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Iot Based Nitrate Measurement And Environment Monitoring System

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ABSTRACT

Numerous methods are available for measurement of nitrate. However, these assays can either be time consuming or require specialized equipments. The principle of this assay is reduction of nitrate by vanadium(III) combined with detection by the acidic Griess reaction. However, these compounds are generally minor constituents of biological fluids relative to the concentration of nitrate. This report introduces a new, convenient assay for the stable oxidation products of nitrogen oxide chemistry in biological samples, such that we can measure the nitrate content in the sample. In an agricultural country, the concentration of nitrate in surface and ground water is concerning and been identified as a critical issue facing by the people. The nitrate concentration in the water is in the range of 0.01 to 0.5 mg/l, if the range is extended it causes harmful diseases to the people. To overcome this issue, we have designed a prototype model which will help them to measure the nitrate content in the water. Extended research on the design and development of a smart nitrate sensor for soil sampling to assess current soil nitrate availability. This system consists of ATMEGA/Arduino microcontroller, Wifi-module-ESP8266, DHT11 sensor, gas sensor, soil moisture sensor, LCD display (16*2). This project extends our earlier work by including a measure of humidity, moisture, motor relay setup in a water level and also a temperature compensation capacity within the sensor. WIFI-based Internet of Things (IoT) has been included making it a connected sensing system. The system is capable of sending data directly to an IoT-based web server, which will be useful to develop distributed monitoring systems in the future. The developed system has the potential to monitor the impact of industrial, agricultural or urban activity on water quality in real-time.

KEYWORD: Griess reaction, WIFI module, sensing system.

I.INTRODUCTION

Nitrogen, an important component of protein is essential for all living things. Nitrogen exists in the environment in many forms and, changes forms as it moves through the nitrogen cycle. However, excessive concentrations of nitrate-nitrogen in drinking water can be hazardous to health, especially for infants and pregnant women. Nitrate is a common contaminant found in groundwater that can have serious health effects if consumed at high levels. Nitrate is colorless, odorless and tasteless.

Low levels of naturally occurring nitrate can be normal,
excess amounts can pollute ground water. The primary health hazard from drinking water with nitrate-nitrogen occurs when nitrate is transformed to nitrite in the digestive system. The nitrite oxidizes the iron in the hemoglobin of the red blood cells to form methemoglobin, which lacks the oxygen carrying ability of hemoglobin. This creates the condition known as methemoglobinemia (sometimes referred to as "blue baby syndrome"), in which blood lacks the ability to carry sufficient oxygen to the individual body cells causing the veins and skin to appear blue as "blue baby syndrome", in which blood lacks the ability to carry sufficient oxygen to the individual body cells causing the veins and skin to appear blue. Nitrate in water is undetectable without testing because it is colorless, odorless, and tasteless. A water test for nitrate is highly recommended for households with infants, pregnant women, nursing mothers, or elderly people. These groups are the most susceptible to nitrate or nitrite contamination. A potential cancer risk from nitrate in water and food has been reported. A possibility exists that nitrate can react with amines or amides in the body to form nitrosamine which is known to cause cancer. Nitrate must be converted to nitrite before nitrosamine can be formed. Nitrite is present in groundwater to a much lesser extent because it is rapidly converted to nitrate, nitrite (NO2) is a contaminant with similar physical properties to nitrate.

Nitrate is a key compound in the N cycle of natural ecosystems and artificial environments, being substrate or product of several microbial, plant, and animal metabolic processes. In aquatic environments, nitrate is produced by nitrification in a two-step reaction: ammonium oxidation to nitrite and nitrite oxidation to nitrate. Nitrate can then be assimilated by photosynthetic organisms, thus being an important nutrient for primary production. Nitrate is also consumed in a variety of bacterial processes such as the anaerobic denitrification or dissimilatory nitrate reduction to ammonium (DNRA). Denitrification reduces nitrate to nitrous oxide, a potent greenhouse gas or molecular nitrogen gas, reducing the nitrogen load of the system, whereas DNRA reduces nitrate to biologically available ammonium that remains in the system. Therefore, the measurement of nitrate and nitrite concentrations in aquatic systems is an important aspect of most studies related to the N cycle in order to determine its production and consumption rates. Numerous methods for the determination of nitrate are available in the literature. Highly sensitive methods are based on the reduction of nitrate to nitric oxide, which is quantified by chemiluminiscence or to nitrous oxide, later quantified by gas chromatography. However, both these techniques require expensive and specialized equipment. Other methods involve the use of strong acids often at elevated temperatures which complicates handling and analyses of the samples.

Although various adaptation of the cadmium reduction method have been proposed in order to increase sample throughput and decrease sample volume required, the method suffers from various shortcomings; it is time consuming, efficiency of the column varies, a continuous activation of the Cd-column is required and cadmium is highly toxic making handling of samples and waste hazardous. Miranda et al. (2001) described a spectrophotometric method using a vanadium solution (VCl3) for the reduction of nitrate. V(III), which is less toxic than cadmium has been commonly used for the reduction of both nitrate and nitrite at high temperatures (80-90ºC) to nitric oxide, then measured by chemiluminiscence. Miranda et al. (2001) showed that at room temperatures nitrate is reduced to nitrite, which can react with Griess reagents and be measured in a spectrophotometer. However, the proposed protocol resulted in a low molar absorptivity for nitrate, indicating low reaction efficiency in the reduction of NO3 - to NO2 - . As a result, nitrite highly interferes with the determination of nitrate. Beda and Nedospasov included an initial step in the method for the elimination of nitrite by the reaction with sulfamic acid, reducing thus the high NO2 - interference in the NO3 - determination. However, as the subsequent steps involving the reduction of NO3 - to NO2 - were not modified, the overall efficiency of the reaction was not improved.

As a result the precision of the method was lower than that using the classic Cdcolumns for nitrate reduction. We describe here an optimized protocol for the sequential measurement of nitrite and nitrate in small volumes (< 1mL) of the same sample by adjusting factors such as vanadium chloride and HCL concentrations, temperature and time of reaction that improved the efficiency of the nitrate reduction to nitrite and the signal measured. As a result, efficiencies higher than 95% were obtained, resulting in a simple, fast and accurate method for the determination of nitrate and nitrite. The proposed methodology was also compared with the most widely used method for NO3 - analysis, the Cd column method) by analyzing in parallel samples from different environments (fresh water reservoir, sediment freeze lysable pore water, estuarine water samples and samples from an acid mine drainage impacted reservoir).

II.EXSITING SYSTEM

Planar type interdigital sensors have been used for the detection of nitrate-N in water samples for previous research. Planar interdigital sensors behave like parallel plate capacitors and the principle of detection is based on a change of electric field generated between two types of electrodes. A low amplitude alternating electrical voltage is applied across the sensor terminals. The generated electric field passes through material under test (MUT) so that the electric field will be affected. The magnitude and phase of the impedance of the sensor is measured. The real and imaginary components of the impedance are used to determine the properties of the material under test. For measurement of nitrate contamination in water, a thin-film layer Parylene coated interdigital sensor has been used Fig. 1 shows the block diagram of previous designed system.

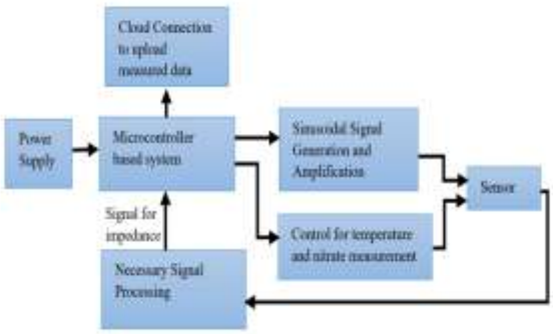

Fig. 1. Block diagram of the previous system

Since the sensor is exposed to air and dipped in water, the potential for oxidation is a real problem. Parylene coating on the sensing surface protects the sensor from oxidation due to moisture and Faradic currents. Different types of sensors have been fabricated and the current research is based on 1-5-50. The 1-5-50 configuration means a repeated pattern of five sensing electrodes (-ve electrode) for one excitation electrode (+ve electrode), with a distance of 50 m between two consecutive electrodes. The sensing area was fixed to 2.5 mm X 2.5 mm. Fig. 2 shows the Parylene coated sensor, which has been used in all experiments.

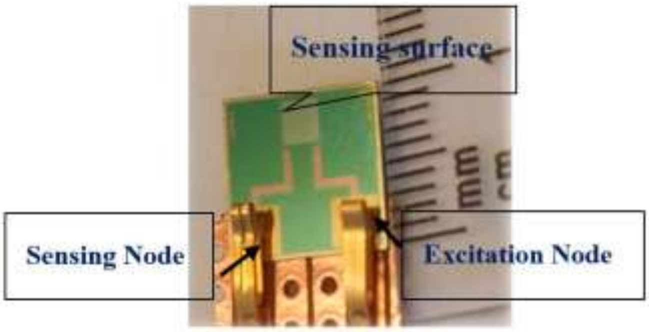

Fig. 2. Interdigital sensor with Parylene coating

2.1.Experimental Setup

Temperature affects the mobility of ions in water therefore, it is important to measure the changing behavior of the sensor at different temperatures. Fig. 3 shows the experimental setup involving a high precision Hioki 3522-50 LCR meter, Hioki 4-terminal probe 9140, mercury thermometer, SCILOGEX MS 7-H550 Digital Hotplate and computer for data acquisition. The mercury thermometer was immersed in deionized water (MilliQ was obtained from MILLIPORE water system (USA)—18 MΩ cm) to obtain a continuous temperature reading. Meanwhile, the sensing surface was also immersed in water and collected data when the temperature reached a steady value. The frequency was swapped from 1 Hz to 10000 Hz, to characterize the sensor under different temperatures. Fig.3. Experimental arrangement for temperature measurement.

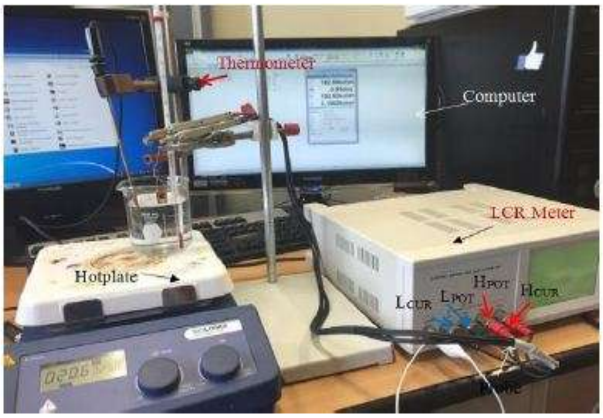

Fig. 3. Experimental arrangement for temperature measurement

The experimental set-up to measure the concentration of nitrate in water is shown in Fig. 4. Ambient temperature and humidity conditions are maintained during experiments. The electronic circuits including the water pump and solenoidal valve are powered from a 12 V battery. The sensor needs an alternating voltage for its excitation.

Fig. 4. Experimental arrangement for nitrate-N detection

An Arduino Yun has been used to generate a sinusoidal voltage waveform to provide excitation to the sensor. The sensor measured the temperature and the same sensor was used to measure the nitrate concentration. All necessary signal processing was done at the microcontroller. The sensing part of the sensor was dipped in the sample water for measurement. The nitrate ions are polarized towards the plates according to their charge. Two water pumps were used for the experiment; one pump was used to pump the water sample for measurement every 15 minutes and another one was used to discharge the sampled water, after one minute. The Arduino Yun communicates with the cloud server to send the final measured data. All the measurements are taken five times and results averaged.

III. PROPOSED SYSTEM

Determination of nitrate in aqueous samples is an important analytical objective for environmental monitoring and assessment. Here in our proposed system we report the analysis of nitrate (plus nitrite) using VCl_3 as reductant instead of the well-known but toxic cadmium column for reducing nitrate to nitrite. The reduced nitrate plus the nitrite originally present in the sample react with the Griess reagent. The Griess reagent and VCl_3 are used as a single mixed reagent solution to simplify the system. The various parameters of the FIA procedure including reagent composition, temperature, volume of the injection loop, and flow rate were carefully investigated and optimized via univariate experimental design. Under the optimized conditions, the linear range and detection limit of this method are 0–100 μM (R^2=0.9995) and 0.1 μM, respectively. The targeted analytical range can be easily extended to higher concentrations by selecting alternative detection wavelengths or increasing flow rate. The FIA system provides a sample throughput of 20 h^{-1}, which is much higher than that of previously reported manual methods based on the same chemistry. National reference solutions and different kinds of aqueous samples were analyzed with our method.

In this contribution a method to analyze nitrate in marine pore water, seawater and freshwater is presented. The method serves to replace the well-known cadmium column method for

the reduction of nitrate to nitrite. Instead, acidic vanadium(III)-solution is used for the reduction avoiding the toxic Cd metal. Fig. 5 shows the block diagram of our designed system.

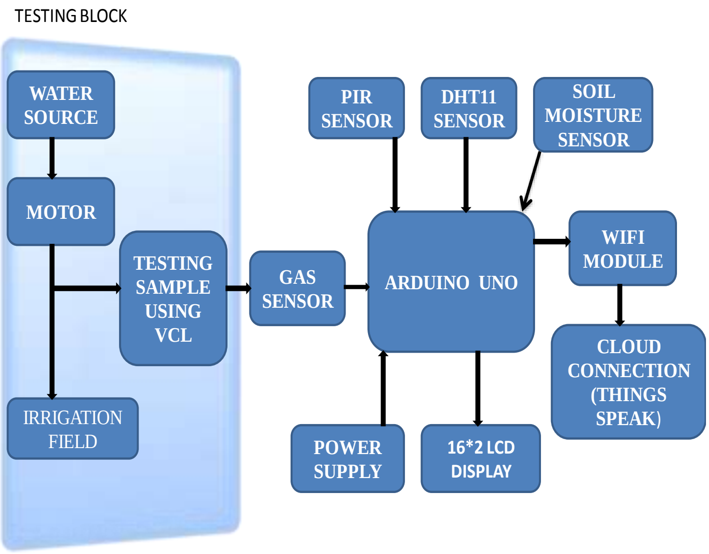

Fig. 5. Block diagram of our designed system

VCl_3 can be used as a reduction agent to convert NO_3^- to NO_2^- in water samples. VCl_3 solution is easier to handle than the cadmium reduction technique. The micro method needs < 0.5 mL for NO_3^- and NO_2^- determination. The method allows also direct NO_3^- determination.

3.1EXPERIMENTAL SETUP

Here our setup initially begins with collecting the water sample using motor and then subjected to testing .The testing process involves in mixing the vcl3 reagent in water sample. Vcl3 is a reducing agent which is used to convert no3- to no2-. They also oxidise the nitrate which in turn measured by using an gas sensor .The aqueous nitrate calibration performed using the vanadium solution is done to check for the acceptable level of nitrate in water sample. If the range exceeds the permitted level in sample. Then the water is needed to subject to respective treatment to bring down the level. If the level is permissible then the water is allowed for the irrigation purpose. Other environmental factors such as temperature, humidity, mositure of the field are also measured in order to provide the water supply when needed. Finally these nitrate temperature moisture and humidity values in uploaded in thinkSpeak website in order to have easy access and monitor. We can also able to design a personal website to monitor the factors and control the motor setup.

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Fig. 6. Web page

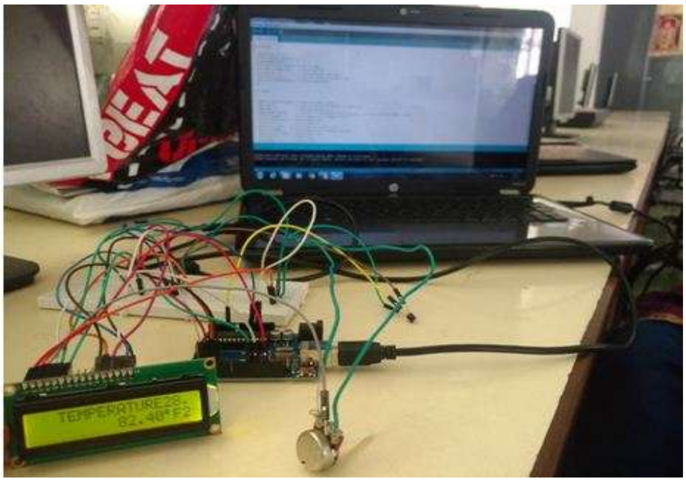

Fig. 7. Experimental arrangement for temperature measurement

3.2 DHT11 SENSOR

This DFRobot DHT11 Temperature & Humidity Sensor features a temperature & humidity sensor complex with a calibrated digital signal output. By using the exclusive digital-signal-acquisition technique and temperature & humidity sensing technology, it ensures high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost-effectiveness. The component is 4-pin single row pin package. It is convenient to connect and special packages can be provided according to users' request.

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Fig. 8. DHT11 sensor

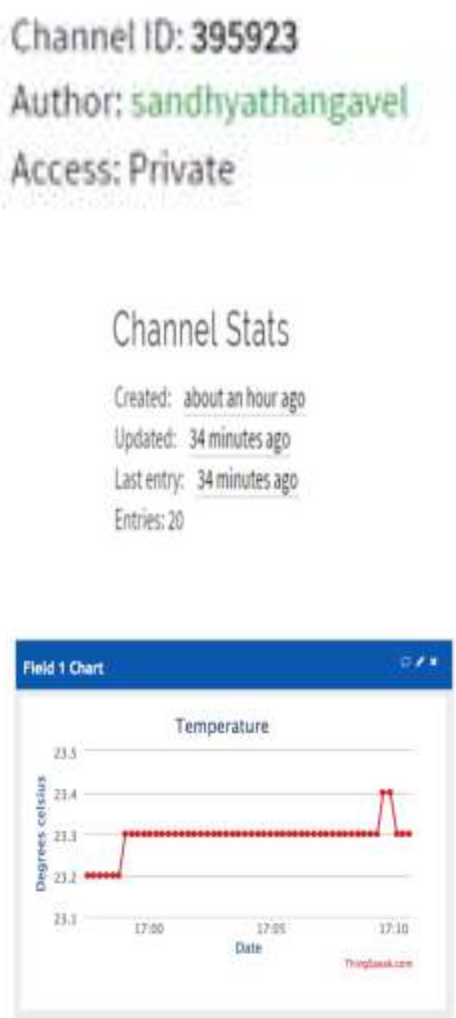

Fig. 9. Temperature measurement in ThingSpeak website

Fig. 10. Humidity measurement in ThingSpeak website

3.3 SOIL MOISTURE SENSOR

Soil moisture sensors measure the volumetric water content in soil. Since the direct gravimetric measurement of free soil moisture requires removing, drying, and weighting of a sample, soil moisture sensors measure the volumetric water content indirectly by using some other property of the soil, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content. The relation between the measured property and soil moisture must be calibrated and may vary depending on environmental factors such as soil type, temperature, or electric conductivity. Reflected microwave radiation is affected by the soil moisture and is used for remote sensing in hydrology and agriculture. Portable probe instruments can be used by farmers or gardeners. Soil moisture sensors typically refer to sensors that estimate volumetric water content. Another class of sensors measure another property of moisture in soils called water potential these sensors are usually referred to as soil water potential sensors and include tensiometers and gypsum blocks. Golf courses are using soil moisture sensors to increase the efficiency of their irrigation systems to prevent over-watering and leaching of fertilizers and other chemicals into the ground. Knowing the exact soil moisture conditions on their fields, not only are farmers able to generally use less water to grow a crop, they are also able to increase yields and the quality of the crop by improved management of soil

moisture during critical plant growth stages.

Fig. 11. Soil moisture sensor

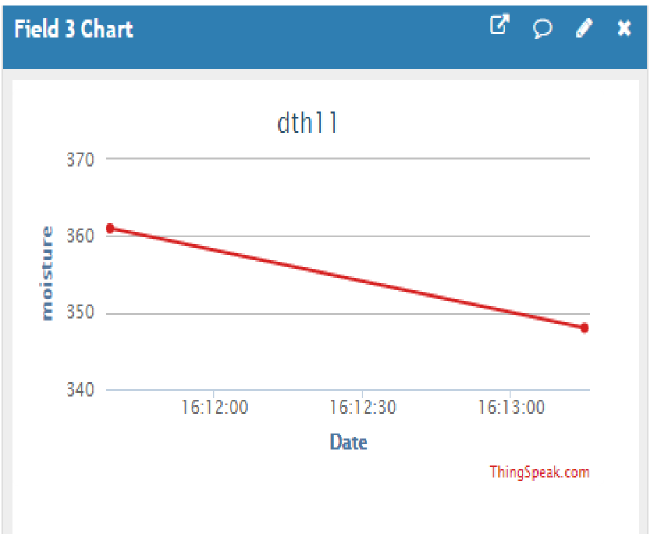

Fig. 12. Moisture measurement in ThingSpeak website

3.4GAS SENSOR

The MQ-135 gas sensor senses the gases like ammonia nitrogen, oxygen, alcohols, aromatic compounds, sulfide and smoke. The boost converter of the chip MQ-3 gas sensor is PT1301. The operating voltage of this gas sensor is from 2.5V to 5.0V. The MQ-3 gas sensor has a lower conductivity to clean the air as a gas sensing material. In the atmosphere we can find polluting gases, but the conductivity of gas sensor increases as the concentration of polluting gas increases. MQ-135 gas sensor can be implementation to detect the smoke, benzene, steam and other harmful gases. It has potential to detect different harmful gases. The MQ-135 gas sensor is low cost to purchase.

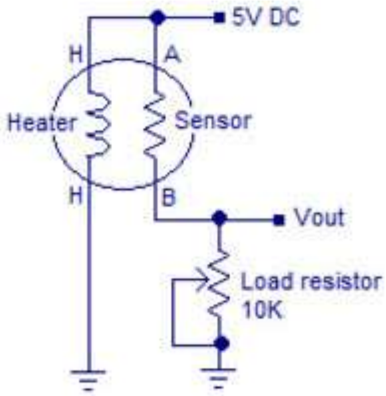

Fig. 13. MQ-135 Circuit diagram

IV.CONCLUSION

A low cost ardunio based architecture for smart nitrates measurement in the water sample is proposed in the paper. This method uses planar type interdigital sensor for the effective detection and measurement of nitrate content in water. The designed system can show a good linear relationship between the measured nitrate concentrations (ranged from 0.01 to 0.5 mg/L) to those measured by the commercial equipment in the collected water samples. Then extensive experimental results demonstrate the performance of proposed technique is better than the previous lowering the cost or complexity method and is comparable to the higher complexity methods in terms. Therefore, it very suitable to be applied to many real-time applications.

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