Celsius. Maintain pH values between 6.5 and 8.1 for best results. Regular water testing and proper exposure to sunlight are also provided. In addition, the density of the algae increased the oxygen output after ten days, the dissolved oxygen level (DO) rose from 5.6 mg/L to 6.4 mg/L. After three months of full growth, DO levels stabilized at 6.5 to 6.8 mg/L.

Table No. 4.2 IOT data of Oxygen generation

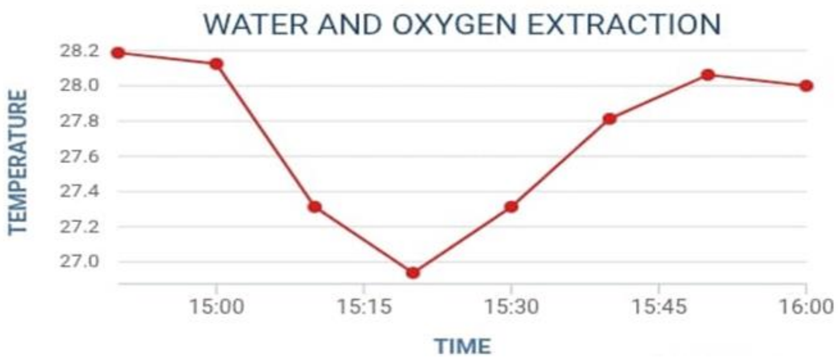
Sr. No.	Temp (C)	DO (mg/l)	Humidity (%)	pH	Air Quality (%)	O2 %
1	27.3125	6.14705	78	7.54374	0	20.95
2	27.0625	6.19953	78	7.58363	0	20.95
3	27.0625	6.19953	78	7.56912	33	20.884
4	27.25	6.16013	78	7.59088	0	20.95
5	27.25	6.16013	78	7.55099	33	20.884
6	27.3125	6.14705	78	7.60538	0	20.95
7	27.3125	6.14705	78	7.59088	33	20.884
8	27.3125	6.14705	78	7.60176	33	20.884
9	27.375	6.13401	78	7.60538	33	20.884
10	27.3125	6.14705	78	7.45308	33	20.884
11	27.3125	6.14705	78	7.46396	33	20.884
12	27.3125	6.14705	78	7.48571	33	20.884
13	27.3125	6.14705	78	7.4422	0	20.95
14	27	6.21272	78	7.47121	33	20.884
15	26.9375	6.22594	78	7.54011	33	20.884
16	26.5625	6.30586	78	7.55462	33	20.884

17	26.375	6.34621	78	7.53286	33	20.884
18	26.375	6.34621	78	7.51835	0	20.95
19	26.5	6.31928	78	7.55824	33	20.884
20	26.5625	6.30586	78	7.53286	33	20.884
21	26.6875	6.2791	78	7.55099	0	20.95
22	26.6875	6.2791	78	7.54374	33	20.884
23	26.75	6.26577	78	7.54011	33	20.884
24	26.875	6.23919	78	7.55462	0	20.95
25	26.9375	6.22594	78	7.55099	33	20.884
26	26.9375	6.22594	78	7.54736	33	20.884
27	27.0625	6.19953	78	7.55099	33	20.884
28	27.1875	6.17323	78	7.57275	33	20.884
29	27.1875	6.17323	78	7.55099	33	20.884

The above table indicates that average results from the recorded data of stable environmental conditions during the experiment work. The average temperature was approximately 25°C to 30°C, while the dissolved oxygen (DO) level stood from 5.5 to 6.5mg/L, reflecting good water quality. The humidity remained consistent at 78%, and the average pH was 7 to 7.5, indicating a slightly basic environment. The average air quality index was around 33, and the oxygen percentage (O_2%) in the air was approximately 20.90%. Following all graphs was generated from ThingSpeak channels.

4.2.1 Temperature graph:

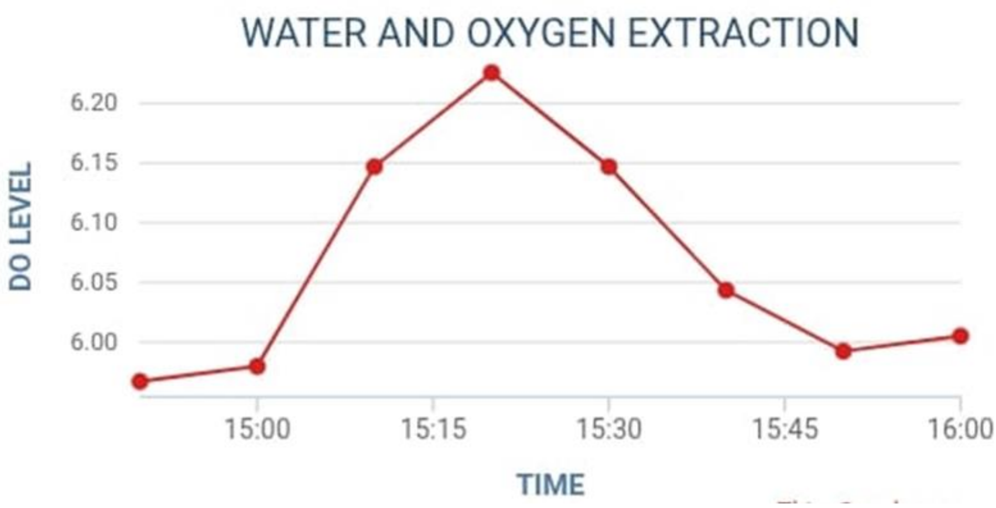
The graph shows that during the water and oxygen extraction process, the temperature initially decreases from about 28.2°C to 27.0°C around 15:20, then gradually rises back to approximately 28.0°C by 16:00.



Graph No. 2 Temperature v/s Time

4.2.2 Dissolved oxygen graph:

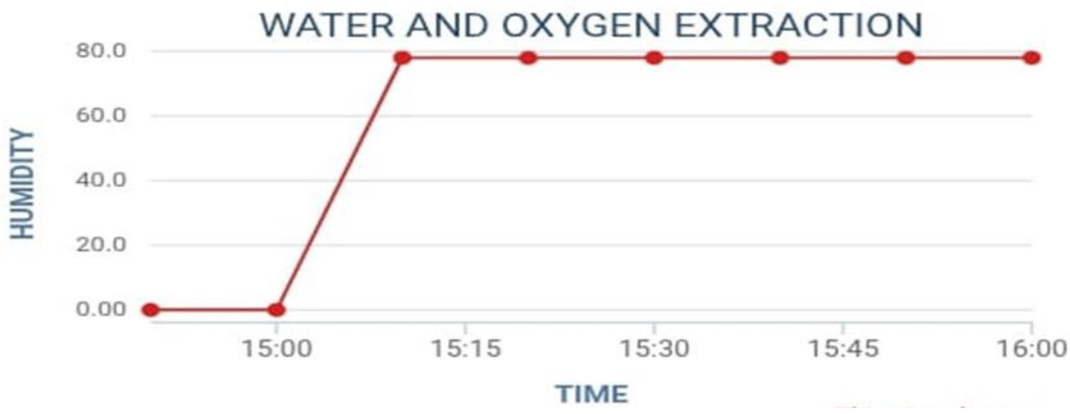
The graph shows that the dissolved oxygen (DO) level rises from 6.00 to a peak of about 6.22 around 15:20, then gradually declines back to around 6.00 by 16:00 during the water and oxygen extraction process.



Graph No. 3 DO v/s Time

4.2.3 Humidity graph:

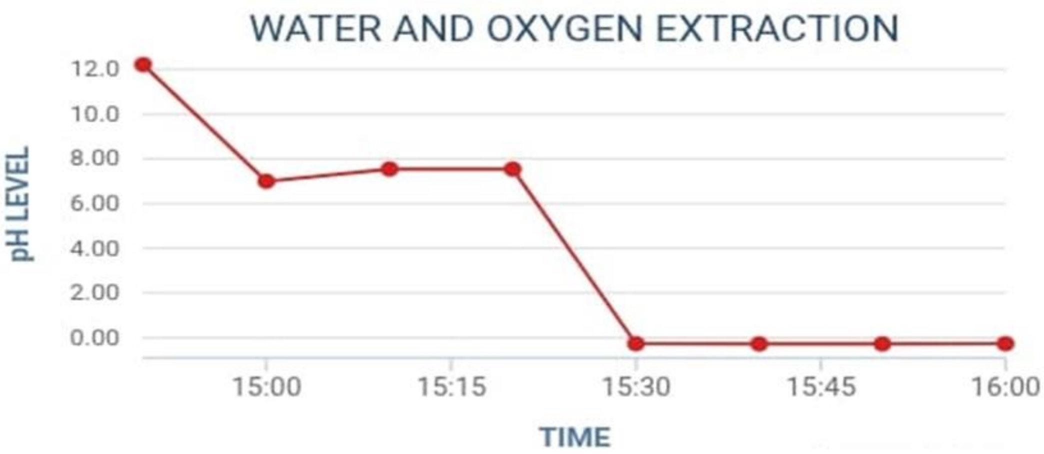
The graph shows that humidity during the water and oxygen extraction process sharply rises to 78% just after 15:00 and remains constant at that level until 16:00.



Graph No. 4 Humidity v/s Time

4.2.4 pH graph:

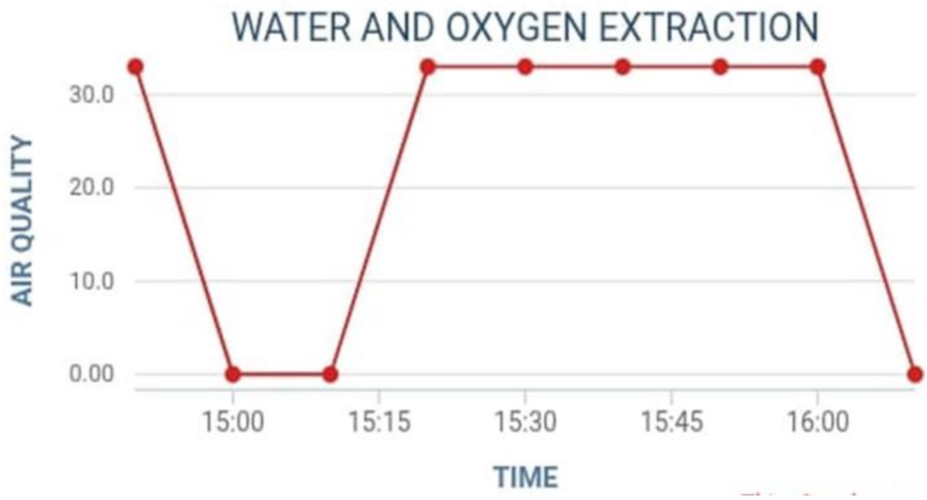
The graph shows that the pH level around 7 to 8.5 between 15:00 and 15:30 during the water and oxygen extraction process.



Graph No. 5 pH v/s Time

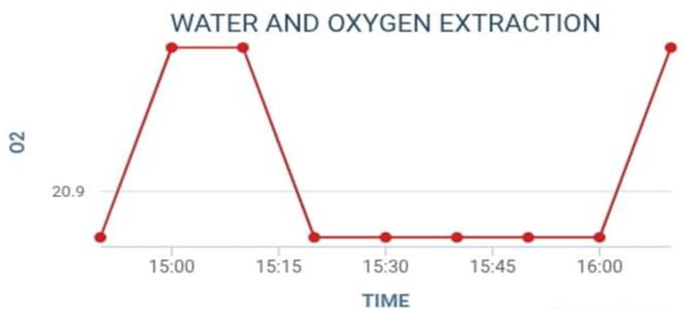
4.2.5 Air quality graph:

The graph shows that the oxygen (O_2) level spikes to a peak around 15:00, drops sharply after 15:15, remains low until just after 16:00, and then rises again at the end of the measurement period.



Graph No. 6 Air Quality v/s Time

4.2.6 Oxygen concentration graph:
The graph shows that air quality drops to zero shortly after 15:00, rises back to 30.0 after 15:15, remains stable until just after 16:00, and then drops to zero again.



Graph No. 7 Oxygen v/s Time

CONCLUSIONS
The conclusions of the study are that the integrated model is a low-energy, renewable method for water harvesting and Spirulina microalgae cultivation, and that it can be used in urban and semi-urban environments.

1. The water extraction Peltier system efficiently operated at humidity levels above 60% and yielding average of 5–7 mL of water per hour, while maintaining low energy consumption for small prototype.
2. Spirulina cultivation contributed to increased oxygen levels, with dissolved oxygen rising from 5.6 mg/L to approximately 6.8 mg/l over a three-month period, under optimal temperature considered is 24–30°C and pH value is 6.5–8.1 conditions. The IOT data confirmed stable environmental factors such as 78% humidity, pH around 7.5, and oxygen concentration near 20.90%, validating the system's sustainability and effectiveness in water and oxygen generation for urban or semi-urban applications.

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