A PRELIMINARY STUDY ON THE STATUS OF VESICULAR ARBUSCULAR MYCORRHIZAL ASSOCIATIONS WITH MANGROVE PLANTS IN SRI LANKA

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ABSTRACT: *The symbiosis between Arbuscular Mycorrhizal Fungi (AMF) and mangrove plant species was investigated in five mangrove swamps in Sri Lanka. Soil samples were collected from rhizosphere areas of dominant mangrove plants in Sarasalai area in Jaffna, Kakkapalliya in Pambala, Negambo lagoon, Trincomalee, and Manmunai Batticaloa, from a depth of 0-20 cm on from March to September 2018, during low tide period. Collected soil samples were clay loam in texture. For all five composite samples AMF spores were extracted using wet sieving and decanting method. Most common mangrove plants species were identified and their underground growing root tips were extracted to assess the colonization percentage of AMF. The results were compared using a one-way ANOVA in Minitab 16.0. AMF were mostly found in the form of hyphae and were commonly associated with most of the mangrove species investigated. AMF species belonging to Glomus, Gigaspora, Scutellospora and Acaulospora were identified in all areas. Root colonization was observed in all species. AM fungal root colonization varied by plant species and site. Lumnitzera racemosa was common to Jaffna and Pambala and the colonization potential was high in Jaffna compared to that of Pambala, but was not significant (at p < 0.554). Rhizophora apiculata in Pambala and Negambo was not significantly different (p<5) so as Avicennia marina in Pambala Batticaloa and Tricomalee. Furthermore, colonizing AMF species can be identified and recommended for inoculating mangrove seedlings in deforested areas for better growth and development of sustainable mangrove ecosystem.*

KEY WORDS: Arbuscular mycorrhizae, Mangrove plants, root colonization;

1. INTRODUCTION

Arbuscular Mycorrhizal Fungi (AMF) inhabit most terrestrial ecosystems, from tropical temperate and arctic-alpine ecosystems (Shi et al. 2006; Muthukumar & Udaiyan 2000; Haselwandter & Read 1980). The importance and functional significance of AMF in terrestrial ecosystems have been well documented. Ecological functions of AMF include helping to increase plant to withstand adverse soil conditions, severe climatic conditions and increasing plant productivity in natural plant communities (Brundrett and Kendrick 1996). Over the last twenty-five years, the presence of AMF in wetland plants has been investigated, and it is evident that AMF occur in wetland ecosystems (Miller 2000). Mangroves form the dominant interface ecosystems between the land and sea in the tropics (Ong et al. 1995). They are formed on sheltered muddy shores where land is extending seaward by accretion (Richards 1996). Mangroves are facultative halophytes, characterized by regular tidal inundation and fluctuating salinity (Gopal and Chauhan 2006). In Sri Lanka, mangroves are scattered mainly along the North-Western, North-Eastern and Eastern coasts

bordering lagoons and river estuaries. These are not widely spread and found as narrow strips of vegetation. The area covered by mangroves today is estimated to be 120 km2 in extent which is about 0.12% of the total land area of the country (Ransara et al., 2 012). The symbiosis between AMF and mangrove plant species was investigated in five mangrove swamps in Sri Lanka. This is the first time to investigate the AMF mangrove interactions in Sri Lanka.

2. METHODOLOGY

Study site.

Sarasalai area in Jaffna, Kakkapalliya in Pambala, Negambo lagoon, Trincomalee, and Manmunai Batticaloa

Soil sampling and root extraction

From two representative plots from each area, 5 soil samples (each soil sample is a composite of 5 soil samples) were collected (5 from each) from a depth of 0–20 cm. All samples from each area were used as replicates for the spore count. Soil samples were collected in ziplock. polythene bags, and were brought to the laboratory and stored at 4°C until analyses. Five most common mangrove plants species were identified and their root samples were extracted to assess the colonization potential of AMF (Mafaziya et al. 2015).

Separation and identification of spores

A 50 g soil from each sample was used for spore extraction by wet sieving decanting method asdescribed by Brundrett et al., (1996). The material retained on 250, 125, 63 and 45 µm sieves was collected on glass fiber filter papers separately (Whatman GF/A) and AMF spores and and differentiated into morphotypes under reflected light on stereomicroscope (Olympus SZ 61), and identified in to generic level based on the descriptions given in the International Culture Collection of Arbuscular and Vesicular-Arbuscular Mycorrhizal Fungi (INVAM, West Virginia, USA; http://invam.caf.wvu.edu) (Mafaziya et al. 2015).

AMF root colonization assessment

Roots were cleared in a water bath by heating with 10% (w/v) KOH at 60-90°C for 1 hour. Once cleared, a few drops of Chlorazol Black E (CBE) solution was added and heated again for about 20 minutes to several hours (until the root samples were stained properly) at 90°C. The excess stain was then washed off, acidified with 1% HCl solution before mounting roots on a glass slide with few drops of 50% Glycerol (Brundrett et al.,1996). The colonization percentage was calculated using the grid-intersect method (Mafaziya et al. 2015).

3. DISCUSSION AND RESULTS:

Table 1: Presence and the extent of root colonization by AMF in mangrove plants

Botanical Name	Family	Mycorrhizal colonization				
		Jaffna	Pambala	Negambo	Batticaloa	Trincomalee
		C%	C%	C%	C%	C%
Lumnitzera racemosa	Acanthaceae	9.3	7.9			
Excoecaria agallocha	Euphorbiaceae	22.8				
Acanthus ilicifolius	Acanthaceae	3.2				
Rhizophora apiculata	Rhizophoraceae		2.6	2.8		
Bruguiera gymnorrhiza	Rhizophoraceae		16.2			
Ceriops tagal	Rhizophoraceae		0			
Avicennia marina	Avicenniaceae		8.3		2.3	3.2
Soneratia	Lythraceae				4.9	

C% -Percentage colonization of roots by Vesicular Arbuscular Mycorrhizae
AMF species belonging to Glomus, Gigaspora, Scutellospora and Acaulospora were identified in all areas

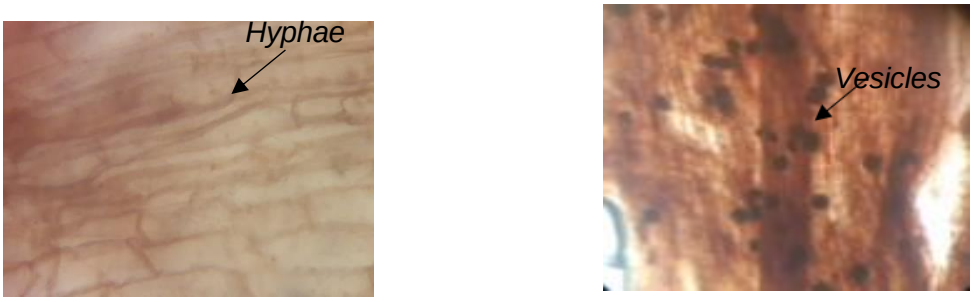

Fig. 1 Typical AMF structures observed in mangrove plant species

The occurrence of AMF in wetland ecosystems has been frequently reported in the recent years (Ipsilantis and Sylvia 2007). Some investigations were carried out in mangrove swamps. In our study, in all species studied AMF colonization was found.

No studies have been conducted in mangrove ecosystems in Sri Lanka to date. In our investigation, most of the studied plant species had Vesicular Arbuscular Mycorrhizal associations. AMF inoculation during an early stage of regeneration or replantation process of mangrove plants can be used for better establishment of the seedlings since mangrove recovery is extremely hard to achieve in spite of fertilizers applied. Therefore, these plants can be grown with minimal expenses using AMF inoculants as a means of protecting and conserving them.

CONCLUSION:

colonizing AMF species can be identified and recommended for inoculating mangrove seedlings in deforested areas for better growth and development of sustainable mangrove ecosystem. Further studies have to be carried out to confirm this justification.

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DEVELOPMENT OF IOT BASED SMART ENERGY METER READING AND MONITORING SYSTEM

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ABSTRACT: *In the most of the developing countries, the effort of collecting electricity utility meter reading and detecting illegal usage of electricity is a very difficult and time consuming task which requires a lot of human resources.Energy meter reading and monitoring system using Internet of Things (IoT) present an efficient and cost-effective way to transfer the information of energy consumed by the consumer wirelessly as well asit provides facilities to detect the illegal usage of the electricity.Aim of this study is to measure electricity consumption in the household and generate its bill automatically using IoT and telemetric communication techniques. Also this study aims to detect and control the energy theft.The Arduino microcontroller is employed to coordinate the activities with digital energy meter system and to connect the system to a WiFi network and subsequently to the Internet and Server. A passive infrared sensor is engagedwith the system to detect when anyillegal alteration happen in the metering system. In such case, system will send an alert to the server as well as it has the facility to disconnect and re-connect the electricity supply automatically.The proposed system is capable of continuously monitor and being notified about the number of units consumed to the energy provider and consumer. The energy consumptions are calculated automatically and the bill is updated on the internet by using a network of Internet of Things. This automation can reduce the needs of the manual labours.*

Keywords: Internet of Things (IoT), Microcontroller, Electricity theft, AMR

1. Introduction

Electricity is one of the essential necessities of human being for their life. It is a non-renewable energy source therefore we must use it judiciously for its sustainable utilization(Tan, Lee, & Mok, 2007). In a country like Sri Lanka, the most of the consumers are not happy and satisfied with the services of electricity suppliers; because of traditional meter reading methods which requires huge number of man power and long working hours to collect metering data for billing process. Manual billing process is sometimes slow by various reasons. Human operative traditional metering method can lead to be inaccurate(Mohamed Mufassirin & Hanees, 2018) and (Mufassirin & Hanees, 2014).

Electricity theft is also a challenging problem to the electricity board in Sri Lanka. Sri Lanka electricity board reported that near 30% of its total supply of electricity was lost due to electricity theft (Mohamed Mufassirin, Hanees, & Shafana, 2016). During the year 2011, officials from electricity board have caught 2935 offenders who used electricity illegally and earned about 199 million LKR by imposing penalties on them(News, 2014). Therefore, the Electricity Board officials are forecastingto take tough laws such as withdrawing electricity supplies to houses or industries who have engaged in electricity theft. The economic impacts of theft reduce the income from the sale of electricity and increase the necessity of overcharging to consumers. Only generating more

power is not enough to meet present day electricity requirements. Electricity consumption and losses have to be closely monitored and managed to efficiently utilize the generated power (Mohamed Mufassirin & Hanees, 2018).
The Internet of Things (IoT)permits object to be controlled and sensed remotely through existing communication network that creates chances for more direct integration between the physical world and computer-based systems. These activities are resulting in improved efficiency, accuracy and economic benefit(Pooja & Kulkarni, 2016) and (Muhammed & Hanees, IOT Based Waste Collection Monitoring System, 2017).This proposed IoT based smart energy meter reading and monitoring systemin this study, measures electricity consumption of each household and generate its bill automatically using IoT and telemetric communication techniques like microcontroller. Also this study provides an effective mechanism for detecting and controlling electricity theft in household site based on infrared sensor and IoT.
The remainder of this paper is organized as follow: Section 2 discusses the objectives of the study. Section 3 discusses the existing worksrelated to the study and Section 4 is dedicated for research methodology. Finally, section 5 concludes the paper.

2. OBJECTIVES

The main aim of this study is to design and develop a fully functional “Automated Energy Metering and Monitoring System” having innovativecapabilities like remote metering,theft detection and controlling the electricity supply to the consumer. The research is about to handle all the information of the consumer regarding energy consumption using a software system.

3. EXISTING WORKS

In this study, authors investigated the existing traditional meter reading system associated with energy provider of Sri Lanka and discovered various drawbacks and difficulties. Here authors have studied different technologies and methods available to reduce the meter reading problems. Finally, authors modeled out a worthy and feasible solution after analyzing the number of research papers and studies. Some of the important papers are summarized and evaluated in this section.
Tan, Lee, & Mok, (2007)suggest a development of a GSM based automatic power meter reading (GAPMR) system to solve this traditional meter reading problems. The GAPMR system contains GSM digital power meters installed in every consumer unit and an electricity e-billing system at the electricity provider side.In this study, it is failed to classify the area in which nonexistence of trusted third party GSM network coverage.
An IoT based system that consists of Power Line Communication (PLC) modem, a theft detection unit and a WI-FI unit was proposed by (Darshan & Radhakrishna, 2015). Two separate sub systems were employed to build upthe

system. One of the systems is to be installed at the consumer's energy meter point while the other unit is to be installed at the utility supplier company. Generally, three microcontrollers were proposed to be used in the project; two of such will be used in the system installed at the consumers end for IoT and theft detection capabilities. The remaining microcontroller will beused in the system located at the utility office (Darshan & Radhakrishna, 2015). However, the proposed system is not cost effective as it involves the operation of two separate systems to form a functional system.

Jain & Bagree, (2011) suggest Electromechanical Energy meters are being replaced by more accurate prepaid digital energy meters. They also claim that a huge percentage of electricity income was lost due to inappropriate meter reading and monitoring. Considerable amount of revenue losses can be minimized by using Prepaid Energy Meters and prepaid cards. The prepaid card system communicates with the power service provider using mobile communication medium. In this research, the proposed prepaid meter was a good solution for revenue collection from consumer, but it increases the effort of the billing process which is very problematic to consumers. In the meantime the authors put forward about communication between prepaid energy meter and power utility using mobile communication infrastructure but the communication module and infrastructure are not clearly exposed in the proposed work.

Authors found most of the systems analysed in the literature require high cost for implementation. Therefore, there is need to develop a cost effective system as a single solution that will read the meter remotely and prevent meter tampering.

4. METHODOLOGY

4.1 IoT- Based Energy Management Technology

The need for proper energy consumption and monitoring awareness has motivated several researchers to provide innovative controlling and monitoring solutions for the energy sectors. Similarly, several companies provide Enterprise Energy Management (EEM) software applications to analyze the collected data. By generalizing those practices, a general system architecture for energy monitoring using IoT can be resultant, as shown in Figure 1.

At the bottom layer of this architecture, there are smart meters and sensors, which may be connected through wired or wireless networks. Smart energy meters available on the market can attain several parameters (e.g. power consumption, max/min of peak voltage and power factor), hence they provide a high level of flexibility in monitoring and analyzing energy consumption.

At the mid layer, collected data are sent to a gateway, and then transferred to a local computer or to the internet via standard communications protocols, such as the ZigBee wireless technology. If wireless networks are used, sensors can be even more flexibly placed throughout the shop floor.

Eventually, data are fed into EEM software for analysis, into other enterprise systems such as Building Management Systems (BMS), Advanced Production and Scheduling systems (APS), Manufacturing Execution Systems (MES), Manufacturing Resource Planning (MRPII), or simply into the Enterprise Resource Planning (ERP). The data from smart metering systems can also be integrated with a supervisory control and data acquisition system (SCADA).

4.2 Design of Method

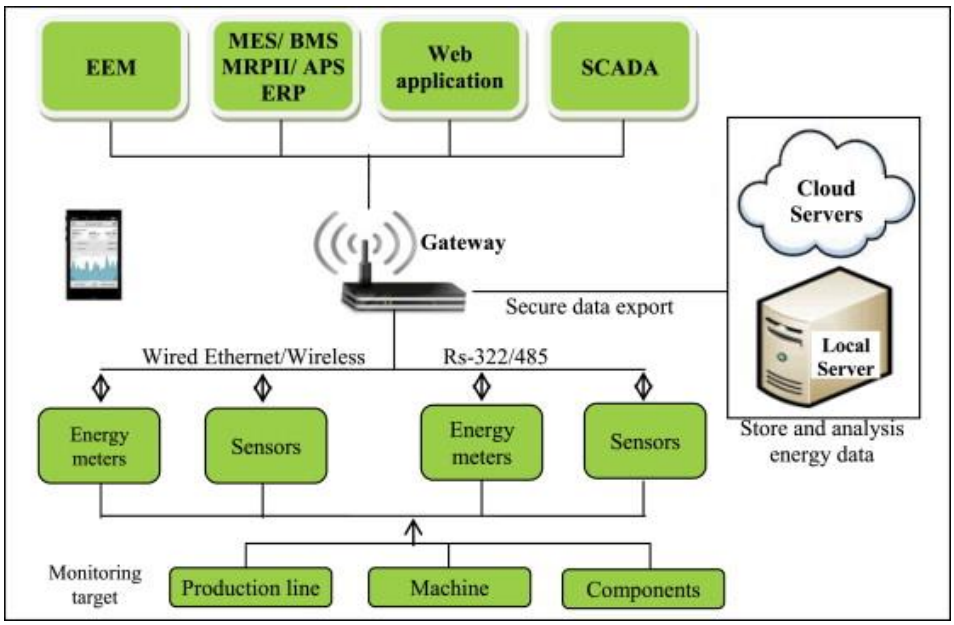

Figure 4.General System Architecture for Energy Monitoring UsingIoT

The concept of Internet of Things (IoT) plays an important role inchanging the current Internet into well featured internet(Muhammed & Hanees, 2018). The proposedIoT based smart energy meter contains mainly five modules.

1. Microcontroller module
2. Theft detection module
3. Energy Metermodule
4. Automated Meter reading (AMR) Module
5. Wi-Fi module

In the design of smart energy meter, the microcontroller is interfaced with AMR module, Theft detection module and Wi-Fi module. The microcontroller is a core component of the smart energy meter system which is placed at the consumer end for the purpose of measuring the meter reading, theft detection and storing the data. This data is transferred between consumer end and energy supplier end using IoT ESP3866 Wi-Fi. The AMR module continuously monitors the meter and collects the reading and sends to the microcontroller. In the current scenario, there is a need to uniquely identify the smartmeter device remotely in a reliable manner. To achieve the characteristic of device remotely we have provided IP address for each connection. In this paper we have concentrated on the theft detection, optimum utilization of power and convey the energy consumption information to the user end. The block diagram given in Figure 2 illustrates the proposed system.

A. Process at Consumer End

At the consumer end, the power supply module provides the entire power needed by the system to function. Also this power supply charges the DC

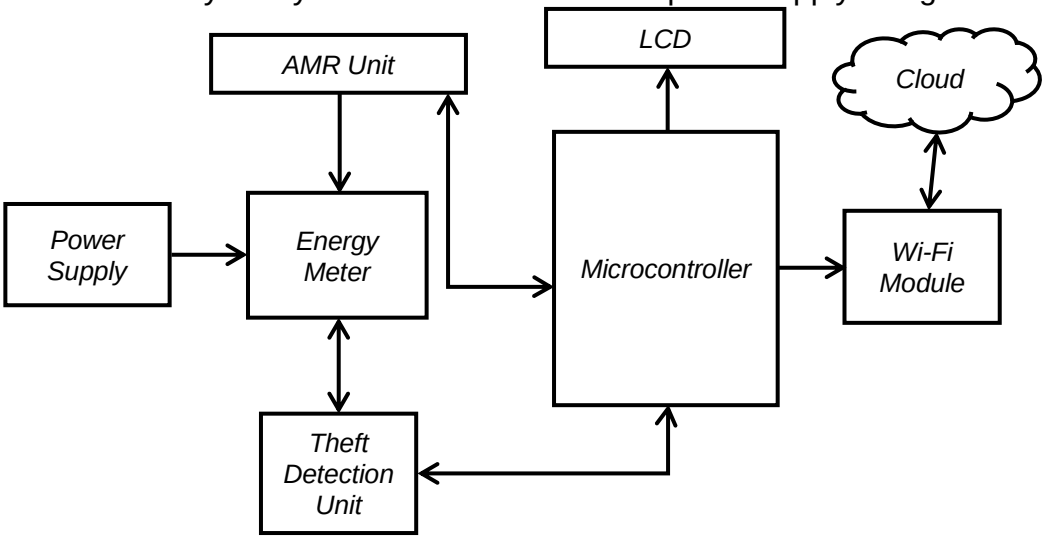

Figure 5. Block Diagram of IoT Based Smart Energy Meter Reading and Monitoring System

Backup so that when there is no power from the utility company, the DC Backup can energize the system. Microcontroller is used to collect and store the meter reading information from the electricity meter and also performs the control process and sends the required information to energy provider such as number of units consumed using Wi-Fi module. The purpose of LCD module is to get visual information about the number of units consumed, alert messages and connection status. This is a backup power supply unit (DC backup) for the system. The purpose of the DC backup is to makes the system active even there is no energy supplyfrom the utility company. A small 8.4V, 5600mAhrechargeable battery is used here.

B. Process at Supplier End

At the energy provider end, there is a server computer to receive the meter reading and generate the bill. If any theft is detected the system sends an alert message and disconnect the energy supply. If consumer fails to pay the

electricity bill amount within the due time by the supplier, the system can disconnect and reconnect the by sending the appropriate command to the controller.

4.3 IoT Analytics and Results

Data analytics is the process of inspectingbig datasets to draw inference about the content of the data. In this research, a data analytic platform was used to monitor the data sent by the energy meter so as to calculate the bill and detect the electricity theft. The Thingspeak.com IoT Data Analytic was used to visualize the status of the meter on the Internet. The infrared sensor senses when the meter has been tampered with, sends signal to the controller and network interface units. The network module connects the meter to the Internet by first connecting to an Internet-ready WiFi network and subsequently uploads the status of the meter to the Internet.An energy providing company may have several energy meters to be watchedand may not be able to effectively monitor the meters at the same time but with the use of a data analytic several meters can be monitored at the same time effectively. Figure 3 shows a sample interfacesthat display the unit consumed and respective bill for it in the server.

5. CONCLUSION

IoT based smart energy meter reading and monitoring system was proposed in

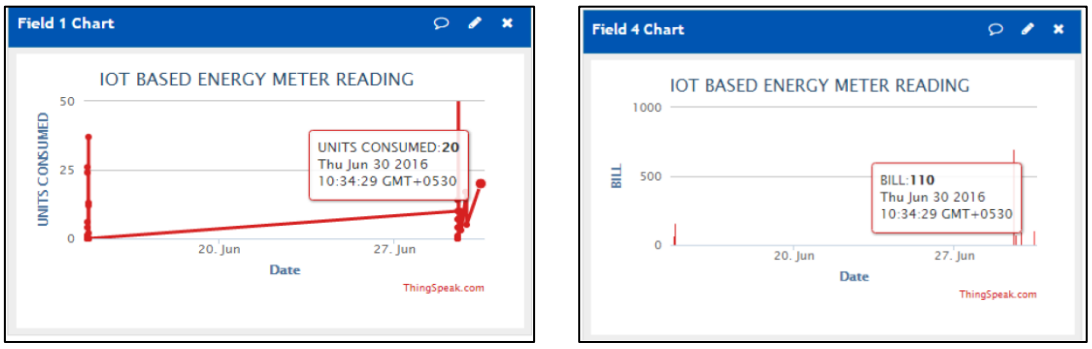

Figure 6. Sample Interface of the Consumed Unit of Energy and Bill in the Server

this paper. The system provides many significant advantages, such as wireless data transmission, low-workload, remote monitoring and controlling, anti-theft mechanism and less-expenses. The system would provide a simple way to collect the meter reading and detect an electrical power theft without any human involvement. The use of embedded microcontroller and Wi-Fi module increases the stability of wireless data transmission. By using this system the customer can anytime check their consumed unit and bill in the Internet in which paper is not required for billing which saves paper and printing cost. The bill can be paid using online customer support system. In future, the project can be integrated to form smart cities using Internet of Things based sensors as done globally. When compare with the existing GSM based and other traditional energy metering and monitoring system, the propose system is more efficient and cost effective. It allows the consumer to check the energy consumption and bill any time they login to the system whereas other existing system send the bill monthly or on request to the customer.

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