International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 04 Apr. 2024, pp: 180-184 www.ijaem.net ISSN: 2395-5252

Hydroponic Monitoring System Using Iot: A Review

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Date of Submission: 01-04-2024 Date of Acceptance: 08-04-2024

ABSTRACT-This paper reviews the integration of IoT technology into hydroponic systems for monitoring and irrigation. Hydroponic farming, known for its precise environmental control, benefits from IoT's real-time monitoring and automation. The review covers hydroponics basics, IoT's role in agriculture, monitoring parameters (pH, EC, etc.), sensor types, and hardware/software components. It evaluates existing systems, discusses challenges, and outlines future directions. Ultimately, IoT promises to revolutionize hydroponic agriculture, enhancing sustainability and productivity.

Keywords- Hydroponic Monitoring, IOT, Blynk.

I. INTRODUCTION

Hydroponic farming offers aoptimistic solution for acceptable agriculture, requiring precise monitoring of environmental factors forperfectplantgrowth. The integration of Internet of Things (IoT) technology enhances this monitoring capability, enabling realtime datacollection and automated control in hydroponic systems. This review explores the synergy between hydroponics and IoT, examining their principles, applications, and benefits. Key topics include sensor-based monitoring, existing IoT-enabled systems, challenges, and future directions in IoT-driven hydroponic agriculture.

Specifically, we will cover:

Background and significance of hydroponic farming, highlighting its advantages and potential for addressing global food security challenges.

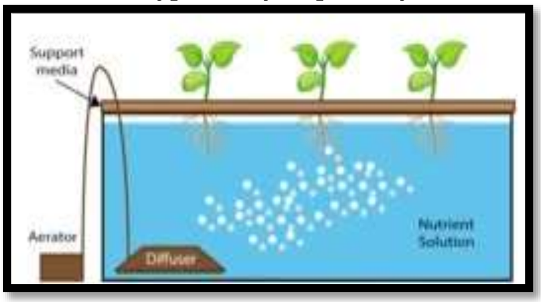
Introduction to IoT technology and its applications in agriculture, with a focus on its role in enabling precision farming practices.

Objectives of the paper, including the exploration of IoT-enabled hydroponic monitoring systems, the review of existing technologies and research, and the identification of challenges and future directions in this field.

1.1HydroponicCultivationTechniques

Hydroponics, in contrast to conventional farming practices, operates without the necessity of soil. Instead, plants are cultivated on either natural or artificial substrates, allowing their roots to easily access nutritions from a prepared nutrition solution. Various hydroponic techniques exist, each tailored to specific plants, local climates, and budgetary considerations.in below Figures.

1.2 Different types of Hydroponic System



(a) Floating Root System

1.2.1 Floating Root System orDeep Water Culture

Floating Root System: Plants grow on floating platforms with roots extending into nutrition solution via a medium. Deep Water Culture Plant roots are suspended directly innutritionsolution, needing active aeration. DWC requires more vertical space, provides direct nutritionaccess, while Floating Root Systems may offer easier setup and management (Figure 1a)

Here's howFloating Root SystemorDWC works:

1. Setup: Plants are suspended above reservoir filled with aerated nutrition solution. Their roots hang freely in the solution.

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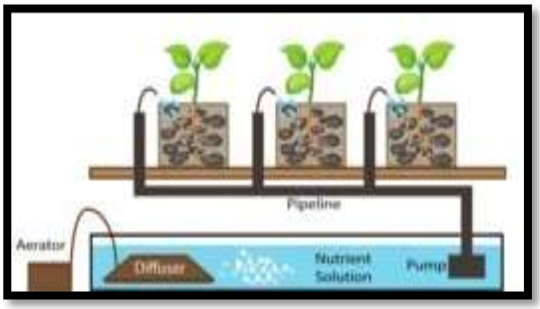
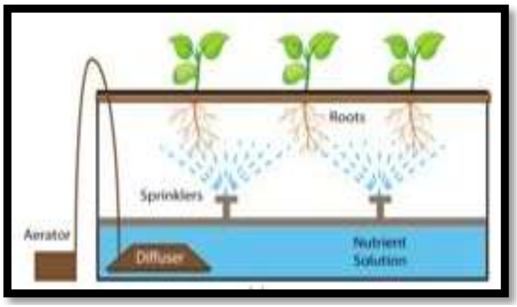
2. Aeration: An air pump continuously oxygenates the nutrition solution in the reservoir, ensuring the roots receive ample oxygen for proper growth.
3. NutritionAbsorption: Plant roots soak up water and nutritiondirectly from the nutritionsolution, allowing for efficient uptake of essential elements necessary for growth.
4. Support: The buoyancy of the roots in the solution provides support to the plants, eliminating the need for soil or other growing media.
5. Recirculation: Excess nutrition solution may be recirculated through the system to ensure consistent nutrition availability and minimize waste.
6. Monitoring: Regular monitoring of nutrition levels, pH, and oxygenation is essential to maintain optimal conditions for plant growth.



(a) Drip System

1.2.2. Drip Irrigation

In hydroponic systems, drip irrigation delivers nutrition solution directly to plant roots through tubing and emitters, ensuring optimal nutrition uptake. Drip systems are commonly used in recirculating setups for precise nutritiondelivery to each plant, promoting healthy growth. Excess solution is often returned to the storage tank in closed systems, maintaining efficiency. (Figure 2b).
Here's how Drip Irrigation works:
1. Tubing and Emitters: Drip irrigation systems consist of tubing and emitters. The tubing runs along the planting area, and the emitters are placed near each plant.
2. Precise Delivery: Nutrition solution is pumped through the tubing to the emitters. These emitters release a controlled amount of solution directly to the plant roots.
3. Optimized Uptake: By delivering nutrition directly to the roots, drip irrigation optimizes nutritionuptakeby the plants. This promotes healthy growthand minimizes waste.
4. Recirculating Systems: Drip systems are commonly used in recirculating hydroponic setups, where excess solution not soak up by the plants is collected and returned to the nutritionreservoir.
5. Efficient Water Usage: Drip irrigation is effective in water conservation as it delivers water directly to the root system, minimizing evaporation and runoff.
6. Preservation: Routine preservation is needed to maintain the proper functioning of the system, including checking for clogs in the emitters and adjustingnutritiondelivery as needed.



(b) Aeroponics

1.2.3. Aeroponics

Aeroponics suspends plant roots in air and deliversnutritionthrough misting, making it ideal for growing tubers and roots. It doesn't need an air system since oxygen is carried by the sprayed solution. Examples include Tower Garden systems and NASA's space gardening experiments, offering efficient nutrition uptake, reduced water usage, and accelerated plant growth in controlled environments (Figure 1c).

Here's how aeroponics works:
1. Plant Setup: Plants are typically grown in chambers or bottleswith their roots exposed to the air. The plats themselves are usually housed in a separate area above the root chamber.
2. Nutrition Delivery: A pump and misting nozzles are used to spray a nutrition-rich solution directly onto the exposed roots. The mist is fine enough to cover the roots thoroughly without causing damage.
3. Nutrition Uptake: The fine mist provides the roots with water, oxygen, and essential nutrition. The roots soak up these nutrition directly from the mist, allowing for efficient nutrition uptake.
4. Oxygenation: The roots are exposed to the air, they have access to ample oxygen. This promotes healthy root growth and enhances nutrition absorption.
5. Recirculation: Any excess nutrition solution not soak up by the roots is collected at the bottom of the root chamber and recirculated back to thenutritionreservoir. This ensures efficient use of water and nutrition.

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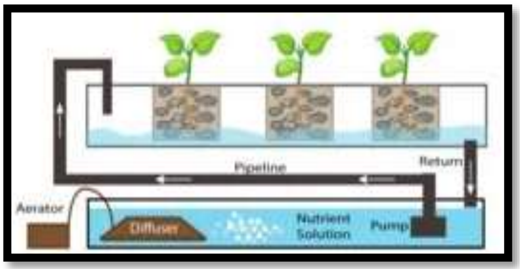
6. Controlled Environment: Aeroponic systems are often used in controlled environments where factors like temperature, humidity, and lighting can be optimized for plant growth.



(c) Nutrition Film Technique (NFT)

1.2.4. NutritionFilm Technique

Nutrition Film Techniqueis a hydroponic method where plant roots are exposed to a thin stream of nutritionsolution flowing through pipes. While it uses less solution than floating root systems, NutritionFilm Technique requires extra energy and components. Excess solution returns to the tank by gravity, and the nutritionflow can be continuous or periodic (Figure 1d).

Here's how it works:

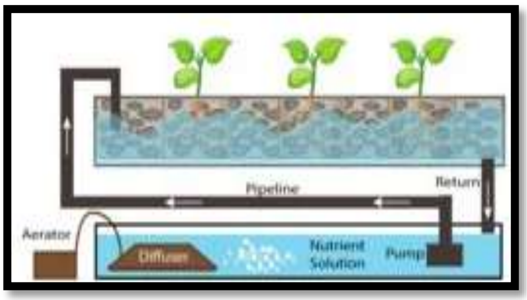
1. Setup: Plants are placed in small pots or baskets with their roots exposed. These pots or baskets are positioned in a sloping channel or pipe.

2. Nutrition Solution Flow:A pump continuously or periodically pumps nutrition-rich water from a reservoir to the top of the channel or pipe.

3.NutritionFilm: The nutrition solution flows down the channel or pipe in a thin film, bathing the roots of the plants as it passes by.

4. Plant Uptake: The plant roots soak up the water and nutrition they need from the thin film. Since the roots are not completely submerged, they can also access oxygen from the air.

5. Excess Solution Return: Any excess nutrition solution not soak up by the plants drains back into the reservoir by gravity. This excess solution can then be recirculated through the system.



(d) Ebb and flow

1.2.5. Ebb and Flow

It sounds like you're describing a simple hydroponic system known as a flood and drain or ebb and flow system. This method allows for efficient nutritiondelivery to the plants while ensuring that excess water is recycled, reducing waste and conserving resources. It's a popular and effective technique for growing a variety of plants hydroponically (Figure 1e).

Here's how Ebb and Flow works:

1. Setup: Plants are placed in trays or containers filled with a growing medium like perlite or rockwool. These trays sit above a reservoir containing nutrition solution.

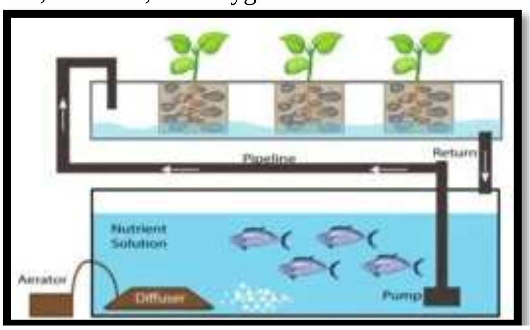
2. Flood Phase: A submersible pump floods the tray withnutritionsolution from the reservoir. The nutrition solution rises in the tray, saturating the growing medium and providing water and nutrition to the plant roots.

3. Absorption: The plant roots soak up water and nutrition from the saturated growing medium during the flood phase. This allows for efficient uptake of essential elements necessary for growth.

4. Drain Phase: After a set period of time, the pump block off, and the nutrition solution drains back into the reservoir by gravity. Excess solutions is collected in the reservoir for reuse in the next cycle.

5. Aeration: During the drain phase, air is pulled into the root zone as the nutrition solution recedes, providing oxygen to the roots. This helps prevent root rot and ensures healthy plant growth.

6. Cycle Repeats: The flooding and draining cycle repeats at regular intervals, typically several times a day, providing plants with a consistent supply of water, nutrition, and oxygen.



(e) Aquaponics

1.2.6. Aquaponics

Aquaponics is a method that merges aquaculture and hydroponics, wherein fish farming and plant cultivation are integrated. Within aquaponic setups, fish are housed in tanks, and the waste they produce, predominantly in the form of

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ammonia, is utilized as a nutrition reservoir for plants, fostering their growth without soil.(Figure 1f).

Here's how Aquaponics works:

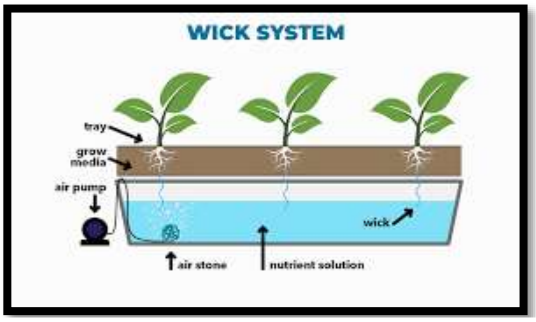
1.Fish Tank: Fish, such as tilapia, trout, or carp, are raised in a tank. As they eat and produce waste, ammonia levels in the water rise.

2.Biofilter: Beneficial bacteria colonize a biofilter, typically made of porous materials like gravel or plastic, where they convert ammonia first into nitrites and then into nitrates through a process called nitrification. Nitrates are less harmful to fish but are still rich in nutrition.

3.HydroponicGrowBeds: The nutritious foodwater from the fish tank is circulated to hydroponic grow beds, where plants are grown. The plants' roots take up the nitrates, effectively filtering the water while obtaining their required nutrition for growth.

4.Plant Uptake and Filtration: As the plants soak up the nutrition, they help to purify the water, removing pollutants and excess nutrition that could be harmful to the fish.

5.Return to Fish Tank: After passing through the hydroponic system, the now-filtered water is returned to the fish tank, completing the cycle. The process of denitrification, facilitated by anaerobic bacteria in the growing media or deep-water culture, converts nitrate back into nitrogen gas, which is released harmlessly into the atmosphere.



(f) Wicky System

Wicky System

A wick system in hydroponics utilizes a porous fabric string, such as cotton or nylon, to draw up water andnutritionfrom a reservoir. This wick then delivers the soak up solution to the plants in containers or trays, providing them with the necessary hydration and nutrition for growth.The wick system in hydroponics is a basic and passive method of delivering water and nutrition to plants(Figure 1g).

Here's how Wicky System works:

1. Setup: Plants are placed in containers or trays loaded with a growing medium like perlite or vermiculite.

2. Wick: A wick, typically made of cotton or nylon, is inserted into the growing medium with one end submerged in a reservoir of nutrition solution.

3. Capillary Action: The wick draws up the nutritionsolution from the reservoir and delivers it to the roots of the plants through capillarymotion.

4. Plant Uptake: The roots soak up the water and nutrition they need for growth and development directly from the growing medium.

5. Continuous Supply: As the plants consume water and nutrition, the wick continues to supply them, maintaining a consistent moisture level in the root system.

II. CONCLUSION

The integration of IoT into hydroponic systems promises enhanced efficiency and sustainability. Through real-time monitoring and control, growers can optimize environmental conditions and nutritiondelivery for maximum yield and quality. Predictive analytics enable proactive decision-making, preventing crop issues before they occur. Remote management capabilities offer flexibility and convenience, allowing growers to monitor operations from anywhere. Precision nutrition dosing minimizes waste and reduces environmental impact. Future advancements may include blockchain integration for supply chain transparency and expansion into vertical farming for urban agriculture initiatives. Overall, IoT-driven hydroponic systems hold immense potential to revolutionize modern agriculture, addressing food security challenges while promoting sustainability and productivity.

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