

Wireless Data Transfer Based Real-Time Drip Irrigation System

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Abstract

Pakistan is an agrarian country. Irrigation is a process that is being used to artificially supply water to the soil. Conventionally, areas, where there is no rainfall or scarcity of water, is supplied through inland waterway or tube wells. Frequently used irrigation techniques have a bunch of problems such as increasing the labor force of humans and soil erosion. As far as agriculture is very important. The productivity of agricultural fields depends on the nutrients in the soil, optimal combination of supply of water according to the requirements of the crops, and environmental conditions that are appropriate for farming. The concentration of wetness in the soil provides water to the plants and crops. Over or under-irrigation leads to an excessive or low water supply which can lead to inferior results. To receive the information of the system with mobile phone wirelessly about the condition of the solenoid valves in water supply pipes, water pump and the level of water in the storage tank. A system is designed to reduce the labor work and save energy, which can result in a uniform water supply required for the plants. Any time the mobile user is informed about the function of the system.

Keywords: *Agriculture, Irrigation, Moisture, Soil, Solenoid Valve, Wireless, Water Pump*

Introduction

The level of water in Pakistan especially in Balochistan declines day by day and water is insufficient in Balochistan. Balochistan is a province that produces high-quality fruits, due to fruit production Balochistan is called a fruit basket of Pakistan. Fruits are the source of income for most of the people in Balochistan. Balochistan is the largest province of Pakistan with 347,000 sq. km. The population of Balochistan province is less than other provinces approximately 7.5 million people [1]. Most of the people's income depends on agriculture and livestock. With the fast change in the weather, agriculture also affects, and the rain decreases. With the decrease in rain, the water requirements of plants do not fulfill, and the plants and trees become weak and their production decreases.

As in economically developing countries, the production of different fruits plays a very important role [2]. Plants and trees also maintain environmental conditions. When an area has many trees there will be more rain as compared to that area where trees are fewer. Trees

maintain ecological balance. Nature has given a lot of different things to Balochistan like climate but unfortunately, the climate changes day by day, and humans, animals, and plants badly affect these climatic changes.

Due to the scarcity of water the level of water in the soil is less than plant requirements and excessive water also affects plant growth. Heat loss is a limiting factor in winter. In hilly areas, the temperature goes negative, and the photosynthesis process stops at that time, the weather is very cold, and the sunlight is not available, or the intensity of sunlight is very weak. Mostly confines many species to the tropics. Another limiting factor is the race against the same resource users. Competition is the basic interaction between plants in nature.

Competitive because the plants have the same requirements of sunlight, nutrients, and water, which means that every plant needs minerals, water, and sunlight for survival.

TABLE I. PRODUCTION AND AREA OF DIFFERENT TYPES OF FRUITS IN BALOCHISTAN 2016-17

Fruits	Area in Hecta-es	Production in Tons	Yield in kgs/ Hectare
Almond	10100	20736	2508
Apple	87171	576376	10644
Apricot	22199	154525	9597
Grapes	14564	65386	6340
Peach	5655	16859	3588
Plum	3585	24392	9004
Pear	190	465	3496
Pomegranate	5778	26868	5971
Charry	1176	2067	2828
Pistachio	176	667	6604
Dates	53264	180762	3815
Mangoes	651	1140	2155
Citrus	1634	6953	6456
Banana	1062	11654	17013
Guava	514	2494	5655
Loquat	27	81	5063
Papaya	766	3525	7223
Chikoo	651	3142	5671
Coconut	1116	8630	7838
Fig	36	63	3316
Olive	83	0	0
Other Fruits	1555	4349	5081
TOTAL	211953	1111134	

The different factors that affect plant growth are:

A. Light

Light from the sun reaches the earth and it falls on the surface of the leaves of the plant. Some of the light is absorbed in the plant and the remaining is reflected from the leaves of the plant. The energy in the form of sunlight is the driving force for the starting of a chemical

reaction called photosynthesis. The process by which green plants produce sugar primarily from carbon. In the presence of water and carbon dioxide chlorophyll use light energy. Oxygen, water, quality, quantity, and light together affect the growth of the plant. Plants directly exposed to sunlight are usually compact, where the shadows are taller and taller.

B. Humidity

Water plays a vital role in the life of every living thing. Every living cell needs water. Water keeps the plant tight; it is also used in the process of photosynthesis. With the help of water, nutrients are carried to the plant. Plants absorb minerals from the soil through the roots and pull them up. The source to provide water manually for plants is irrigation.

C. Temperature

Temperature affects plants. It has a main role in germination, respiration, photosynthesis, and the flowering of the plants. With the increase of temperature, the germination stops, and the seed is then unable to germinate, and the transpiration also increases, and the plant loses more and more water. Depends on the plant the increase or decrease in temperature affects plant growth and health.

Importance Of Water For Plants

An increase or decrease of water affects the plant's growth and health. If the level of water is very high in the soil the root of the plant may rot (Spoil). On the contrary, if there is not enough water the traveling of nutrients will be impossible through the plant. Rot roots are not good for the plant and if the plant does not have healthy roots, it cannot grow. In short, the proper balance of water is very important for plant growth. The simple way is to check the water in the soil is to insert the finger in the soil, if it is moist then the water is available in the soil, if it is not moist then enough water is not available, and the plant needs water.

Plants use water to carry nutrients. Dissolved sugar and nutrients plants absorb from the soil. Enough water is required for the plant, otherwise, the plant will be droop, so the water saves the plant to stand. Without the proper balance of water, the plant will be nutritious, but it will be also weak and impossible to support the weight itself. Different plants have different water requirements. Some plants need more water like a Guava tree and some plants need less water like a peach tree. Water is entered through the roots of the plant then it goes to the stem and after that, it reaches, the leaves according to the requirements otherwise it stores in the stem. Through xylem vessels, water travels through a plant, like capillaries. Xylem transport the water to different parts of the plant. The water regulates the temperature of the plant. Properly watering a plant is important for health and appearance.

The nature of the plant is not parasitic. They prepare their food. The plants use a process called photosynthesis by which they prepare their food and by this process of photosynthesis light energy is converted to chemical energy. The prepared food is then stored in the form of starch to use later. Photosynthesis is an important process in plant growth. Photosynthesis is done with carbon dioxide water and sunlight. As a result of photosynthesis, process products are oxygen and carbohydrates. Oxygen is released and carbohydrates are the source of energy for the plant. To synthesize glucose plant, utilize light. This process begins with the water absorbed by the roots which enter the cells called the chloroplast. Chloroplast contains a green chlorophyll that reflects the green wavelength light.

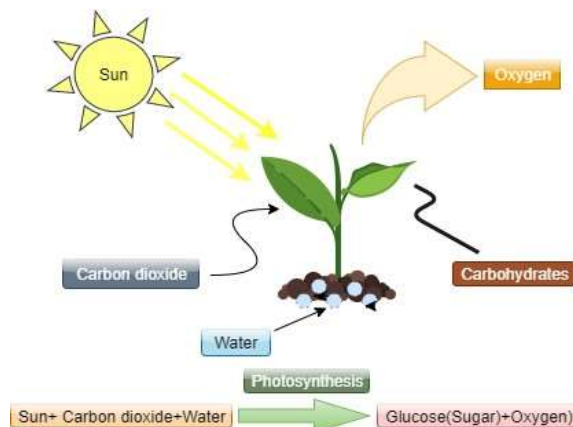


Fig. 1. Photosynthesis process in plant

Chlorophyll absorbs light in the red and blue portion of the spectrum and speeds up the chemical reaction. In the chloroplast, the molecule of chlorophyll absorbs light photon and electron in exchange. A series of chemical reactions occurs, and finally, replace the loss of electrons with water molecules in the leaf. The oxygen atom separates from a water molecule and it is released through the stomata. The hydrogen is collected to form a carbohydrate molecule.

Light energy is not used directly but is converted to chemical energy. Only about 5% of the leaf is used for photosynthesis. Only 30-50% of it is stored in the cell as chemical energy.

Photosynthesis is a very important process because it not only helps plant growth but also provides humans with the oxygen they need to survive. In this way, plants not only make their food but also maintain the balance of the ecosystem.

Irrigation

The method used to artificially supply the water to plants is known as Irrigation. When the soil is properly irrigated it is fit for agricultural purposes. For the growth of a plant, water plays a very important role. Irrigation provides the periodic supply of water to the plants. The water which is used for irrigation comes from different sources like lakes, canals, wells, tube wells, krezes, dams, etc.

Importance Of Irrigation

Irrigation is very necessary for agriculture because of the following reasons mentioned below.

- Transportation of minerals in the plant is done with the help of water.
- Water is used by plants in the process of photosynthesis to prepare the carbohydrate.
- Water provides hardness to the plant. So due to water, the plant is rigid.

Due to the above reason's irrigation is very important because water is very necessary for the plants. In different areas like Balochistan, the level of rain is less and the requirements of water of plants are not completed. So, irrigation for areas like Balochistan is very necessary.

Irrigation Methods

There are two types of irrigation methods.

A. Traditional Irrigation Methods

The traditional irrigation method was used in previous times. It was cheaper but these methods were not efficient. Humans or animal labor were required for these methods. The methods are as under.

1. Pit

In-pit system, a pulley is used to pull the water from a well and irrigate the land. It is a system that consumes a lot of time and work but is very profitable. Also, water wastage is avoided when a pit irrigation system is used.

2. Chain Pump

In the chain pump system, two wheels are used, and cubes are attached at some distance from each other on the chain. When the wheel rotates through humans or animals the wheels rotate, and the buckets collect the water from the water source.

3. Rahat

The Rahat irrigation system uses animal labor. On top of the well, a wheel is tied, and animal turns the wheel and water extracts from the water source like well.

4. Kreze

In this type of irrigation water travels from one place to another underground. At first time it is very laborious because it needs pipes and other required things, but nowadays this process does not use commonly.

B. Modern Irrigation Methods

Modern irrigation methods are more efficient than traditional irrigation methods. These methods used water efficiently as compared to traditional irrigation methods. The two most important ways are used.

The spraying system works like rain. Water is transported to the center of the ground with a pipe and a sprinkler is attached to the pipe. This is an efficient way for grounds.

Nowadays mostly drip irrigation is used. The pipes are for crops or plants. Plastic inputs have holes. These holes make the water flow and drop; hence its name is drip irrigation. This is a very efficient method as compared to all other methods of irrigation.

Table II. Number Of Different Sources Of Irrigation In Balochistan

Items/ Year	2006-07	2016-17	Percentage Increase/ Decrease
Canal	607562	535651	-11.8
Tube Wells	459698	481676	4.8
Wells	86887	63138	-27.3
Krezes, Springs	149238	29095	-80.5
TOTAL	1109560	1303385	-14.9

The decrease in canals, well and krezes are -11.8, -27.3, and -80.5 respectively. The maximum decrease is in springs and karezes because every year the water level decrease. So proper methods of irrigation are required to irrigate the plants and to save water.

Literature Review

To achieve the maximum yield of water by using a small amount of water to use the method of drip irrigation [3]. Scientists had indicated that the underground level of water is going

down day by day and the people are facing a deficiency of water. A large amount of fresh water is used in the agriculture sector. The adaptation of drip irrigation is to use a small amount of water to achieve the required yield. So that the country is stable economically. They do not discuss wireless sensor concepts in drip irrigation in this article they compared the flood and micro-irrigation system [4]. They also explained the three different techniques for drip/micro-irrigation. The methods which are discussed are about automatic and manual irrigation systems [5]. Drip irrigation system technique of wireless sensor was used which is a quick communication system but used Zigbee

[6] and this device is ban due under some rules of government in Pakistan. This system is based on an ARM microcontroller and GSM module. This system operates on the uninterruptible power supply (UPS) and having storage, but the disadvantage of this system was it was designed for many plants like rice, wheat, or another type of crops, and there was no way to controlled and save the water [7]. This technology was based on RF wireless and they used the solenoid valve, but the disadvantage of this system was that the system was too expensive because numbers of sensors were used in their irrigation system [8]. In this method, Raspberry Pi and Arduino UNO are used, the mail is sent through mobile to the user when the system is going to start functioning, but again they used Zigbee and raspberry pi which makes this system expensive and again the same reason Zigbee is banned [9]. This smart irrigation system is used in African countries, particularly in Tanzania, this system is controlled by the solar system to eliminate the bills, and everyone can use this model in the area where there is no electricity. They developed a simple feedback control system and using a fuzzy logic method with the latch valve [10] but the first-time installation is very expensive. The method that they are using is a wireless sensor network and the technique is embedded based, but the system is very expensive because of hardware cost and a lot of components lead to more power losses. [11]. This drip irrigation system used the technology of the wireless RF module for transmission and receiving units. RF transmission in the system collects data by using RF transmission [12]. The technology of WSNs for drip irrigation systems including the temperature and moisture of soil, to monitor the terms which are effecting drip irrigation they also used the drop emitter pipes which drop the water to the roots of the plants. But when the pipe was broken, or the emitter block the system malfunction occurred [13]. The system was not having memory and is not automated properly. In this, they have used the technology of wireless sensor networks (WSNs). The water is properly managed due to observing the sensor reading from the field where plants are grown or farm. They designed the web application which provides an easy way to monitor and controlled the water by the farmer. They used the technology of the cloud computing technique. They used the technology of sensors for sensing like temperature, Light intensity, humidity, and moisture. This model was a complicated model [14] and cloud computing needs a paid trial which is hard for uneducated people to use. Drip irrigation system wireless sensor network uses but this system is used in small-scale drip irrigation. One of the major things in this system was it has real-time collection and recording of data on the field which includes soil moisture, temperature, light intensity, and humidity. They used the technology of the Lora module, at the mega microcontroller and boost converter which boosts the input signals according to the requirements, which makes the system highly expensive [15]. The designed model is called a smart irrigation system. In this type large fields are cultivated and

are divided into many parts or plots, then they implement the drip irrigation in each independent plot. The system is used for each plot is an automatic irrigation system. So, to manage easily, they implement an independent irrigation system in each plot. They connected the data server through the cloud system. They apply the concept of master and slaves. The distance between the master and slave must be less than 100m. So, it is not an efficient model because it does not monitor the temperature, humidity, and other environmental effects. This system does not have any storage to store and record the data [16]. Large power-based system up to 30kV which is a very big amount of power for ordinary peoples, because people try to invest less and get more output [17]. The system requires that it have to be cost-effective, reliable, less power consumption, and efficient.

Methodology

The level of moisture in the soil is measured through a moisture sensor which is operated by 5V direct current (DC) and then the data is sent to the control unit. Side by side the ultrasonic sensor monitors the level of water in the storage tank, when the level of water becomes less than 10cm it gives the command to the control unit to activate the relay and start the water pump, the level of the tank when reaches 20cm below the top-level the ultrasonic sensor again sends the command to the control unit to turn the relay and power off the motor to stop the flow of water. The level of moisture when drops from 25% the control unit turn ON the solenoid valve and water supply start to the soil with the help of pipes and drip emitters. The soil moisture level when reaches 55% the moisture sensor sends the command through the data bus to turn OFF the solenoid valve. All the commands are sent to the user's mobile phone through the GSM Module. The used GSM module is 3G and the data speed of 3G communication is 7.2Mbps for download and 2Mbps for upload. The power battery gives the power to the overall system and at daytime, the solar panel provides the power to the system, and at nighttime, the sun is not available the battery provides the power to the overall system. At daytime, the solar panel charges the battery and gives power to the overall system. On the backup when these two sources fail a third option is available to use which is AC power which is provided by different Electric Supply Companies. Mostly, the power provided by Electric Companies is 220VAC~50Hz or 110V~60Hz, but the required voltage is 3VDC, 5VDC, and 12VDC. For these different levels of voltages, a power supply is designed that first converts the AC to DC and then converts again the voltage to the required level of voltages i.e 3V, 5V, and 12V DC. For fast communication devices plays a very important role because with less time and more privacy things to be transferred wirelessly. The overall power consumption of the system is 24.12Watts calculated and 28.057Watts practically. which is less power compared to other systems.

Hardware

Arduino is an open-source microcontroller board. Arduino is used to receive and read the data from sensors and to control different devices like LEDs or actuators. The Arduino microcontroller and ports allow us to upload a program to this board and that can communicate with real-world objects. With Arduino we able to create devices that respond to the world. For example, a moisture sensor in the soil in which the plant is present and automatically turns on the watering system if it gets below the level of moisture of the soil or

we can create a lot of different control and communication systems with this platform. If there is something that is somehow controlled by electricity, then somehow interface with it and even if it is not controlled by electricity, we can still use things such as motors to interface with it.

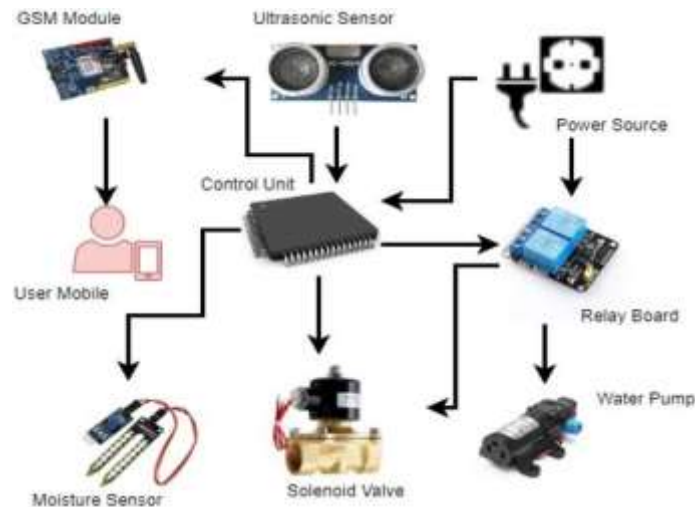


Fig. 2. Block Diagram of Drip Irrigation System

GSM module is a device that is used for wireless communication. The SIM808 GSM module provides the best edge to the GSM module industry.

GSM provides data with SMS, voice data with low power consumption. The sensor (Soil Moisture) detects the moisture of the soil and converts it to an analog value (by measuring the permeability of the soil that is a function of water content. The sensor is easily insertable in the soil. The ultrasonic

sensor creates ultrasonic waves. The transmitter produces the waves, and the receiver receives the transmitted waves. The ultrasonic sensor calculates the distance as:

$$L=1/2 \times T \times C \quad (2)$$

A solenoid valve is an electro-mechanical device that works is to start or stop the flow of water. Internally it has a solenoid, and this solenoid is controlled with an electrical signal.

Circuit Description

The microcontroller unit is the brain of the overall system. The soil moisture sensor is attached to the Arduino analog pin A1. The soil moisture sensor measures the moisture level in the soil and gives the signal to the Arduino. One side of the probe is directly connected to the VCC. The potentiometer is attached to the sensor to adjust the sensitivity of the sensor. GSM module receives the data from the Arduino and sends it to the user mobile through wireless communication. The power rating of the GSM module is from 3.8V to 12V but the preferred voltage is 3.8V. To properly supply the voltage to the GSM module an LM317 voltage regulator is used. The adjustment in the center of the voltage regulator is used to adjust the voltage.

The Arduino gives the command to the solenoid valve. The solenoid valve turns ON and when the Arduino gives again the command to the solenoid valve and it turns OFF. Solenoid valve has coil and stud. The stud moves in the center of the coil.



Fig. 3. Implemented System

The ultrasonic sensor continuously creates the signal and transmits it when the signal comes back the receiver receives the signal and the distance is calculated. When the level of water is low in the tank the sensor gives the signal to the Arduino and then it gives the command to the relay to start the water pump. With time the water level increases. At the filling point, the tank fills and the sensor sends the command to the Arduino and the water pump is turned OFF. The LCD shows the current water level in the water tank and the status of the water pump that it is ON or OFF.

Automatic drip irrigation is very easy to install and operate. First, it is a fully automated system and does not require any human labor at the time of operation. The moisture sensor senses the moisture and gives the data to Arduino, the Arduino gives commands to the GSM module and controls the solenoid valve and water pump. When the level of moisture is low a message sends to the user and the solenoid valve turns ON when the moisture in the soil reaches a proper level the solenoid valve turns OFF and again message is sent to the user mobile.

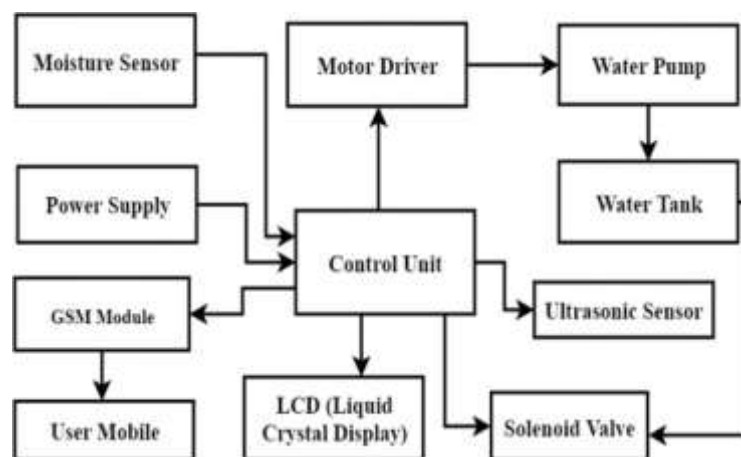


Fig. 4. Block Diagram of the System

Results And Discussions

The efficiency of a system means that how its performance is, surplus loss occurs, or a lesser amount of loss occurs in the output of the system. Efficiency is a measuring concept which is the ratio of the output to the input.

As efficiency increases the system becomes more profitable and energy-saving. The efficiency of drip irrigation is very high as shown in fig. 5. The most efficient method is the drip irrigation method because of the loss of water in the form of vapors or an extra supply of water to the soil. The sensor measures the level of water in the soil becomes less than 25 percent it sends the message to the control unit.

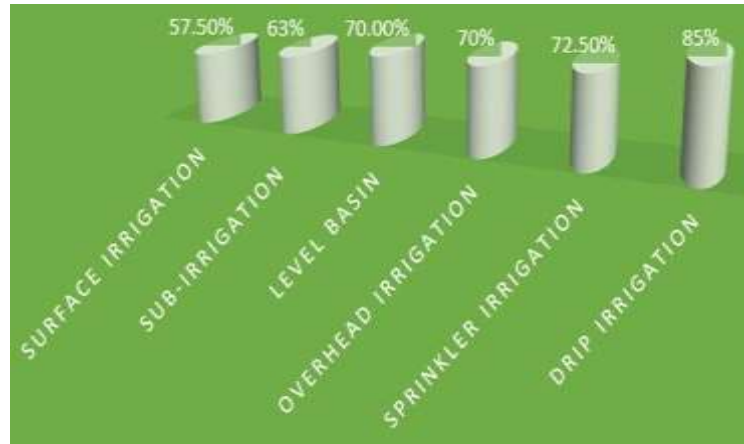


Fig. 5. Comparison of Efficiencies of Irrigation Methods

In Balochistan, a lot of fruit trees are grown, and different types of irrigation methods are used which leads to a big loss of water. As water evaporates very easily and due to evaporation water is lost and this is avoided using drip emitters Water level decreases day by day and we must save the water. So, drip irrigation gives very good results for the management of water. The decrease in the productivity of different fruits is due to drought. Due to the scarcity of water, a lot of trees were affected. The installation of this is easy and is not expensive. Devices provide good results as control valves, water pumps, and filling of the tank is very difficult and laborious for humans manually. In this system, the tank is automatically filled, and in short, every device controls automatically with the control unit. The power consumed by this system is very low as compared to other systems. The power consumed by AC systems is approximately 300 Watts which is a very large amount of power as compared to our system.



Fig. 6. Measured Power of the used devices

The difference between both systems is that our system operates totally on direct current (DC) and the difference is 243.943Watts which is a very big difference. DC operating devices consume less power as compared to AC operating devices as shown in fig. 6. Communication is also done with the user's mobile, and he/she knows about the system operation.

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