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Automatic Solar Powered Water Pumping With Purifier

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ABSTRACT

This is an integrated solar-powered system with efficient energy utilization and automated water quality management.Thesolarpanel,controlledbytwoservomotors for dual-axis tracking, can adjust its position in real time to maximize solar energy absorption. The harvested energy is stored in a 12V battery. the DC voltage sensor ensures the monitoring of real time performance to ensure consistent availability of energy. A floating switch controls the water flow according to the liquid levels. This way, it ensures that the resource is not over- or underused. The pH sensor is always monitoring the water's acidity or alkalinity and sends a signal topump motorstoreleasebaking sodaorvinegarfor neutralization.Atreated watertransfermotoris provided for further usage. The LDR sensorsenses the ambient light level, thus helping in environmental monitoring and improving the efficiencyofsolarpanels.TheArduinoUnomicrocontrolleris the system's control hub, where all components are coordinated using the I2C protocol. Real-time feedback of batteryvoltage,pHlevels,andlightintensityaredisplayedon anLCDscreentoenhancethetransparencyofthesystemand its monitoring by users. This system integrates real-time monitoring with renewable energy harvesting and allows for an automated water treatment system that provides sustainable self-regulated provisions to water resource management. The technology can be extended to application in agriculture and industrial processing with domestic water treatment.

Keywords: *Arduinouno,LightDependingResister (LDR), LiquidCristalDisplay(LCD), ServoMotor,ChargeController, 12VBattery, MotorDriver, FloatingSwitch,PHSensor, Pump Motor, purification.*

1. INTRODUCTION

Current water quality management systems primarily depend on external power sources, leading to increased operational costs and inefficiencies in energy utilization. Many of these systems require manual intervention for pH regulation, water level control, and turbidity monitoring, making them time-consuming and less reliable. While some solutions incorporate solar energyforpowergeneration,theyoftenlack an integrated

approach that includes both automated water treatment and energy optimization. Furthermore, most conventional systems do not dynamically adapt to environmental factors such as fluctuating pH levels, water turbidity, and varying solar intensity.

Thislackofreal-timeresponsivenesslimitstheir effectiveness, `especially in remote or off-grid areaswhere access to clean water is already a challenge. Additionally, traditional systems are designed for either water pumping or quality monitoring but rarely combine both functions into a single, self-sustaining unit. Shortcomings of existing systems and provide a cost-effective, scalable, and eco-friendly alternative for water resource management. Management systems can have a significant impact on global sustainability efforts. By reducing dependence on fossil fuels and promoting efficient water usage, such solutions contribute to environmental conservation and help address the global watercrisis.Fordevelopingregionswithlimitedaccessto clean water and reliable electricity, these systems offer a cost-effective and scalable solution to improve public health and economic development.

2. METHODOLOGYANDMATERIALS

A. Solarpanel

Solar PV panel is among the renewable sources of energy.PVpanelisusedtotransformthelightenergyinto electrical energy, which is stored in the battery. Solar panels are the collection of solar or photovoltaic cells which, transform solar energy i.e. sunlight into electrical energy or electricity. Extraction of electricity from sunlight directly is known as a photovoltaic process. A photovoltaic cell or a self-generating barrier layer cell is also a PV detector, which converts radiant flux directly into electrical current. Furthermore, electricity cannot be generated from heat by means of PV cells, since sunlight is a required prerequisite for that.

B. SolarTrackingandHarvestingModule

This system is made to be extremely efficient with solar energy through a solar panel placed on servo motors. Such motors are always changing the position of thepanelduringthedaytokeepthepanelalignedwiththe path of the sun, and this helpscapture maximum sunlight. Tracking the sun's path gives the system a better energy absorption that results in more efficiency with the generation of solar power. The generated solar energy is stored in a 12V battery after being harvested, thereby providing a continuous and stable source of power. ADC voltage sensor is implemented to ensure steady and efficient power management by keeping track of the voltage levels in the battery. The sensor avoids overcharging and deep discharging, thus preserving the life of the battery. The energy stored is utilized mainly to drivewaterqualitymanagementprocessesinasustainable and environmentally friendly manner. The intelligent tracking system maximizes energy output compared to conventional fixed solar panels. The automatic adjusting system saves time for manual adjustments, increasing efficiency and convenience. The use of battery storage also provides the facility for energy availability during cloudy conditions or nighttime. Use in water quality management improves sustainability throughminimization of reliance on traditional sources of energy. Throughtheuseofrenewableenergy,thesystemsupports conservation of the environment and minimizes carbon imprints. This sophisticated solar tracking system is of prime importance in maximizing energy use for essential operations [1-3]. This module consists of a solar panel mounted on servo motors, which adjust its position to track sunlight throughout the day, ensuring maximum energy absorption. The harvested solar energy is stored in a 12V battery and a DC voltage sensor continuously monitors the battery's voltage. The system ensures efficient energy utilization, optimizing the power needed for the water quality management processes [4].

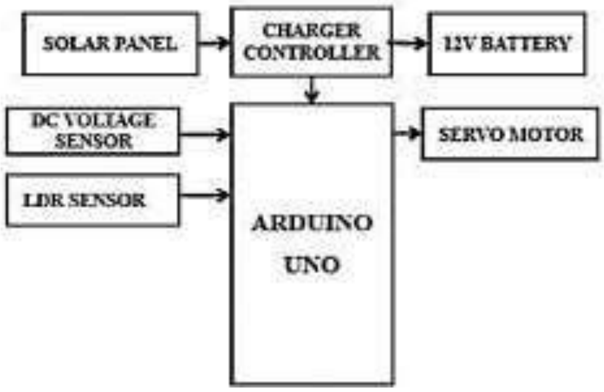

Fig1.BlockdiagramofSolartrackingModule

C. WaterqualityandPHadjustmentmodule

This module is structured to provide maximum water quality through the incorporation of several sensors and automated correction systems. A floating switch is also provided to track the water level within the tank to avoid overflow or depletion by sending an alarm when the water level hits set limits. There is also a pH sensor that tracksthe acidity or alkalinity of the water on a continuous basis, offering real-time data for quality measurement [5-6]. Maintaining the right balance of pH is critical, since highor low pH levels may render water undesirable fordrinking and industrial use. To control the pH level, the system involves two pump motors regulated according to sensor readings [7]. When the water becomes too acidic, a pump releases baking soda to counterbalance excessacidity and restore equilibrium. On the other hand, when the water becomes too alkaline, a dedicated pump dischargesvinegartoreducethepHleveltoanidealrange. Automatic control in this way maintains the water safe for use in drinking, irrigation, and industrial purposes. The feature of real-time monitoring allows accurate and effective adjustment without the need for human involvement, enhancing system reliability [8]. The automated pumps' integration removes the requirement for manual dosing of chemicals, minimizing errors and providing a consistent water quality. The floating switch also serves as a safety feature by avoiding dry running of pumps, which may lead to damage. This smart water quality management system offers an environmentally friendly and effective means of ensuring water purity. The use of sensors and actuators increases the overall performance and makes the system applicable in households, industries and farming establishments.

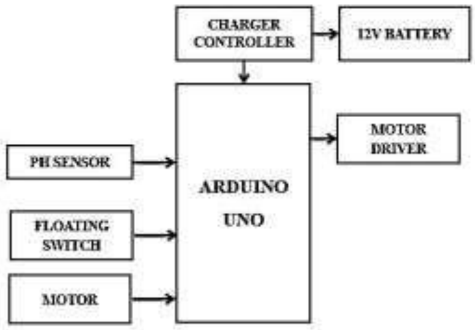

Fig2.BlockdiagramofwaterqualityandPHmeasurement

D. ControlandMonitoringModule

The Control and Monitoring Module is an essentialpartofthesuggestedsystem,whichalsoplaysthe role of its central intelligence unit. It oversees and coordinates all components that are connected with it for smooth and efficient functioning. The heart of this module is the Arduino Uno, a microcontroller, which also acts as the central processor. The Arduino Uno constantly gathers data from various sensors, such as the DC voltage sensor, floating switch,pHsensor,and LDRsensor.Thesesensors give real-time data regarding different system parameters like power availability, water level, water quality, and ambient light levels.The DC voltage sensor assists in monitoring the power supply so that the system runs efficiently, especially in renewable energy-based systems. The floating switch senses the level of water in the tank and indicates when it is time to switch the pump on or off to avoid overflow or dry running. The pH sensor monitors the acidity or alkalinity of the water so that the system can control water quality through chemical dosing. The LDR sensor senses the level of ambient light, and this is afeature that comes in handy in solar-powered applications to maximize energy consumption. The Arduino Uno integratesalltheseinputsfrom the sensorsand makesreal- time intelligent decisions [1]. Depending on the received data, it adjusts the turning of pumps and motors to ensure an equilibrium between water flow, water quality and energy efficiency [9]. When the level of water decreases below a level, the pump is automatically started to fill up the tank. In the same way, whenever the pH value strays away from the best range, corrective measures areactivatedbythecontrolmoduletoensurewatersafety.The module makes automation more advanced, minimizes human interaction and guarantees the entire system is in perfect order with minimal energy loss. Through its capability of making real-time decisions, it enhances efficiency, reliability and sustainability, rendering it a core component of smart water management and renewable energy incorporation [10].

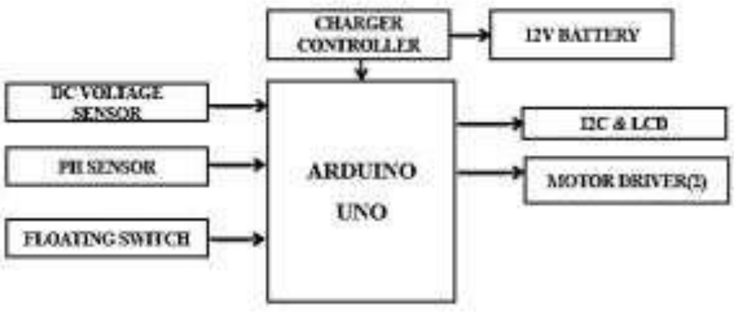

Fig3.BlockdiagramofControlandmonitoringmodule

3. HARDWARE INTERFACE

The system to be proposed combines solar power with an automatic water quality management system, in response to the shortcomings of current systems. It employs a solar panel coupled with servo motors to follow sunlight and enhance energy harvesting. A DC voltage sensor detects battery levels while a floating switch regulates water flow according to tank levels. The system uses a pH sensor to sense water alkalinity or acidity and trigger pumps to release neutralizing chemicals. Arduino Uno manages all the devices, and an LCD screen offers real-time data for effective water and energy management. The suggested system combines a solar-powered system with water quality sensing and correction features.

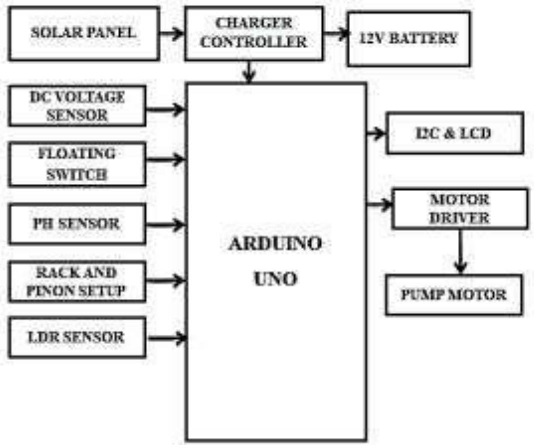

Fig4.Blockdiagramofthehardware

The solar panel which has servo motors on either side rotates according to the position of the sun in order to achieve maximum energy absorption. The Arduino Uno- controlled servo motors keep the panel aligned with sunlightduringthedaytime.Theelectricityharvestedfrom the solar panel gets stored in a 12V battery which is continuouslyunderthesurveillanceofaDCvoltagesensor for determining the optimum operation. A float switch is employed to sense the liquid level in a tank or vessel. It serves as a control device to switch the water flow on oroff to avoid overflow or dry running. ApH sensor gauges thealkalinityoracidityofthewater.Whenthewateristoo alkaline or acidic, two pump motors are engaged. One releases baking soda to neutralize acidity and the other releases vinegar to neutralize alkalinity. This helps to ensure that the pH level of the water is kept in a favorable range. A sensor based on LDR is used to sense the light aroundandconvertitintoanelectricalsignal.Thisdata

can be utilized to monitor the environment and give feedbackregardingtheperformanceofthesolarpanel.A

third motor is also used to transport the treated, high- quality water for additional utilization.

The Arduino Uno serves as the main controller, coordinating all motor controls and sensor inputs. It communicateswithanLCDdisplayviatheI2Cprotocolto present real-time data, such as voltage, pH value and light intensity. This system guarantees optimal utilization of solar energy and automatic water quality control for efficient and effective operation.

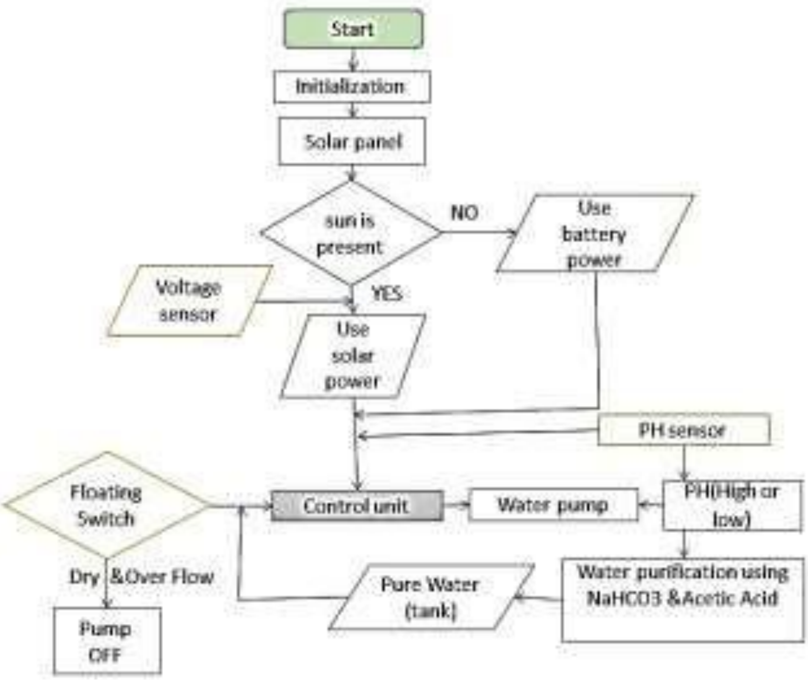

Fig5.FlowChartofHardwareinterface

The Automated Solar-Powered Water Purification System effectively utilizes water resources based on solar powerasthemain powersource,whileabatterystandbyis provided if sunlight is lacking. The process starts with an initialization that wakes up sensors, the control module, and the power sources. Asolar panel verifies sunlight and utilizes solar power if present, or turns on battery power instead. A voltage sensor is placed to detect stable power supplysothatoperationscontinuesmoothly.Waterlevelis regulated by a float switch, which switches off the water pump if the tank runs dry or is full, thereby avoiding wastage. The pH level is constantly monitored by a sensor for acidity or alkalinity of the water. Sodium bicarbonate ($NaHCO_3$) or acetic acid is introduced if the pH is excessively high or low and needs to be neutralized. The control unit handles the data from the sensors and controls the water pump to store purified water in the pure water tank for reuse. The system employs renewable energy,real-time monitoring and auto-purification, providing an eco-friendly, cost-saving and scalable system for agriculture,industryandhouseholduse.Byminimizing

fossil fuel dependence and human intervention, it ensures effective energy use and water savings and hence is especially useful in remote and off-grid regions. Coupling solar energy, automatic sensors and real-time control optimizes water management and that results in environmental sustainability and public health.

4. HARDWAREIMPLEMENTATION

The new system integrates solar power withhigh-tech automated water quality management to eliminate the weaknesses of conventional systems. It has a solar panel mounted on servo motors, which enables it to follow the sun during the day, maximizing energy harvesting for the entire system. For the purpose of ensuring the stored energy is adequate for continuous operation, a DC voltage sensor keeps monitoring the batterylevelsallthetime,supplyingimportantinformation for energy management. A floating switch is incorporated to monitor water levels in the tank and control water flow automatically, avoiding overflow or under filling.

A pH sensor is employed to continuously monitor the acidityoralkalinityofthewater,whichiscriticaltoensure proper water quality. On the basis of real-time readings from the pH sensor, pumps that release neutralizing agents are activated by the system to maintain the water at the desired pH level. The whole system is managed by an Arduino Uno, a robust microcontroller that operates the different components effectively. Furthermore, an LCD display offers real-time data, enabling users to view water quality,energylevels,andsystemperformance,facilitating an effortless balance between water and energy management. This combination of solar energy with automated systems seeks to develop a sustainable,efficient, and dependable water quality management system.

5. RESULTANDDISCUSSION

The performance of the installed system and assesses its efficiency in solar tracking, pump control and water purity monitoring. The system was operated under various conditions to examine its accuracy and effectiveness. The outcomes show the potential of the system to maximize solar energy absorption, optimize water utilization, and guarantee water purity. The performance of each component was evaluated based on real-time reactions and the results are thoroughlydiscussed.

LDRSENSORS	LIGHT DENSITY	SOLAR PANEL DIRECTION
LDR1	High	TowardsLDR1
LDR2	High	TowardsLDR2
LDR1&LDR2	Equal	Stable

TABLEI.RESULTOFSOLARTRACKING

The solar tracking system properly changed the orientation of the solar panel according to the reading of the LDR sensor. While testing, when LDR1 sensed greater sunlight intensity, the panel rotated to perpendicular to the sun appropriately, and when LDR2 sensed greater light,the panel rotated to perpendicular to the sun. Whenever boththesensorssensedthesameintensity,thepanelstayed inabalancedposition accordingtothesun'sposition.This maximizes the absorption of solar energy, enhancing the overall efficiency of the system.

WATERLEVEL	STATEOFPUMP
High	OFF
Low	ON

TABLEII WATERPUMPCONTROLSYSTEM

The water pump control system is configured to automatically manage the water level in a storage tank for effective water management. It turns on the pump whenthe water level is low and deactivates it when the tank is full, avoiding dry running and overflow. The automation provides a consistent supply of water while lowering energy usage and wasting water. By employing sensors such as floating switches or level detectors, the system guarantees proper operation without the need for manual intervention. This enhances overall efficiency, sustainability and conservation of resources in water management systems.

TABLE III.WATERCONDITION BASEDON PHLEVELS

PH -LEVEL	WATER CONDITION
pH<6.5	acetic
PH>8.5	neutraland safe
6.5<PH>8.5	alkaline

The pH monitoring system efficiently tested the quality of water according to whether it was acidic or alkaline. It designatedacetic water (pH < 6.5) and alkaline water (pH > 8.5) as contaminated,whichindicatespossiblepollution.Waterfallingin the middle range (pH 6.5 to 8.5) was pure, and therefore safe for use. This is how only pure and safe water is utilized, eliminating health threats. With constant pH tracking, the system gives live measurement of the purity of water. It can also be incorporated into automated purification systems to further secure watersafety. The findings affirm its accuracy in identifying unsafe water conditions. Future developments may involve real-time notification and automatic corrective measures to ensure water quality.

6. CONCLUSION

Theproposedsolar-poweredwatermanagementsystem offers an economical and eco-friendly solution to maximizing water and energy consumption. The system decreases reliance on traditional power sources by harnessing solar power, minimizing operation costs and facilitating environmental protection. Asolar tracking system increases energy absorption and real-time monitoring of pH with automatic neutralization through the useof baking soda and vinegar maintains safe water quality. The water flow controlled by the floating switch reduces human interventionto aminimum,whichissuitableforremotelocations where there isnoelectricity.Thesystem can greatlycontribute to agriculture, aquaculture, and industries by optimizing resource utilization and saving costs. The Arduino Uno-based control system also provides a user-friendly interface for real-time monitoring and operation. In general this innovative method encourages sustainability, self-sufficiency and effective water resource management.

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