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A Survey on Novel Integration approach for Monitoring of Primary Nutrients using Wireless Sensor Network Technology

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Abstract – *The objective of this paper is to propose a novel design and development of an agricultural crop monitoring system using Wireless Sensor Network (WSN) to increase the productivity of crops and to recognize several macro-nutrients present in the soil by deploying chemical sensors in different locations in the crop field. The primary subjected macro-nutrients for observation are Nitrogen (N), Phosphorus (P), and Potassium (K). Wireless Sensor Network collects data and the range in quantity of different soil nutrients and transmits to the data server through the wireless sensor networks. The chemical level of the soil is monitored by the sensors and data is transmitted over the wireless channel to the farmer's system through which he can timely get the knowledge of chemical level in the soil in his field and accordingly he can nurture crops by acknowledging fertilizers to his farm. The application of commercial N, P, and K fertilizers has contributed to an incredible increase in yields of agricultural crops. However, excessive use of these fertilizers has been cited as a source of contamination of surface and groundwater. There are different stages in crop growing and each step requires different nutrient levels. The farmer has to spend a lot of time in nursing the field area. There are various techniques available to measure and monitor soil nutrients level hence farmers can improve the crop production. Insufficient nutrient levels can unhelpfully affect crop production while excess nutrient levels will either have a similar effect or simply be wasted.*

Keywords: Sensor Nodes Wireless Sensor Networks, Soil nutrient smart phone, Crop productivity.

1. INTRODUCTION

India is an agricultural country and agriculture constitutes the largest sector of the economy. Majority of the people, directly or indirectly depends on this segment. Therefore, a farmer has to spend a lot of period in nursing the fields.

Elements of soil contain macro- nutrients. The primary macronutrients like Nitrogen (N), phosphorus (P), and potassium (K), are considered as three most essential macro-nutrients of soil. Adverse effect on the productivity of crops is mostly observed scenario due to insufficient nutrient levels and it may result in wasting of crops and same can be observed if the nutrients are excess than required.

The soil macro-nutrients, Nitrogen (N), Phosphorus (P), and Potassium (K), are prime essential elements for crop growth. The main application of commercial macro-nutrient is N, P, and K fertilizers and they have contributed to a tremendous increase in yields of agricultural crops.

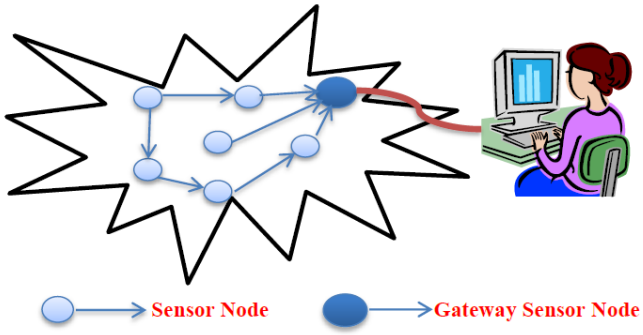

Fig - 1: Wireless sensor Network Architecture

However, excessive use of these fertilizers has been cited as a source of contamination of surface and groundwater.There are different stages in crop cultivation and each stage requires different nutrient levels. During the process of analysis and monitoring, we can measure the nutrients present in the soil. WSN technologies can be used to analyze, determine and describe the level involvement of nutrients in a soil. Meanwhile no confirmed cost-effective methods has been yet devised to effectively and efficiently allocate chemicals to meet crop needs, hence substantial quantity energy waste occurs in application of agriculture chemicals. So chemical substances and composts are applied in uniform amount irrespective of local changes in soil chemical situations.

WSN are widely used in agriculture to increase the productivity and monitor the various physical and chemical properties of the soil. Different kinds are used which perform various job like water monitoring, soil moisture monitoring, monitoring of soil biochemical level and weather change effects.

In this paper wireless sensor network technology is presented to test and sense the soil chemical condition in real time and as per the measured deficit or excess chemical condition, appropriate amount of fertilizer and compost are applied to the soil.[2]

The first step is to plant different sensor nodes and scattering them to different areas of interest in the soil, and these sensors are connected to base station through the

network. These base stations are connected with local management by gateway networks to control and monitor the crops and field conditions. This is called as precision agriculture. Precision agriculture is a soil and crop management system that assesses variability in soil properties like PH value and soil nutrients.

The sensor nodes will collect data in the range of different soil macro-nutrients using chemical sensor and transmit to the database server through the Wireless Sensor Networks (WSN). The chemical level of the soil is monitored by the sensors and data is transmitted over the wireless channel to the farmer's system through which he can timely get the knowledge of chemical level in the soil in his field and accordingly he can apply fertilizers to his farm. [3]

2. LITERATURE REVIEW

a. Current laboratory methods of soil nutrient analysis

Nutrients are the essential for plant growth are categorized as macro-nutrients and micronutrients. Micronutrients are just as essential as macronutrients but are required by plants in smaller amounts. There are three main primary essential macro-nutrients (Nitrogen (N), Phosphorus (P), and Potassium (K).

b. Sensing Technologies for Soil Quality Assessment

Broad reviews of various types of sensing techniques to measure the various nutrients present in soil have been presented in [1] Most of the soil nutrient sensing techniques described in literature involve one of the two methods *first is Optical sensing and second is Electrochemical sensing.*

2.1 Different approaches of Soil Nutrients Testing.

a. Optical sensing Method.

Optical sensing that uses reflectance spectroscopy to detect the level of energy absorbed or reflected by soil particles and nutrient ions. In Spectroscopy the interface between incident light and soil external properties, such that the features of the reflected light vary due to the soil physical and chemical properties, makes the basis for diffuse reflectance spectroscopy [2].

In optical method UV spectroscopy component is used. It deals with the interactions of ultraviolet radiation with the sample under investigation. It is based on the absorption of electromagnetic radiation at wavelengths in the range of 200-400 nm. In this technique non-bonding electrons can absorb the energy in the form of infrared or visible light to stimulate these electrons to higher anti-bonding molecular orbitals.

The light can be absorbing for the extensive wavelength. UV spectroscopy tracks Beer-Lamberts law. The absorbance of a solution is directly proportional to the concentration of the absorbing classes in the solution and the path length is called Beer- Lamberts law. For a static wavelength, UV spectroscopy can be used to determine the concentration of the absorber in a solution. It is essential to know how rapidly the absorbance changes with awareness. The energy transmission can be measured as the plot of energy versus wavelength, which is called as a spectrum. These optical methods are preferred by many researchers due to their good-looking advantages such as nondestructive measurement and no need to take a soil sample over electrochemical technology [3].

While reflectance spectroscopy can respond to total nutrient concentrations in soil, standardization of the reflectance signal to the plant available portion of the nutrient pool measured by standard soil examinations is a considerable trial. This trial has donated to the inability to obtain consistently good approximations across a range of soils, relatively high standard errors and significant effects of soil type.

b. Second is Electrochemical sensing

Ion-selective electrodes are used in electrochemical sensing which is used to generate a voltage or current output in response to the activity of selected ions. In Electrochemical Sensing furthermost of the electrochemical systems used to determine soil primary nutrient levels are based on the use of an Ion-Selective Electrode (ISE), with glass or an ion-selective field effect transistor (ISFET). Ion-selective films are available for sensing most of the important soil nutrients, including NO_3, K, Na, Ca, Mg, and Cl.

In general, laboratory examinations using Ion-Selective Electrode have shown to be likely to determine macro-nutrients in wet soils or soil extracts due to a robust direct connection to typical methods. [4].

However this review focuses mainly on optical sensing methods and principles for measuring the macronutrients and other properties in soil. Optical sensing approaches are being investigated and studied by researchers worldwide due to their attractive advantages over electrochemical technology due to their non-destructive measurement nature and no need to take sample [5]. Measurement of reflectance, absorption or transmittance characteristics of a material provides a nondestructive and rapid technique to evaluate its properties. Determination of the amount of energy reflected from soil surface in a particular spectral range is the most popular approach in agriculture [6]. Optical sensors are frequently affected by the different soil properties and exhibit different response in different regions of the spectral field which provide the opportunity to separate several effects with a single sensor response.

c. On-the-go soil macronutrient sensing

In this method rapid measurements of soil nutrients are an ideal approach to variable- rate application of agricultural fertilizer, several researchers, have reported real-time on-the-go soil nutrient sensing using custom-designed soil samplers and commercially offered ion-selective electrodes for sensing nitrate and pH in soils. The arrangement consists of a soil sampler, an extraction unit, a controller and a flow cell. A designed prototype shows a tractor-mounted area monitoring organization to measure soil nitrate levels in fields using Ion-Selective Electrode because it was originate that a nitrate ion-selective electrode gave more reliable sensor readings and acceptable response. The main drawback of on-the-go sensors based on ion selective technology is that soil sampler and nutrient extraction are required, increasing the difficulty of the system and the time required for a measurement.

3. METHODOLOGY

3.1 Wireless Sensor Network.

WSN is a wireless network is an integrated low-power sensing device, and it **c**ontains of base stations and numbers of nodes. Wireless sensor networks (WSNs) are self-possessed of sensor nodes with limited resources. It refers to a group of spatially dispersed and dedicated sensors for measure the environmental condition like temperature, humidity, chemical concentrations, pollutant levels and so on and it collected data at a central location. A sensor network consists of multiple detection stations called sensor nodes; each sensor node is small, lightweight and portable. In every sensor node is armed with a transducer, microcomputer transceiver communication and power kit is enabling the design of sensor nodes.

3.2 Sensor Technology.

A sensor is a device, whose purpose is to detect proceedings in its atmosphere and send the data to other displaying devices, frequently a computer processor. A sensor is a self-sufficient logical device that can provide information about the chemical configuration of its environment. The statistics data is provided in the form of a assessable physical signal that is connected with the concentration of a certain chemical classes. The main steps are involved in the operational of a chemical sensor, namely, recognition and transduction. For identifying the soil macro-nutrient level, the sensors are deployed in to different location in the soil. But basic technology working in the sensors remains same. This different arrangement plays an important part as when used efficiently these sensors save time and required power and also may decrease the channel traffic thus increasing the overall efficiency of the whole network. [7].

3.3 Different Sensors Arrangement

Sensor prearrangement is done in specific manner. Sensor Organization is done in a hexagonal geometry. Because it is the best geometry like square, triangle and hexagon. Each color specifies different type of sensors. Hexagon covers the largest area of three. Smallest amount of hexagon cover largest area. Six different types of sensors are used for measurement of six different nutrients & no one sensor of same type is interferes to other due to such arrangement. In each and every sensor is work at different incidence that's why there is no problem of interference in between dissimilar type of sensors.

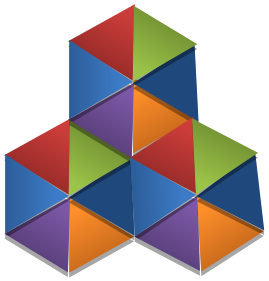

Fig-2 : Different types of sensor arrangement

3.4 Mechanism of a Sensor Network Technology.

The main components of a sensor node are a microcontroller, Transceiver it is built in communication system, power source and more sensors.

Microcontroller controls and monitors various sensors deployed and their input data. *Transceiver* is a built in communication system and it used to generate radio waves to transmit data obtained from sensors over wireless communications.

The statement is carried out between a gateway and a sensor node and also among two sensor nodes. Power supply devices such as primary battery or secondary battery. Sensors are used by wireless sensor nodes capture data from their environment. Wireless sensor nodes are typically very small electronic automated devices they can only be armed with a limited power source of less than 0.5-2 ampere-hour and 1.2-3.7 volts. The continuous analog signal produced by the sensors is digitized by analog-to-digital converter and sent to controllers for further processing. Reiterating data communicates, these sensor nodes carefully transmit data to the gateway. Additional, the gateway sends the data to a server or the cloud. The server or cloud examines the data for suitable use. This group cans facility for every aspect of wireless sensor networks, including uploading data to the cloud via a gateway or router and sharing data to your smart phone or any other terminal. The whole network is based on the occurrence of multi routing algorithm which is also called as wireless ad hoc networking. As shown in the below figure 3.

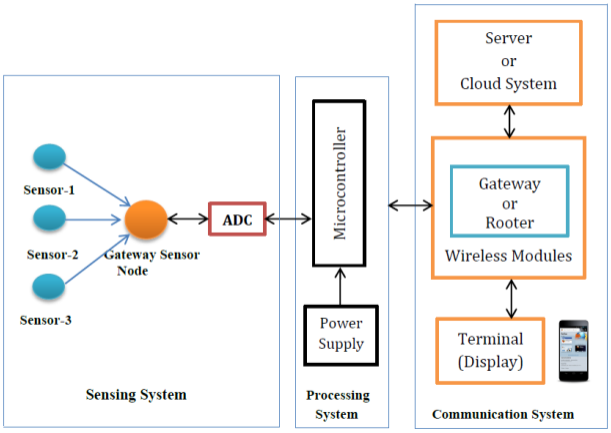

Fig- 3: Typical Architecture of Sensor Node

4. PROPOSED METHOD

The below figure 4 shows that the multiple sensor nodes are scattered in the chosen location in the soil. These nodes will collect data in the range of different soil nutrients using chemical sensor and transmit to the database server through the wireless communications modules to the base station or server where the data is accumulated.

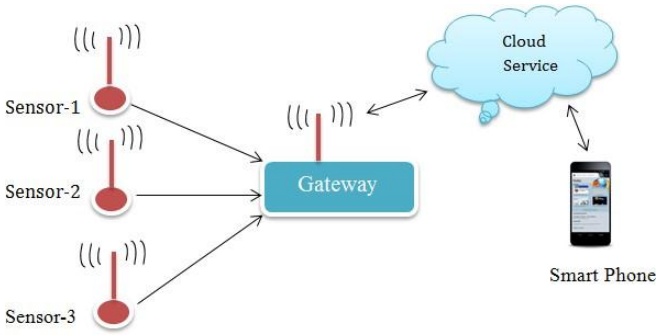

Fig- 4: Sensor Network Technology for soil nutrient

The chemical level of the soil is monitored by the sensors and data is transmitted over the wireless channel to the farmer's display system by a smart phone through which he can timely get the knowledge of chemical level in the soil in his field and accordingly he can apply fertilizers to his farm. In this technique the sensor technology can help former known exact time to apply fertilizer and dung to the field to increase the crop productivity, save time, money and energy.

5. CONCLUSION

Now a day's primary nutrients are very import part for the growing crops. In this paper a novel remedial system has been proposed can be defined as real deployment of Wireless Sensor Network based crop monitoring which is intended and implemented to understand modern precision agriculture. Increasing the alarms about ecological pollution by extreme use of fertilizers has led to increasing needs to monitor soil nutrients required for crop growth. This technology will help the formers to known the soil requirements which will help them take better decisions and preventive measures at the right time. End Users can adapt the mote operation to a variety of experimental setups, which will permit farmers to reliably collect data from different locations previously unreachable measurement scale. Such type of an association can be easily fitted and preserved. Lastly the comprehensive real time and past environment information is expected to help the agro-ecological specialists achieve efficient organization and utilization of environmental resources. Agro-ecological authorities achieve efficient management and utilization of agro-ecological resources.

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