# Information Acquisition for Farmland Soil Carbon Sink Impact Factors Based on ZigBee Wireless Network

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**HAL Id: hal-01614185**
**https://inria.hal.science/hal-01614185**

Submitted on 10 Oct 2017

# Information Acquisition for Farmland Soil Carbon Sink Impact Factors Based on Zigbee Wireless Network

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**Abstract:** As the main part of terrestrial ecosystem, farmland ecological system's estimation of carbon sink not only can help to understand the soil organic carbon content in farmland and increase the crop yield, but also can have great significance to the research on farmland ecosystem's influence to global climate warming. Through analyzing soil organic carbon estimation model of carbon sink factors, this article provides a method using multi sensors technology to acquire impact factors of soil carbon sink estimation and upload the results to the host computers by Zigbee+GPRS technology to realize the estimation of regional soil organic carbon in farmland. This research sets its research area in wheat experimental field in Yanzhou, Shandong Province, and by laying sensor nodes in the experimental field to acquire impact factors, the research aims to build reliable transmission of acquired factors by the Zigbee wireless sensor network, combined with GPRS technology. The result shows that this method can realize the reliable transmission of impact factors of the soil carbon sink in farmland and is of great significance to improve the accuracy of the estimation of soil carbon sink.

**Keywords:** farmland soil organic carbon；carbon sink; Zigbee; GPRS

## 1 Introduction

In recent years, with the increasing of the greenhouse effect and the deepening of the global change research, the estimation of carbon sink has drawn more attention. Estimation of soil carbon sink in farmland, as a part of estimation of carbon sink in farmland, is the estimation of the organic carbon content in the farmland soil. As an important indicator of the stability of agricultural ecosystem, the estimation results of soil carbon sink in farmland have great significance in the field of maintaining the function of agricultural soil carbon sink, improving the levels of soil organic carbon, mitigating the climate warming tendency and ensuring food security. The estimation of soil carbon sink in farmland needs substantial amounts of impact factor data of carbon sink. The traditional way of gathering data comes from the analysis of the existing soil survey data, the previous research data and field test data and this kind of research method usually has many shortcomings, such as the amounts of data is small, data timeliness is not good and data cannot be continuously acquired[1-3].

In recent years, with the application of wireless sensor networks technology in China's precision farming, the technology provided the feasibility for obtaining accurate information of farmland ecosystem thanks to its low cost, low power consumption, easy networking and other advantages. With the help of Zigbee technology, Liu Hui et al built the wireless sensor network to monitor the

temperature and humidity of the farmland soil; Sheng Ping et al, by combining Zigbee and 3G technology, realized the automatic control, accurate control and remote real-time monitor to environment and video information of greenhouse crops; Sun Baoxia et al, using the wireless sensor network, made the real-time monitor to the rice field come true and this can realize the real-time acquisition, wireless transmission and remote monitor of the growth environmental parameters of the large area of rice field[4-9].

Zigbee technology is one of the wireless sensor network technology and it is a new short distance wireless transmission technology. The technology has the characteristics of high reliability of data transmission, low power consumption, short delay and easy network and provides the possibility of real-time, accurate and reliable transmission of soil carbon sink in farmland.

This article takes the experimental field in Yanzhou of long-term location experiment as the research object. Many terminal sensing nodes, router nodes and the corresponding coordinator nodes are set in the experimental field to build the Zigbee sensor network. Combining Zigbee with the GPRS technology, the research acquires and transmits efficiently the estimated impact factors of soil carbon sink in farmland and improves the accuracy of estimation of soil carbon sink.


## 2 Analysis on impact factors of soil carbon sink in farmland

At present, there are many kinds of estimation models of soil organic carbon in farmland, such as Model Soil-C, proposed by Huang Yao et al, Model CENTURY, built by Parton et al from Colorado State University in the United States and Model RothC, built by Jenkinson et al based on the long-term field experiment data collected from the famous Rothamsted station in UK. The model proposed by Huang Yao et al is currently applicable to China's regional soil organic carbon estimation and this article applies this model to estimate the soil organic carbon in farmland in Yanzhou experimental field. There are four factors affecting the model proposed by Huang Yao et al: soil temperature, soil humidity, soil pH and soil texture and the former three kinds of data can be collected by sensor technology[10-17].

# 3 Survey of the research area and research method
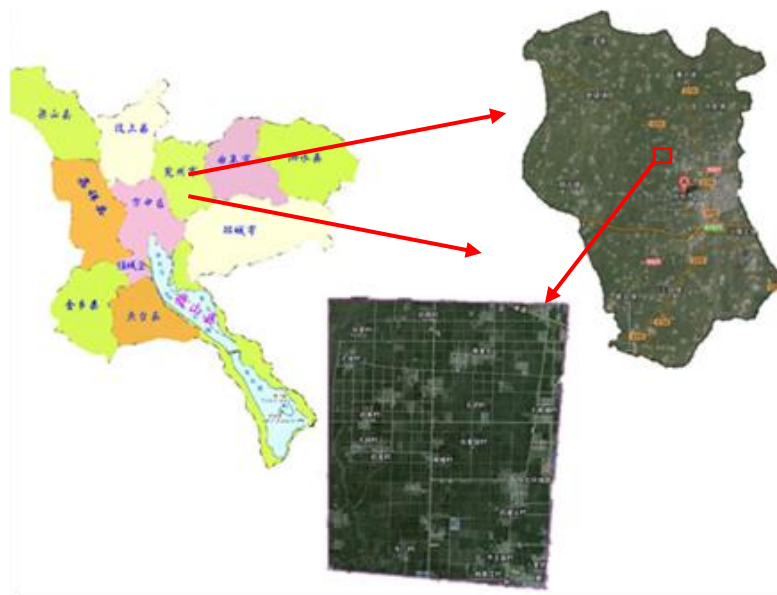
## 3.1 Survey of the research area



**Figure 3.1** location of the research area

Yanzhou City is located in the southwest of Shandong Province, the Plains of Southwest of Shandong Province and is situated between east longitude $116°35'21'' \sim 116°51'36''$, north latitude $35°23'31'' \sim 35°43'17''$. Figure 3.1 shows the location of the research area.

The research area has superior natural conditions and four distinct seasons. The average temperature over a year is 13.6℃. The average temperature of spring is 19℃, summer 22℃，autumn 20.5℃ and winter -0.3℃. Soil in this area is mainly cinnamon soil and has good soil physico-chemical properties and permeability.

## 3.2 Reach method

1)The overall research plan

The system of collecting soil carbon sink in farmland, which based on Zigbee wireless sensor network, not only can collect automatic data, but also has function of accurate data transmission, data storage and management and data analysis and processing. Therefore, through three modules, data acquisition and pre-processing module of Zigbee carbon sink impact factors, data collection and storage module of carbon sink impact factors based on GPRS server side and management and estimation module of carbon sink impact factors based on Web, accurate collection and estimation of soil carbon sink in farmland can be achieved and this can help make decisions about changes of China's regional soil organic carbon reserves. The overall structure is shown in Figure 3.2:
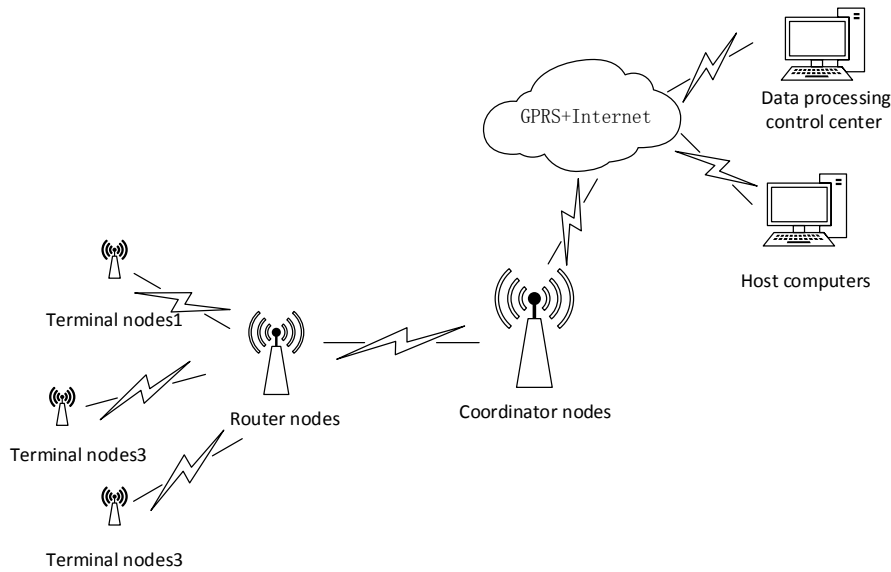
**Figure 3.2** the overall structure

Data acquisition and pre-processing module of Zigbee carbon sink impact factors employs sensors of soil temperature, sensors of soil humidity and sensors of soil pH as its terminal nodes to collect data and converges all these data to coordinator nodes, which have the function of data storage and pre-processing, through router nodes. Coordinator nodes, through core module, which has GPRS Modem, send data to the remote control center by GPRS network and Internet to store and apply.

Data collection and storage module of carbon sink impact factors in the sever side receives and stores data through SQL Sever database platform and data receiving and storage procedures running on the database. If the request to store the received data is legal, the sever will receive and store the collected data.

2)Design of Zigbee nodes

Zigbee wireless sensor network nodes are composed by the terminal nodes, router nodes and coordinator nodes. The terminal nodes apply RFD(Reduced Function Devices), coordinator nodes FFD(Full Function Devices) and router nodes both RFD and FFD.

In this study, the terminal nodes in the experimental field are responsible for the data collection of carbon sink impact factors, therefore their main components, various related sensors(sensors of temperature and humidity, sensors of pH) can monitor the real-time soil carbon sink impact factors in the farmland; MCU(Micro Controller Unit) processes and transmits the collected data, which is mainly constructed by chip CC2530; the inverted F-style PCB antenna is responsible for receiving and sending signal; Flash memory chip is of low energy consumption; and the power module is supplied by lithium battery. Figure 3.3 shows its structure.
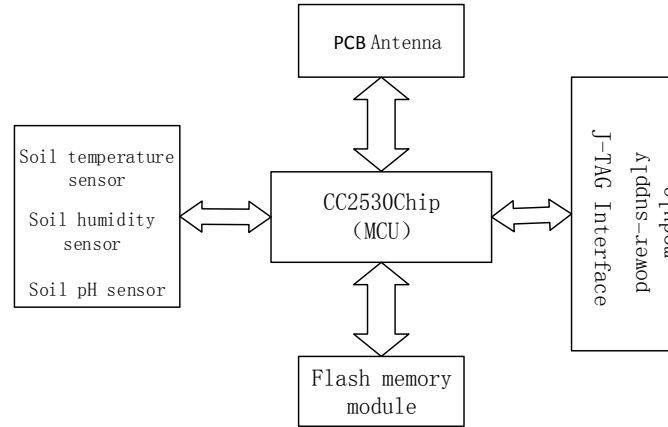
**Figure 3.3** Terminal node structure

In Zigbee wireless network, router nodes generally acts as a transit node. Collected data from the terminal nodes needs to be transmitted to the coordinator nodes. Usually distance between the two nodes shall not be so long, otherwise the data cannot be transmitted directly. In practical application, the increase of router nodes can keep the transmission between the terminal nodes and coordinator nodes to expand the network scope, so the router nodes are placed closely to the terminal nodes and far from the coordinator nodes.

The research applies the common communication interface RS-232 to realize the communication between the coordinator nodes and the host computers. The core module of the coordinator nodes transmits the collected data to the host computers by serial circuit RS-232. Serial circuit RS-232 is widely used in industrial standard[18].

3)GPRS and Internet connection

In this article, the way to access to Internet is dependent on the GPRS network. After converged carbon sink impact factors, which are collected by remote Zigbee wireless sensor network, to the coordinator nodes, data are transmitted to the remote data center by GPRS DTU(Data Transfer Unit). Figure 3 shows the structure:
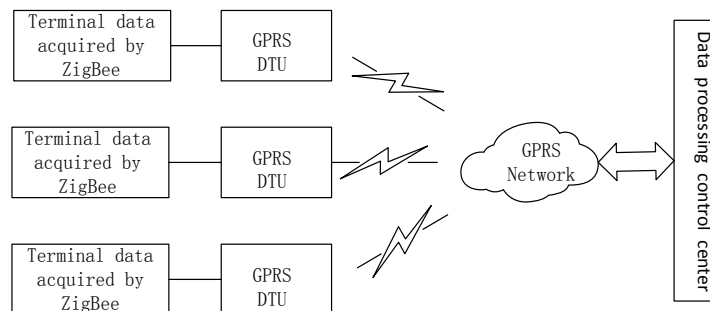


**Figure3.4** structure of GPRS and Internet connection

Data of carbon sink impact factors converged in the coordinator nodes, are transmitted transparently between data collection terminal and data center by GPRS network. The interfaces between the data terminals and GPRS DTU are generally RS-232, RS-485 or TTL and the interface used in this research is RS-232. The data control center of the host computers is the main equipment of the Internet center station. The center receives and processes the data transmitted by GPRS DTU, converts the protocol, and stores data to the database.

4)Routing technology and routing algorithm

Accurate and reliable transmission of data in Zigbee wireless sensor network depends on not only the reasonable allocation and selection of routing nodes and routing protocols, but also the selection of data fusion processing technology.

In this research, topological structure of Zigbee network nodes is tree structure, including a coordinator node and a plurality of router nodes and terminal nodes. The equipment can only directly communicate to its own parent node or child node point to point, other communication can only be transmitted by tree structure routing. Therefore, it is very important to select the appropriate routing protocol for reliable transmission of data. The routing protocol is mainly responsible for the transmission of collected impact factors from terminal nodes to target nodes by network. It mainly includes two aspects: finding optimized path from the terminal nodes to target nodes and correctly forwarding data packets along the optimized path. On the basis of the existing Zigbee routing protocols, the article applies the cellular ant colony routing algorithm(CACO) proposed by Sun Yuwen et al. The algorithm combines the advantages of LEACH algorithm and the traditional ant colony algorithm and the network terminal nodes are mapped into cellular from cellular automaton to generate a search ants in the region. The randomly generated cluster heard node data are transmitted into the coordinator nodes in an effective and energy-saving way to fulfill the information routing process. The design of cellular node dormancy conversion mechanism and the pheromone updating rule can effectively reduce the blindness of the search path, balance network energy consumption and prolong the network lifetime[19-20].

## 4. Comparison analysis of carbon sink impact factors in the experimental area

The content of the research in this article has been tested in the experimental field in Yanzhou City. To verify the accuracy of carbon sink impact factors acquired by Zigbee wireless sensor network, the data is compared and calibrated with the corresponding data acquired by the portable instruments. Figure 4 and 5 show the comparison between data of soil temperature and soil humidity acquired by Zigbee and data acquired by the portable instruments from Group 3 No. 1 node for 24 hours in a row on April 30, 2015 in the experimental area and the selected cycle is 30 min. Compared with the measured values, the average relative tolerance of soil temperature and soil temperature are 0.27% and 0.68% respectively. The way acquiring soil carbon sink impact factors based on multi sensors and Zigbee technology can not only obtain a large number of continuous data, but also meet the needs of soil carbon sink estimation in farmland.
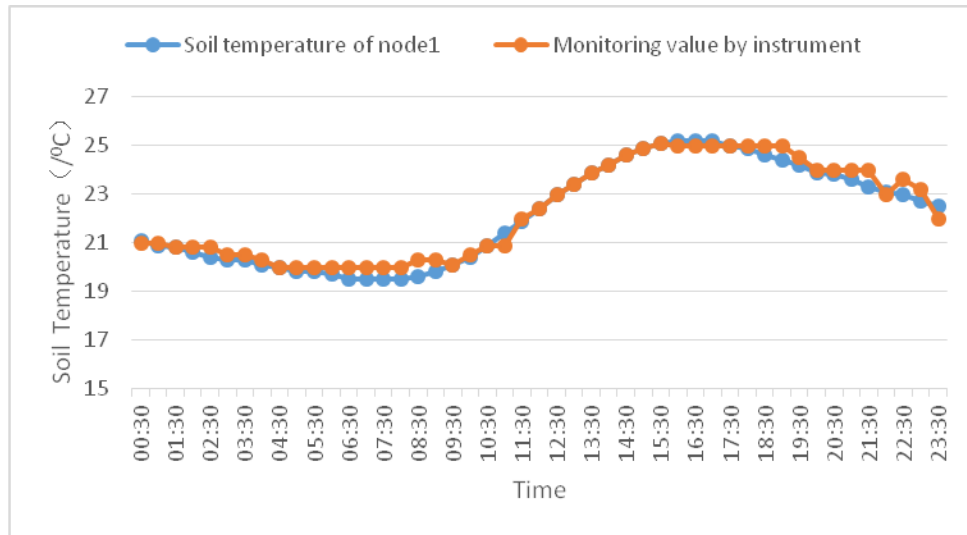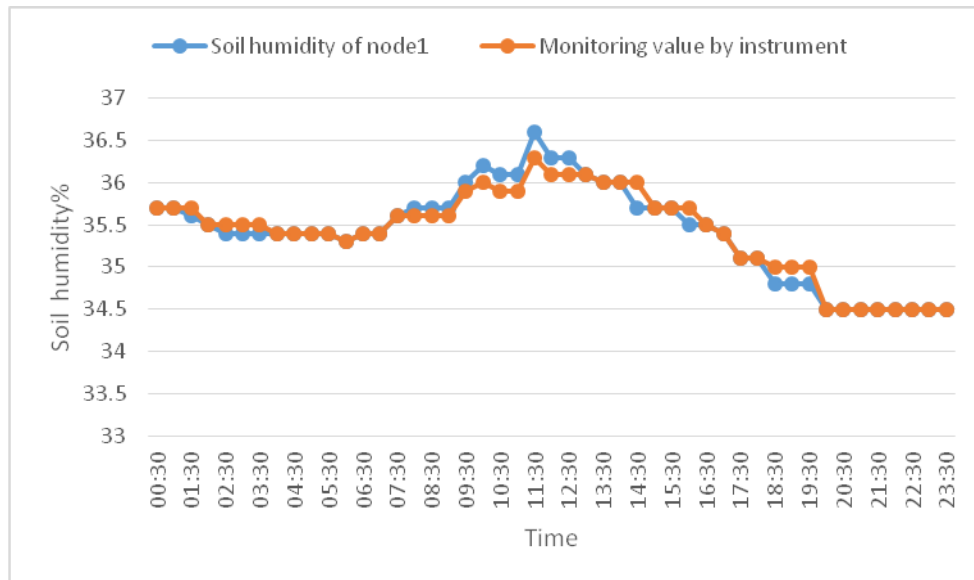
**Figure 4.1** comparison figure of soil temperature



**Figure 4.2** comparison figure of soil humidity

## 5. Conclusion and summary

Aiming at the current situation of large data, poor continuity and low reliability about the regional soil carbon sink estimated impact factors in farmland and widely application of wireless sensor network technology in acquisition and detection of farmland basic information, the article proposed the way of obtaining soil carbon sink impact factors in farmland with the help of ZigBee wireless sensor technology.

Monitoring network scheme of clustered wireless sensor network is designed in the experimental area of the city of Yanzhou. Each cluster works as a monitoring site and there are four sites to collect carbon sink factors in the experimental area in a continuous and real-time way, combining with ZigBee+GPRS technology to achieve the reliable transmission of carbon sink factor data . By comparing and analyzing the collected data and the measured data, one conclusion can be achieved that this method can effectively obtain the impact factors of soil carbon sink.

Compared with the traditional way, the method to obtain the impact factors of farmland soil carbon sink in this article, can realize the real-time and continuous acquisition of carbon sink impact factor data, can effectively improve the soil organic carbon estimation, and can provide a theoretical basis for the influence of global carbon source/sink from farmland ecosystem.

## Acknowledgment

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