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# Fertigation System to Conserve Water and Fertilizers Using Wireless Sensor Network

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***Abstract:*** **- This Paper is based on crop monitoring system to maintain proper soil pH level and soil water content for citrus tree.MSP430 Microcontroller based Automatic Fertigation System. The goal is to conserve the water and fertilizer through Fertigation System. Wireless sensor network for communication between sensory unit and main station is used. ZigBee network is used for wireless communication. ZigBee technology is IEEE 802.15.4 Standard using data rate of 250 kbps on 2.4 GHz ISM band. It is expected to provide low power and low cost connectivity, results in long battery life for several months to several years. Main sensors are (a) Soil Moisture Sensor and (b) Soil pH sensor. The MSP430G2533 16 bit RISC processor is used.Fertigation is an application of water soluble fertilizers through micro-irrigation systems. Application of dry fertilizers remains on soil and causes loss of nutrients due to leaching and volatilization. In this paper analyzing soil pH value and soil moisture content is required for healthy plant using soil pH sensor and soil moisture sensor and controlling entire system using wireless sensor network. Test has been carried out on Citrus tree as it is major fruit crop. It is grown in more than 140 Countries. Micro-irrigation System and Fertigation management is one of the main concerns of Citrus fruit production. The aim is to create crop monitoring system with soil moisture sensor and soil pH sensor based on Wireless Sensor Network (WSN) for precise irrigation and fertilizer supply to produce profuse crop production while diminishing cost and assisting farmers in real time data gathering. WSN in agriculture helps in distributed data collection and monitoring in harsh environments. There is a great need to modernize the conventional agricultural practices for the better productivity. Due to unplanned use of water, the ground water level is decreasing day by day and solubility of the fertilizers in irrigation water contains various chemical constituents some of which may interact with dissolved fertilizers with undesired effects which may leads to inferior quality of fruit production.**

***Keywords*****: - Fertigation System, Soil Moisture Sensor, Soil pH Sensor, Wireless Sensor Network.**

## I. INTRODUCTION

This paper presents the preliminary design on the development of Fertigaion System based on Wireless Sensor Network for crop monitoring application. The proposed WSN system will be able to communicate each other with lower power consumption in order to deliver their real sensory data collected to remote GUI System and to actuate the Fertigation System. Application of fertilizers through irrigation system is referred to a 'fertigation'. Fertigation through micro-irrigation system provides a technique of application of water and nutrients to an area of the soil where most of the roots are present to coincide with the timing of nutrient requirement by the trees. Figure 1.1 is the proposed Fertigation System. Two tanks are used; one for the water supply and other tank is for pouring water soluble fertilizer towards plants. Valves of tanks are operated using MSP430 Microcontroller. Three sensors are used for this system one is soil moisture sensor, Temperature sensor and soil pH sensor. Sensors send the sensory data to microcontroller i.e. MSP430 Ultra low power microcontroller. It processes the data from sensors and shows the output on remote terminal using Graphical User Interface (GUI)

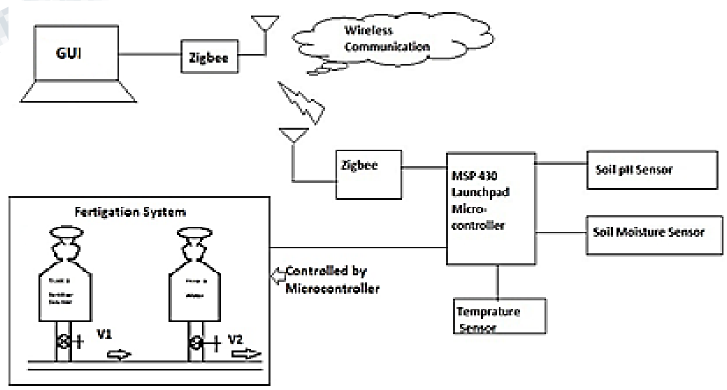


***Figure 1.1: Fertigation System***

## II. AIM & OBJECTIVE

### A. Conservation of Water by maintaining proper soil Moisture Level.

Watering any Tree in initial stage is very critical stage. Less amount of irrigation with high frequency is preferable.

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Frequency and quantity of irrigation depends on soil type and growth stage of Citrus plant. Tree with very effective watering can makes Citrus healthy and over watering cause wet soil which is favorable condition to spread fungal disease. The soil texture should be moist, not wet. Therefore slow and deep irrigation system is preferred for planting. In this paper slow automatic drip irrigation is used. Irrigation system stops and starts automatically depending on percentage of soil water content [1]. Based on "Soil field capacity "and "Permanent wilting point" soil moisture scale can be determined. Soil moisture scale for soil moisture variability analysis is given in following table [1].

| Volumetric Soil Water Content | Soil Moisture Condition |
|---|---|
| 0.0 % to 7.9 % | Dry |
| 8.0 % to 16 % | Ideal |
| 16.1 % to 25.0 % | Wet |
| 25.1 % to 35 % | Very Wet |

***Table 2.1: Soil moisture scale***

Volumetric soil water content between 8.0 % to 16 % is ideal.

**B. Conservation of Fertilizer by maintaining proper soil pH and Nutrients uptake**

Maintaining the proper level of soil pH is critical element. Soil pH is one of the important properties of soil and it is also factor of soil fertility, so we can say that soil fertility is mostly depending on soil pH. Sensing soil pH and efforts to maintain proper soil pH is crucial part [2]. Mineral nutrient like Nitrogen and Iron etc. when they dissolve in water, the soil solution (water and nutrients) may become acidic or alkaline. In this case some nutrients will not dissolve so they will not be uptake by plant's root [20]. At the pH value below 5.5 nutrients such as Nitrogen (N), Phosphorus (P) and Potassium (K) are less available. When pH exceeds 7.0 Iron (Fe), Manganese (Mn) and Phosphorus (P) are less available. The soil pH value is to be maintained for Citrus plant is 5.5 to 7.0. Generally soil pH is corrected using Iron sulphate for lowering pH value and Lime (Calcium carbonate) for raising pH value. Some organic soil improvers are also available to stabilize soil pH on neutral [20] [21].

**C. Wireless Sensor Network for Precision in agriculture**

A WSN is composed of various sensor modules attached to radio modules (motes). They can be deployed in areas where the parameters of interest need to be measured. Their sensing and computational capability is limited, so the data is transmitted at low speeds; few bytes per hour at most. Motes transmit the data from mote to mote in an ad-hoc way back to a base station where the data is stored, processed and displayed. The radio motes require minimal attention if they are setup in appropriate locations and with the appropriate housings which protect the electronic components. The versatility in which WSN can be applied to any system and their flexibility require extensive research and development. The concept of WSN is based on a simple equation: Sensing + CPU + Radio = Thousands of useful applications.

Wireless sensor network (WSN) is a low-cost communication network that allows spatially distributed sensing and wireless connectivity in applications with limited power. A WSN consists of randomly deployed embedded wireless devices, called sensor nodes that are equipped with one or more sensors, a lightweight processor, and a low power radio transceiver.

## III. SYSTEM DEVELOPEMENT

The entire fertigation system which is shown in Figure 3.1 will be set up at main station. There will be computer based Graphical user interface (GUI) which will be built up using Visual basic software. On GUI all sensory data will be displayed as well as it will have alert alarm for improper soil water content and soil pH value. User can also control the entire fertigation system manually from main station. In fertigation system block diagram shown in Figure 3.1, sensors are interfaced with MSP430 microcontroller which is 16 bit RISC processor. Microcontroller is processing all input sensory data and sends it to ZigBee module located at sensing unit i.e. microcontroller's end. Whereas at main station i.e. at receiving end another ZigBee module will be receiving sensory data which is displayed on GUI of a computer.GUI is having full Controls and command over entire fertigation system so that user can start and stop the system from GUI.

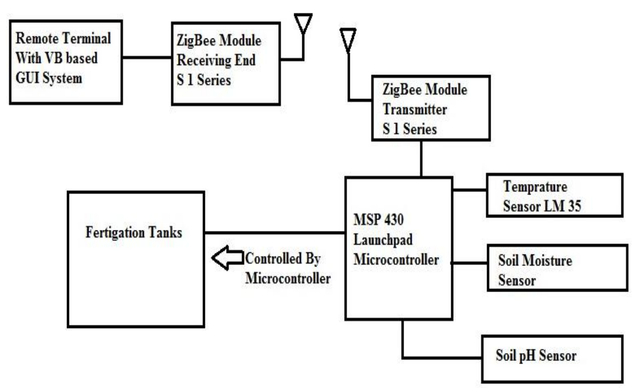


***Figure 3.1: Block Diagram of System***

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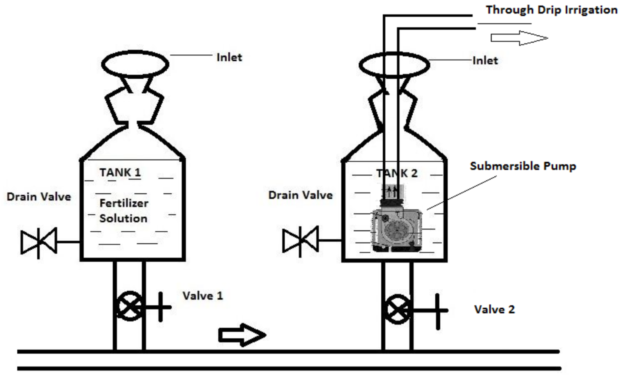
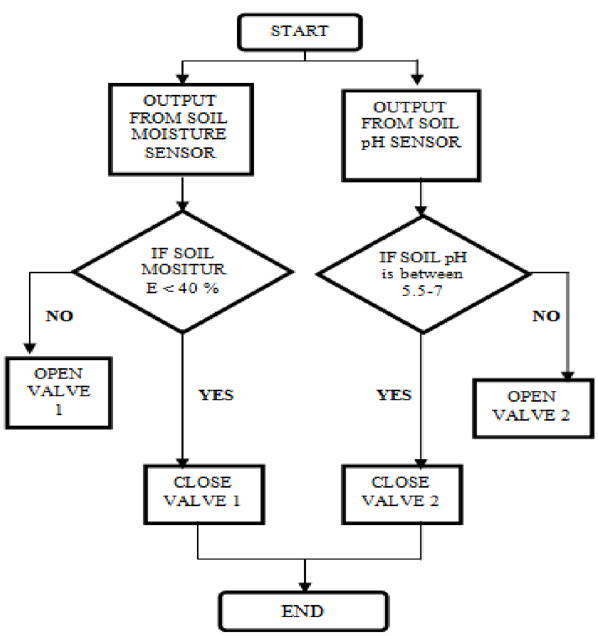



*Figure 3.2: Fertigation Tanks*

In fertigation system, two tanks will be used, one is filled with water i.e. Tank 2 and another is filled with water soluble fertilizer i.e. Tank 1. So when water scarcity occurs or when there is need of watering plant, relay of submersible motor pump in tank 2 will trigger to pour the water to plants through drip irrigation pipelines. And pH sensor is continuously sending soil pH value which is nothing but showing fertility of soil so if the soil pH is not adequate for Citrus tree (i.e. pH value 5.5-7.0) necessary soil improver fertilizers would be supply through fertilizer solution tank (Tank 1) i.e. valve 1 to correct the deficiency in nutrient uptake of plants .In order to produce more crop per drop, drip irrigation is used.

**Flowchart**




## IV. PERFORMANCE ANALYSIS

### 4.1 Results and Analysis:

Testing of the system had done in the little farm field as shown in Figure 4.1 and Figure 4. 2 both soil moisture and soil pH sensors are installed near plant roots and observation had been taken by changing soil moisture content Testing was carried out for daily basis to check the performance of the system.

*Figure 4.1: System Setup in Small Farm Field*

Depending upon different soil water content and different soil pH ,valve's opening and closing of fertigation tanks are tested as shown in Figure 4.2 .Opening and closing of valves of water tank as well as fertigation tank is programmed into microcontroller like for soil moisture content for 0% to 30 % water tank valve will remain opened beyond 30% valve of water tank will be closed to save the water.Simillarly for pH range between 5.5-7 the valve of tank containing water soluble fertilizer will remain closed all the time. Because pH value between 5.5 to 7 is suitable for profuse production.

*Figure 4.2: Testing valves operation*

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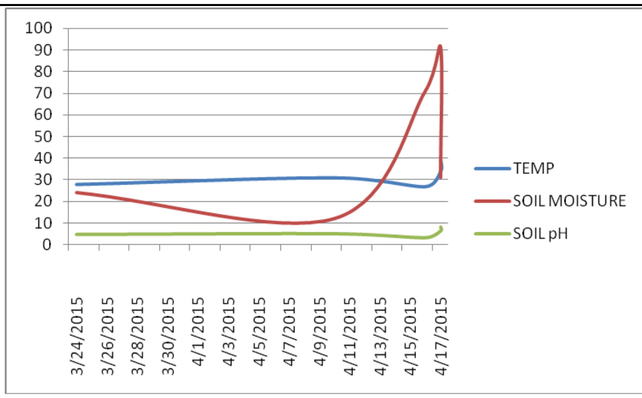


***Figure 4.3: Graph on the basis of Sample readings.***

Above graph shows the readings taken by Sensors & graph is plotted. Green line shows variation in soil pH, Red Line shows variation in Soil Moisture that is water content of soil similarly blue line is for temperature variation. The reactions of soil particles with the various chemical compounds delivered in the trickle irrigation solutions, however, are very complex. They involve chemical interactions between the constituents of soil particles which carry permanent electrical charges on their surfaces, precipitation reactions with calcium carbonate (lime) in basic reactive soils and with aluminum and iron in acid soils [16]. The main purpose is to explain the basic behavior of soluble fertilizers supplied by trickle irrigation in growing different crops on various soil types under varied climatic conditions. Fertigation enables the grower to select and use high quality fertilizer most suitable for his soil, irrigation water source, crop and climatic conditions to produce high quality crops and, at the same time, prevent environmental pollution [16].

## V. MATHEMATICAL ANALYSIS

The amount of water associated with a given volume or mass of soil ("soil water" or "soil moisture") is a highly variable property. It can change on time scales of minutes to years. However, most soil properties are more stable, and should be referenced to dry soil weight.

**A. Expressing Soil Water Concentration**

There are several ways to express soil water concentration (Note: the Greek letter theta$\theta$ is also commonly used for water concentration):

Gravimetric -- dry-weight basis

$$W_d = \frac{\text{grams water}}{\text{grams dry soil}}$$

Range: 0 to 1 i.e. 0% to 100 %.

For our experiment: Water is taken 250 grams dry soil is taken 500 grams then,

Wd= 250/500

Wd=0.50 (1)

2. Gravimetric -- wet-weight basis

$$W_m = \frac{\text{grams water}}{\text{grams of moist soil}}$$

$$= \frac{\text{grams of water}}{\text{grams of water} + \text{grams dry soil}}$$

Wm= 250/ (250+500)

Wm= 0.33 i.e. 33 % (2)

Range: 0 to 1 (i.e.0 to 100%).

**To convert between dry and wet basis:**

$$W_d = \frac{W_m}{(1 - W_m)}$$

Therefore

Wd = 0.33 / (1-0.33)

= 0.49 i.e. approximately 0.50 i.e. 50%

$$W_m = \frac{W_d}{(1 + W_d)}$$

W m= 0.50 / (1+ 0.50)

= 0.33 i.e. 33 %

Water Concentration in Soil Depth

Wz = cm of water in a given depth zone of soil

To convert: Wz = Wv* depth

For example, water is in the top 15 cm of soil that has a volumetric water concentration of 0.2 cm3/cm3.

Then

Wv = 0.2 cm3 water/cm3 soil

Depth =15 cm soil

Wz= 0.2 * 15

= 3 cm3 water/cm3 soil

= 3 cm water depth per unit area of soil.

## VI. FUTURE SCOPE

Fertigation is expected to increase the nutrient uptake efficiency; thereby it will minimize leaching losses compared with the application of fertilizer in dry granular form broadcast over a large soil area at less frequent intervals. In addition to the tree response, fruit yield and quality, the changes in groundwater nitrate concentrations impacted by the different fertilizer delivery methods. fertigation is a modern agro-technique, It will provides an excellent opportunity to maximize yield and minimize environmental pollution by increasing fertilizer use efficiency, minimizing fertilizer application and increasing return on the fertilizer invested. In fertigation, timing, amounts and concentration of fertilizers applied can be easily controlled.

## VII. CONCLUSION

In this paper Fertigation System Using MSP 430 launch pad microcontroller, soil moisture sensor, soil pH sensor, Temperature sensor and wireless sensor network for communication using Zigbee modules is designed. Using

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Soil moisture sensor we have controlled the valve of water tank to avoid excess water supply to Citrus plants. And using soil pH we controlled the valve of water soluble fertilizer tank. As soil pH value 5.5-7 is considered to be suitable the programming is being done on MSP 430 microcontroller such that when the soil pH is below 5.5 i.e. soil is acidic so valve of fertilizer tank will be opened to make the soil pH between 5.5-7 i.e. by pouring alkaline solution, when it reaches value 5.5-7 valve will be closed and vice versa for very alkaline soil. Therefore by controlling water supply and water soluble fertilizer supply adequate amount of water and fertilizer will be needed for farm fields and hence we can conserve the Water as well as can avoid over use of fertilizer. All sensory data from sensing unit have successfully sent to the receiving terminal i.e. remote location. All data has been displayed on VB based GUI at remote location.

## REFERENCES

1. Alexander Bertrand,JosephSzurley,PeterRuckebusch, Efficient Calculation of Sensor Utility and Sensor Removal in Wireless Sensor Networks for AdaptiveSignal Estimation and BeamformingIEEE Transactions on Signal processing, VOL. 60, NO. 11, NOVEMBER 2012.

2. Lingli Yang, LI Xiao-juan, GONG Hui-li, ZHAO Wen-ji, Lei WANG and Yong Hua SUN," Study on Distribution of Soil pH in Urban Area Using GIS Technology", IEEE Trans.,vol.7803-9050-4/05,pp.4477-4480,2005.

3. Joaquín Gutiérrez, Juan Francisco Villa-Medina, Alejandra Nieto-Garibay, and Miguel ÁngelPorta-Gándara "Automated Irrigation System Using a Wireless Sensor Network and GPRS Module" IEEE TRANSACTIONS.

4. S. Dzikiti, S. Verreynne, A. Strever, J. Stuckens, W. W. Verstraeten, R. Swennen and Pol Coppin"Detecting Citrus tree water status by integrating hyper spectral remote sensing physiological data in water flow. ", IEEE Trans.Volume-9, Page No. 348-350, 2009.

5. P. R. Chaudhari and D. V. Ahire, Journal of Chemical, Biological and Physical Sciences

6. P. R. Chaudhari*and D. V. Ahire"Electrical Conductivity and Dielectric Constant as Predictors of Chemical Propertiesand available Nutrients in the Soil." Journal of Chemical, Biological and Physical Sciences,an International Paper Review E-3 Journal of Sciences.February 2013- April 2013, Vol. 3, No. 2, 1382-1388.

7. P.S. Shirgure , Scientific Journal of Review ,Micro-irrigation systems, automation and fertigation in citrus,November 2012 1(5)156-16

8. PETER COPPIN, Growing Citrus Successfully, © PETER COPPIN 2007, revised 2009 & 2010

9. Irrigation and Fertilizer control for Precision Agriculture using WSN: Energy Efficient ApproachShiv International Journal of Advances in Computing and Information Researches ISSN:2277-4068, Volume 1– No.1, January 2012

10. Gracon H. E. L. de Lima, Lenardo C. e Silva, Pedro F. R. Neto "WSN as a Tool for Supporting Agriculture in the Precision Irrigation" 2010 Sixth International Conference on Networking and Services, DOI 10.1109/ICNS.2010.26

11. Carole Palmer and Loretta Hostettler, Master Gardener Journal, Revised 01/2011.

12. S. K. Jata, M. Nedunchezhiyan,TapasRanjanSahoo and ViswanathSahooFertigation in High Value Tuber Crops,A Review Paper ,Odisha,May - 2013

13. Patricia S. Muir, HUMAN IMPACTS ON ECOSYSTEMS Journal, Winter 2014

14. G. Sri Krishna ,journal of Agricultural Research Station, Utukur, Drip Fertigation in Horticultural crops

15. U. Kafkafi and J. Tarchitzky,Fertigation "A Tool for Efficient Fertilizerand Water Management."International Fertilizer IndustryJournal,Paris, France, 2011.

16. KT VenkataRamana*, L Mukunda Lakshmi, K Gopal, VNP Sivarama Krishna, T Naga Lakshmi, G Sarada, V Gopi, and T GouriSankar. Nitrogen and Potassium Based Fertigation Response on Plant Growth, Yield and Quality of Sweet Orange Research and Reviews: Journal of Agriculture and Allied Sciences, April 2014.

17. P.S. Shirgure , " Citrus fertigation – a technology of water and fertilizers saving", Scientific Journal of Crop Science ,ISSN 2322-1690, vol. 2(5),pp. 56-66,November 2013.

18. KRISHI MITRA,Web article "Model Profile of 1.0 ha Citrus cultivation."

19. U. Kafkafi and J. Tarchitzky ,"Fertigation A Tool for Efficient Fertilizerand Water Management"First edition, IFA, Paris, France and IPI, Horgen, Switzerland, May 2011 Copyright 2011 IFA and IPI. ISBN 978-2-9523139-8-8

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)

Vol 5, Issue 3, March 2018

20. Harald Hoffmann, ,"Soil pH and plant health in the home garden.",Department of Western Australia agriculture and food, ISSN 0817-5969,Note: 174,2010.

21. David Whiting, Adrian Card and Carl Wilson (Colorado State University Extension) and JeanReeder, Ph.D., (USDA-ARS, retired)," Soil pH", CMG Garden Notes #222, pp. 222-4, December 2011.